THE EMERGENCE OF DISTINCTIVE FEATURES

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate

School of The Ohio State University

By

Jeff Mielke, B.A., B.A., M.A.

* * * * *

The Ohio State University
2004

Dissertation Committee:

Professor Elizabeth Hume, Adviser

Professor Keith Johnson

Professor Brian Joseph

Approved by

____

Adviser
Linguistics Graduate Program

ABSTRACT

Since the mid 20th century, distinctive features have been widely assumed to be part of Universal Grammar. While the theory of innate features predicts that a small set of distinctive features can describe most if not all natural classes, this prediction has never been explicitly tested. The usefulness of distinctive features in phonological analysis is clear from decades of research, but demonstrating that features are innate and universal rather than learned and language-specific requires a different kind of evidence. This dissertation presents the results of the first large-scale crosslinguistic survey of natural classes. Based on data from 561 languages, the survey reveals that unnatural classes are widespread: among 6077 unique classes of sounds which are targets or triggers of phonological processes, analyzed in three popular feature theories (*Preliminaries*, Jakobson, Fant, and Halle 1954; *SPE*, Chomsky and Halle 1968; and Unified Feature Theory, Clements and Hume 1995), no single theory is able to characterize more than 71% of the classes, and over 24% are not characterizable in *any* of the theories. While other theories are able to account for specific subsets of these classes, none is able to predict the wide range of classes which actually occur and recur.

Even so, many approaches to innate features allow for the existence of unnatural classes as idiosyncrasies or historical oddities. However, it is shown in this dissertation that there is no objective way to partition classes into natural and idiosyncratic categories.

Many apparently unnatural classes recur in multiple languages, and ranking classes according to frequency results in a bell-like distribution which slopes gently from the common classes which are easily described in phonetic terms and easily characterized in traditional phonetically-defined features, all the way down to the rare classes which occur only once in the survey. Not only is there no visible boundary between the natural and the unnatural, the two are interleaved, with some of the most common unnatural classes being more frequent than most natural classes, and with the vast majority of the natural classes which are predicted by combining distinctive features completely unattested. While many unnatural classes are describable as the union of two natural classes, the most common of the classes which can be analyzed in this way are composed of phonetically-similar segments, but analyzable only as the union of classes which are very rare on their own, casting doubt on the idea that they are simply the result of the cooccurrence of classes predicted by the theory.

Even without these findings, there are many reasons to be suspicious of the idea that distinctive features are innate. Humans have been evolving (separate from other primates) for a relatively short time. For all distinctive features, including the uncommon ones, to have emerged in the human genome, humans must have been exposed to contrasts motivating all of them at some time before the life of a common ancestor of all modern humans who would have all these features (all humans). This includes the distinctive features for sign languages, which appear to use entirely different phonological features and feature organization (e.g., Brentari 1998, Corina and Sagey 1989, Sandler 1989), even though deafness is generally not hereditary. All of this evidence, along with the survey results, point to the conclusion that the distinctive features used in language are learned rather than innate.

Many different types of explanation are available to account for all the ways in which sounds may be grouped together. As is shown, sounds may be grouped together as a result of their shared participation in a sound change, and others can be attributed to phonetically-based generalizations. It is seen that the segments which are the most fickle in their patterning crosslinguistically are those whose phonetic cues are the most ambiguous, regardless of the features traditionally used to define them. These sources predict that classes will tend to involve phonetically similar segments, and the use of phonetically-defined distinctive features is just one way to describe classes of phonetically similar segments. While these types of explanations are often invoked to account for "idiosyncratic" unnatural classes, it is shown that they are even better at accounting for "natural" classes, and the result is a unified account of what were previously considered to be natural and unnatural classes.

Dedicated to Sara J. Mielke

ACKNOWLEDGMENTS

I would like to thank my committee members, Beth Hume, Keith Johnson, and Brian Joseph, for cultivating my interest in phonological theory, phonetics, and historical linguistics, and inspiring me to try to believe in them all at the same time. Beth and Keith more or less taught me how to be a linguist in our Perception in Phonology seminars in 1999-2000, and Brian planted thoughts in my head over the years which re-emerged in 2002 as part of a dissertation topic.

The research was funded by a Presidential Fellowship from OSU and teaching and research assistantships in the OSU Linguistics Department. All of the ideas put forth here were collected in the course of working in the linguistics community at Ohio State, and traveling to conferences, which was generously paid for out of the department 's Language Files fund. My dissertation topic first dawned on me at the 2002 MOT phonology workshop at McGill, and crystalized later that year somewhere on I-80 in Pennsylvania, with the help of Giorgos Tserdanelis, when we made the drive from Columbus to New Haven for LabPhon. I have had the good fortune to be able to discuss this stuff with other students at OSU, including Robin Dautricourt, Kathleen Currie Hall, Grant McGuire, Anton Rytting, Tom Stewart, and Steve Winters. Mike Armstrong was a great help in converting my survey data to a searchable format, and Wes Davidson helped me at a crucial point with lattices. Chris Brew helped me get the phonetic similarity model on the right track.

I have benefited much from talking about features and phonological patterns with Mary Beckman, Nick Clements, Dave Odden, Doug Pulleyblank, Janet Pierrehumbert, Donca Steriade, and Andy Wedel, and this dissertation would have been a lot harder to write without the help of Scott Myers, Keren Rice, and Donca Steriade. I am also grateful for the hundreds of linguists who wrote the descriptive grammars that supplied the data for my survey, to the folks at SIL for making *Ethnologue*, and to the Ohio State University and the people of Ohio for funding my research.

A whole lot of people were instrumental in making it possible for me even to be in the position to write a dissertation. The earliest part of my graduate school experience was dominated by the death of my wife, and I am most grateful to Beth Hume not only for being the best academic advisor I can imagine, but for somehow knowing what to do with a 22-year-old widowed graduate student. Beth (and Keith) kept me busy working on the ICPhS satellite meeting in 1999, when I needed to be kept busy, got me started on my Turkish /h/ deletion project when I needed a project to get started on, and then let me do my own thing.

I owe much of my current emotional health to friends I didn't know six years ago, including Paul Davis, Vanessa Metcalf, Jason Packer, Andrea Sims, and especially Robin Dodsworth, and my dog Hudson. Pat Hammel, my neighbor and landlord, went above and beyond the call of duty, and assured that every landlord I have from now on will seem completely inadequate and uninspiring. Oxley 225 has been my home away from home for the past five years, and that has been all the more pleasant since I have been able to share it with Hope Dawson, Shelome Gooden, Crystal Nakatsu, Na'im Tyson, and a bunch of other people, including some already mentioned above.

I am most indebted to my parents, Rich and Marilee Mielke, and my sister Alison, for their love and support, and for putting me in a position where it was possible to go to college and graduate school. And I am grateful to Rick, Sheri, Lindsay, Erica, and Kelly Backous for their continued support. Finally, I am indebted to Sara, who was my wife when we moved to Ohio so that I could study linguistics, and who died in a car accident on her way home from work nine months later. This dissertation is dedicated to her.

VITA

August 16, 1976 …………………………...... Born – Vancouver, WA

1997 ……………………………………….. B.A. Linguistics, University of Washington

1997 ……………………………………….. B.A. Japanese, University of Washington

1999 ……………………………………….. M.A. Linguistics, The Ohio State University

1998 – present ……………………………... Graduate Teaching or Research Associate or Fellow, The Ohio State University

PUBLICATIONS

1. Mielke, Jeff (2003) The Interplay of Speech Perception and Phonology: Experimental Evidence from Turkish. *Phonetica* 60.3: 208-229.

2. Mielke, Jeff (2003) The Diachronic Influence of Perception: Experimental Evidence from Turkish. *Proceedings of BLS 29*.

3. Mielke, Jeff, Mike Armstrong, and Elizabeth Hume (2003) Looking through opacity. *Theoretical Linguistics* 29.1-2: 123-139.

4. Mielke, Jeff (2002) Turkish /h/ deletion: evidence for the interplay of speech perception and phonology. In Hirotani, M. (ed.) *Proceedings of NELS 32*. Amherst, Mass.: GLSA. 383-402.

5. Mielke, Jeff (2002) Turkish /h/ deletion: evidence for the interplay of speech perception and phonology. In Hall, T.A., Bernd Pompino-Marschall, Marzena Rochon, eds., ZAS Papers in Linguistics 28: *The Articulation, Acoustics, and Perception of Consonants*. 55-72.

6. Mielke, Jeff (2002) Perception in phonology: the case of Turkish /h/ deletion. In Andronis, M., C. Ball, H. Elston and S. Neuvel, (eds.) *CLS 37: The Panels*. Papers from the 37th Meeting of the Chicago Linguistic Society. Vol. 2. Chicago: CLS. 59-72.

7. Mielke, Jeff, and Elizabeth Hume (2002) Considerations of Word Recognition for Metathesis. In Hume, E., N. Smith and J. van de Weijer (eds.) *Surface Syllable Structure and Segment Sequencing*. Leiden: HIL. 135-158.

8. Mielke, Jeff (2001) Explaining directional asymmetry in Turkish [h] deletion: A crosslinguistic study of perceptibility. In Hume, E. and K. Johnson (eds.) *The Interplay of Speech Perception and Phonology*, OSUWPL, vol. 55. 117-171.

9. Hume, Elizabeth, and Jeff Mielke (2000) Review of C. Gussenhoven and H. Jacobs (1998) *Understanding Phonology*. *Phonology* 17.2. 281-286.

FIELDS OF STUDY

Major Field: Linguistics

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER 1

NATURAL CLASSES AND DISTINCTIVE FEATURES IN PHONOLOGY

1.1. Natural class behavior

Speech sounds in spoken languages do not always act independently. Instead, multiple sounds frequently participate in the same sound patterns. When a group of sounds exhibits the same behavior, it is often the case that these sounds are phonetically similar to each other. This type of grouping of sounds has been termed a *natural class*. The observation that phonological alternations often involve groups of sounds which share phonetic properties has led to the proposal that phonological alternations act upon specific properties of sounds, or *distinctive features*, rather than on the sounds themselves. If a particular feature is targeted by an alternation, then all sounds bearing that feature are involved. Because many of the same groupings of sounds are observed in unrelated languages, it has been proposed that distinctive features are part of Universal Grammar, the innate and uniquely human capacity for language. It follows from this that possible natural classes are those which can be characterized using the innate distinctive features. This has been a standard assumption in phonological theory since the 1960s.

For example, Turkish final devoicing applies not just to one type of sound, but to all of the nonnasal voiced consonants in the language, some of which are shown in (1). Consonants which are voiced word-medially are devoiced word-finally.

(1) Turkish final devoicing

a. Root-final nonnasal voiced consonants occur before vowel-initial suffixes.

kitabɨm	'my book'
kadɨm	'my floor'
kazaːɨm[1]	'my sweater'

b. These consonants are voiceless when word-final.

kitap	'book'
kat	'floor'
kazak	'sweater'

Because devoicing is something that happens to all of these consonants in Turkish, it is claimed that the process applies not to segments, but to the feature [voice]. Final devoicing is observed in many unrelated languages, and this is taken as evidence that [voice] and other features are innate.

Distinctive features have been widely assumed to be part of Universal Grammar since the mid 20th century. While the theory of innate features predicts that a small set of distinctive features can describe most if not all natural classes, this prediction has never been explicitly tested. The usefulness of distinctive features in phonological analysis is clear from decades of research, but demonstrating that features are innate and universal rather than learned and language-specific requires a different kind of evidence. This dissertation presents the results of the first large-scale crosslinguistic survey of natural

[1] In standard Turkish, the voiceless [k] corresponds to a lengthened vowel (historically [g]), while in other varieties of Turkish it corresponds to a voiced fricative or approximant.

classes. Based on data from 561 languages, the survey reveals that unnatural classes are widespread: among 6077 unique classes of sounds which are targets or triggers of phonological processes, analyzed in three popular feature theories (*Preliminaries*, Jakobson, Fant, and Halle 1954; *SPE*, Chomsky and Halle 1968; and Unified Feature Theory, Clements and Hume 1995), no single theory is able to characterize more than 71% of the classes, and over 24% are not characterizable in *any* of the theories. While other theories are able to account for specific subsets of these classes, none is able to predict the wide range of classes which actually occur and recur in the world's languages.

This dissertation argues that the natural classes and distinctive features found in human languages can be accounted for as the result of factors such as generalization and phonetically-based sound change. It follows that phonological distinctive features no longer need to be assumed to be innate.

It is no secret that there are phonological patterns which do not conform to models of innate features, and a common approach is to treat these as marginal processes which are beyond the purview of innate feature models. One example is palatalization in the Chi-Mwi:ni dialect of Swahili (Kisseberth and Abasheikh 1975, Clements 1985), in which certain consonants undergo palatalization before the perfect suffix -i:ɫ-. The only place feature these consonants retain their value for is SPE-era [anterior], except for [g], which loses its value to change to [z], instead of the expected [ʒ] (2).

(2) p t̪ t → s
k → ʃ
b d̪ d g → z / [+nasal]__
ɫ → z

This is problematic for innatist approaches which hold that all place features are expected to spread as a constituent. Rules such as this apparently are the result of telescoping (the merging of previously independent rules), and Clements (1985:246) draws a distinction between this type of rule and those which are captured simply using innate features and feature organization:

> We will not relax the empirical claims of our theory in order to provide simple descriptions of rules such as these, since if we did so we would fail to draw a correct distinction between the common, widely recurrent process types that we take as providing the primary data for our theory, and the sort of idiosyncratic phenomena whose explanation is best left to the domain of historical linguistics.

Many approaches to innate features allow for the existence of unnatural classes as idiosyncrasies or historical oddities. However, it is shown in chapter 6 that there is no objective way to partition classes into common and idiosyncratic categories. In fact, many apparently unnatural classes recur in multiple languages, and ranking classes according to frequency results in a bell-like distribution which slopes gently from the common classes which are usually described easily in phonetic terms and easily characterized in traditional phonetically-defined features, all the way down to the rare classes which occur only once in the survey. Not only is there no visible boundary between the natural and the unnatural, the two are interleaved, with some of the most common unnatural classes being more frequent than most natural classes, and with the vast majority of the natural classes which are predicted by combining distinctive features completely unattested.

While historical explanations are often invoked within innate feature approaches in order to account for problematic cases, it is unclear how often such an explanation can be invoked. Is it a coincidence that this model of synchronic phonology (innate features) is well-suited to modeling processes which commonly arise from phonetic motivations (and for which a phonetic explanation exists) and ill-equipped to model less common phonological processes (for which only a more complicated phonetic explanation exists)?

Suppose that explanation from innate distinctive features is a medium-sized square, and that explanation from phonetics and language change is a large triangle. The argument that phonological processes can be explained by innate distinctive features (phonetically-grounded or not) amounts to saying this:

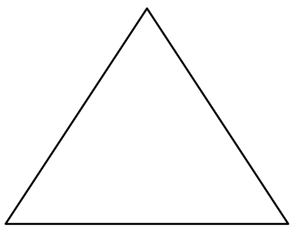
It's not  it's  .

Figure 1.1. Factors vs. features

Suppose that a sample of phonological processes includes examples (such as the one from Chi-Mwi:ni Swahili) that fall outside the square:

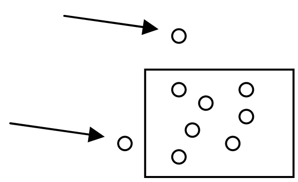


Figure 1.2. Innate feature theory with exceptions

Counterexamples such as these are often argued to be beyond the purview of innate features, and have been accounted for by invoking external factors such as language change and physiology. Accounting for these by invoking external factors amounts to adding extensions (small triangles) to account for problem cases:

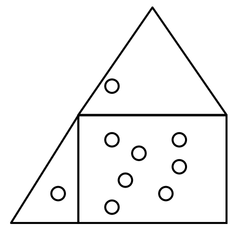


Figure 1.3. Innate feature theory with extensions

It is argued in this dissertation that sound patterns can be accounted for more effectively by dispensing with the square-triangle distinction.

1.2. Emergent Feature Theory

In the chapters that follow, it will be shown that innate distinctive features are unnecessary to explain the existence of natural classes. This is not a denial of features as a relevant part of a phonological system. Features which arise in the way proposed here are just as well suited as innate ones for defining phonological patterns, forming contrasts, and doing everything else that features have been claimed to do. Emergent Feature Theory simply offers a different explanation for the existence of phonological features, one which is more compatible with knowledge of genetic and linguistic change, and with known synchronic phonological patterns. Emergent Feature Theory is at least partially consistent with and/or inspired by a good deal of work in synchronic and diachronic linguistics (see e.g. Martinet 1968, Andersen 1972, 1973, Anttila 1977, Anderson 1981, Ohala 1981, 1983, 1992, 1993, 2003, Lindblom 1983, 1984, 1986, 1990a,b, 1999, 2000, Ladefoged 1984, Corina and Sagey 1989, Beddor 1991, Labov 1994, 2001, Port 1996, Steels 1997, Bybee 1998, MacWhinney 1998, Newmeyer 1998, Dolbey and Hansson 1999, Janda 1999, 2001, 2003, Buckley 2000, de Boer 2000, Hale and Reiss 2000, Hyman 2001, Hume and Johnson 2001a, Janda and Joseph 2001, 2003, Pierrehumbert 2001, 2003, Kochetov 2002, Myers 2002, Vaux 2002, Beckman and Pierrehumbert 2003, Guy 2003, Hale 2003, Kiparsky 2003, Pulleyblank 2003, Blevins 2004, Culicover and Nowak 2004, Hume 2004a,b, Wedel 2004, and references therein).

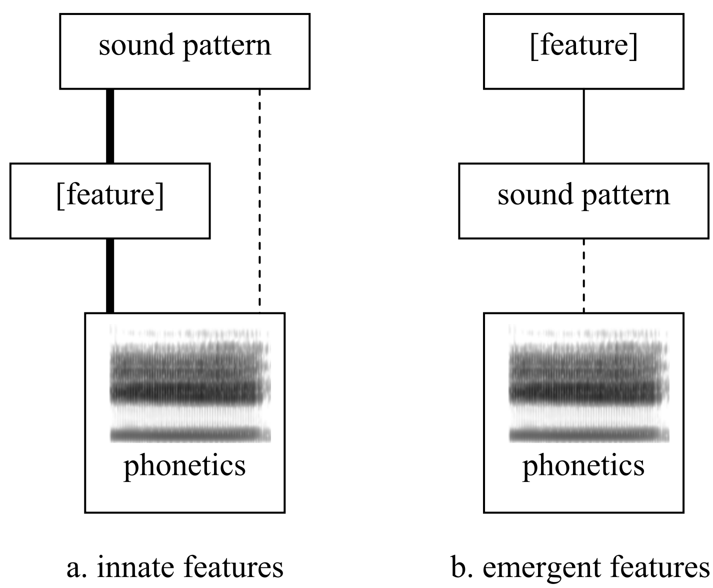


Figure 1.4. Relationships between phonetics, features, and phonological patterns

In Emergent Feature Theory, features are abstract categories based on generalizations that emerge from phonological patterns rather than the other way around. Instead of being grounded directly in phonetics, recurrent phonetically-defined features reflect phonetics *via* the phonetically-grounded phonological patterns they are motivated by. Because they are abstract, there need not always be a connection between phonetics and the phonological pattern. This is illustrated in Figure 1.4.

Phonological patterns result not from features, but from various external factors which influence language over time. Both of these approaches posit relationships between phonetic substance, abstract features, and the phonological patterns found in human languages. The difference lies in the nature of these relationships. For innate features (Figure 1.4a), abstract features are grounded directly in phonetics, and phonological patterns reflect both the features and the phonetic substance because features are the building blocks of phonological patterns. The relationship between phonological patterns and phonetics (bypassing features) is less direct, but necessary in order to provide the phonetic or historical accounts for "idiosyncratic" phenomena which are difficult or impossible to analyze with features. For emergent features (Figure 1.4b), this loose relationship between phonetics and phonological patterns is the sole connection between phonological patterns and phonetic tendencies anyway. Just as phonetics (and other grammar-external factors) can be used to account for idiosyncratic phenomena in an approach which otherwise depends on innate features, phonetics can account for these unusual phonological patterns, and *also* for more common patterns, which also tend to reflect more common phonetic tendencies. In this way, Emergent Feature Theory employs a single mechanism to account for common and rare phonological patterns, in contrast with innate feature theory, which requires two. Features are abstract generalizations made by language learners on the basis of the phonological patterns found in the language they are learning.

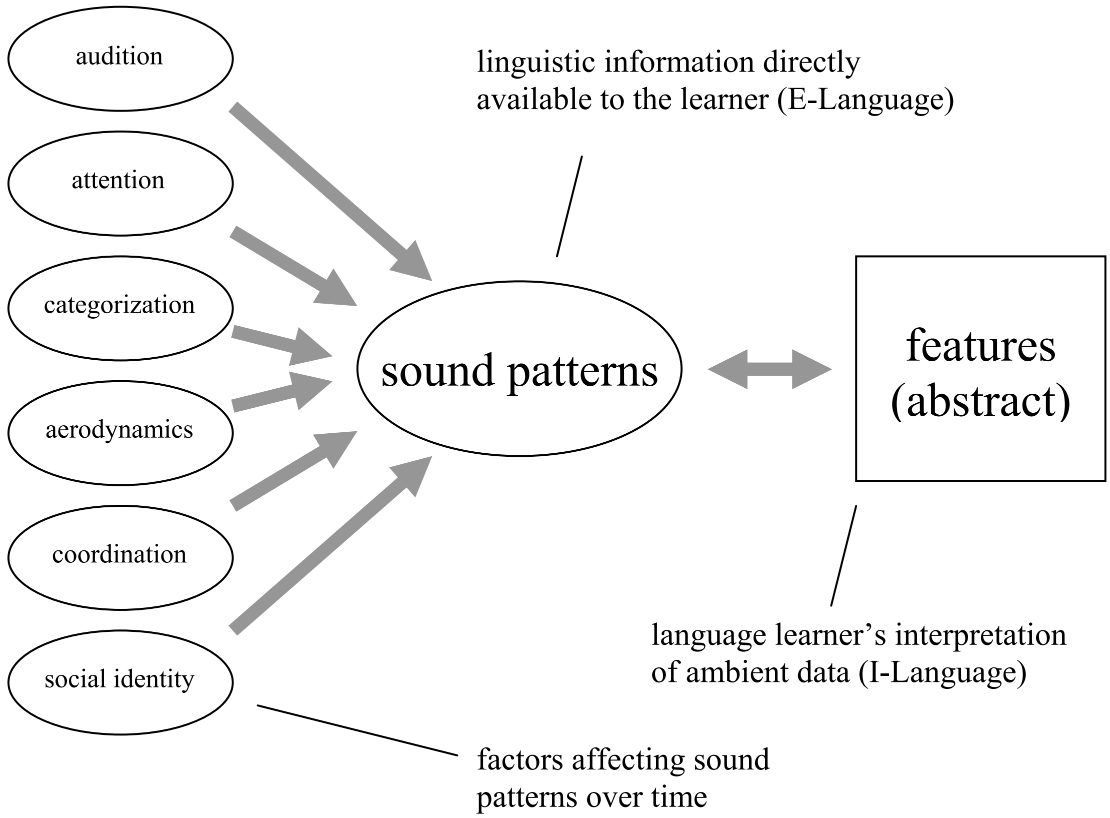


Figure 1.5. Abstract features from concrete external factors

A more detailed view of the relationship between features, phonological patterns, and external factors is given in chapter 4. The environment in which language is used includes the anatomy used to produce and perceive speech, the laws of physics they are governed by, the social context in which language is used, and the cognitive mechanisms employed in learning and using language. These factors contribute to the development of the phonological patterns found in language, making some patterns more common than others. The role of speech production and perception is not to be interpreted as simply ease of articulation and ease of perception, but as the physiological and cognitive realities in which language exists. The six factors audition, attention, categorization, aerodynamics, coordination, and social identity will be discussed in more detail in chapter 8, in a more general model of the emergence of linguistic structure.

Emergent Feature Theory holds that phonetic factors shape the phonological patterns of the world's languages, and these patterns are internalized by speakers in terms of features which are necessary to describe them, rather than in terms of predetermined innate features (Figure 1.5). These external influences predict that classes will tend to involve phonetically similar segments, and the use of phonetically-defined distinctive features is just one way to describe classes of phonetically similar segments. While these types of explanations are often invoked to account for "idiosyncratic" unnatural classes, it is shown that they are even better at accounting for "natural" classes, and the result is a unified account of what were previously considered to be natural and unnatural classes.

1.3. Incorporating insights of innate features into Emergent Feature Theory

Innate feature theory has captured many different insights about phonological patterns over the years. Because it abandons the assumption of innateness, Emergent Feature Theory needs to account for these observations in other ways. The first concerns the observation that there are a limited number of phonetic parameters available for use in language. Jakobson, Fant, and Halle (1954) suggest that all languages can be described using the 12 oppositions vocalic/non-vocalic, consonantal/ non-consonantal, interrupted/ continuant, checked/unchecked, strident/mellow, voiced/unvoiced, compact/diffuse, grave/acute, flat/plain, sharp/plain, tense/lax, and nasal/oral. It will be seen below how well these features are represented in the phonologically active classes of 561 of the world's languages. To the extent that there is a crosslinguistic preference for these oppositions, Emergent Feature Theory accounts for them in roughly the same way Jakobson, Fant, and Halle (JFH) account for them, by observing that there are a limited number of phonetic parameters available to language, and that phonological patterns reflect that. JFH's features are stated in acoustic terms, but they observe also that the acoustic parameters associated with these features correspond to specific articulatory parameters. They account for typological observations in terms of these parameters. For example, they account for the apparent absence of languages which contrast pharyngealization and labialization separately by noting the acoustic similarity of the two types of articulatory gestures, and consequently allow the feature flat to represent the acoustic property that is produced by two different articulatory means. It is now known that there are languages such as Tamazight Berber (Abdel-Massih 1968) with contrastive pharyngealization and labialization, but the finding that the coexistence of these contrasts is much rarer than the coexistence of many other contrasts still stands.

Emergent Feature Theory attributes the *rarity* of such languages to acoustic *similarity*, and attributes the *possibility* of coexistence to the articulatory difference and acoustic *nonidentity*. Because it uses similarity to predict the likelihood of phonological patterns, Emergent Feature Theory is better equipped to distinguish between similarity and identity than innate feature theory is. In formulating linguistic theories, it is very tempting to identify similarity with identity. The upside of confusing similarity with identity is that it allows more sweeping generalizations to be made. The downside is that they are often wrong.

A second observation is that articulatory parameters are relevant to phonology. It has been proposed (e.g. Chomsky and Halle 1968, Sagey 1986) that all phonological patterns can be accounted for with an innate set of articulatory features. In SPE, the features themselves, rather than phonetic parameters, are the explanation for observed phonological patterns. Emergent Feature Theory accounts for the same observations on the basis of phonetic similarity, the cognitive process of generalization, and language change. As I show in chapter 5, the classification of phonologically active classes involves many of the articulatory parameters identified by Chomsky and Halle, as well as parameters they do not identify.

A third observation to be accounted for is that some phonetic parameters are interdependent on each other, and some act independently. This is represented in Feature Geometry (e.g. Clements 1985, Sagey 1986) by a feature hierarchy with constituents which correspond to features that pattern together. Features which are linked under the same node tend to be features which are linked articulatorily. In this way, Feature Geometry is an abstract model of some of the phonetic parameters relevant to phonology. In abstracting away from the phonetic basis for phonology, the different versions of Feature Geometry highlight some of the phonetic parameters which are most important for determining phonological patterns as well as the ways in which they interact with each other.

1.4. Definitions

The term “natural class” is used to mean different things, and it will be necessary to be precise about how the term is used in this dissertation. The traditional definition has two parts, as in (3). These two definitions are often assumed to be equivalent, and if it can be demonstrated that phonological alternations do indeed act only upon features, then these definitions would be equivalent. Because one of the goals of this study is to find out if the two definitions really are equivalent, this is not something we will be assuming.

(3) Natural class (traditional two-part definition):

i. a set of sounds in an inventory which share one or more distinctive features, to the exclusion of all other sounds in the inventory

ii. a set of sounds in an inventory which participate in an alternation, to the exclusion of all other sounds in the inventory

When the term “natural class” is used in rest of this dissertation, it will be used in terms of a particular feature theory, using the theory-dependent definition in (4).

(4) Natural class (feature theory-dependent definition):

a set of sounds in an inventory which share one or more distinctive features *within a particular feature theory*, to the exclusion of all other sounds in the inventory

It is often assumed that that phonological natural classes are phonetically natural, as defined in (5). If this is the intended interpretation, then the term “phonetically natural class” will be used instead.

(5) Phonetically natural class:

a set of sounds in an inventory which share one or more phonetic properties, to the exclusion of all other sounds in the inventory

Note that this definition is generally broader than the one in (4), because not all phonetic properties have features assigned to them in each theory. An "unnatural class" is a class that does not meet a particular set of criteria for being natural. What has been dispensed with in the definitions in (4-5) is any reference to phonological patterning, which is crucially not *assumed* to be identified with phonetic similarity or shared features. To refer to classes which participate in phonological patterns, the term "phonologically active class" will be used. This term is defined in (6). It is a crucial point that while any phonologically active class is, by definition, naturally occurring, there is no guarantee that it is a "natural class" with respect to any given feature theory (4) or "phonetically natural" with respect to any interpretation of phonetic similarity (5).

(6) Phonologically active class (feature theory-independent definition):

a set of sounds in an inventory which do at least one of the following, to the exclusion of all other sounds in the inventory:

- undergo a phonological process,
- trigger a phonological process, or
- exemplify a static distributional restriction.

With these definitions in hand, it is now possible to proceed to investigating the connections between these different types of classes, and how they might be accounted for.

1.5. The case against innate features

Even without findings in support of emergent features, there are many reasons to be suspicious of the idea that distinctive features are innate. In this section, I present arguments from biological evolution, signed languages, and phonological theory which point to the conclusion that features are not universal or innate. The purpose of this discussion is not to underestimate the contribution these proposals have made to our understanding of phonological systems, but to examine the specific proposal that distinctive features are innate. While innate features are central to the way most of these approaches to phonology are implemented, the insights about phonological patterning which have been cast in terms of innate features in the past fifty years stand on their own, and Emergent Feature Theory could hardly proceed without them.

1.5.1. Evolution

Consider evolution. Humans have been evolving (separate from other primates) for a relatively short time. Worden (1995) argues that for Universal Grammar to have developed as quickly as it would need to have developed would be incompatible with what is known about limits on the speed of evolution (see also Steels 1997). For all distinctive features, including the uncommon ones, to have emerged in the human genome, humans must have been exposed to contrasts motivating all of them at some time before the life of a common ancestor of all modern humans who would have all these features (all humans). This includes the distinctive features for sign languages, which appear to use entirely different phonological features and feature organization (e.g., Brentari 1998, Corina and Sagey 1989, Sandler 1989), even though deafness is generally not hereditary.

Innate distinctive features could not exist without emerging from biological evolution, but this is rarely if ever discussed in the literature on innate distinctive features. Steels (1997:16) points out that if a new distinctive feature appears in an individual as the result of a genetic mutation, this does not give the individual any advantage, unless other speakers also share the same mutation. Unlike other types of biological evolution, the newly-evolved phonological primitives would need to be shared by other members of the community, and would need to be incorporated into their shared language before being useful (before there would be any reason for this mutation to be favored).

Arguments for innate distinctive features generally have focused on phonological and phonetic evidence, and have not dealt with these serious questions about the plausibility of these features emerging in the human genome through biological evolution. Similarly, it has not been shown that it is *implausible* for features to be learned rather than innate. These issues, along with the evidence in the rest of this section and in later chapters, point to the conclusion that the distinctive features used in language are learned rather than innate.

Given the thorny and unresolved issues over the evolution of distinctive features, it is not bad for feature theory if features turn out to be emergent. Because many of the insights of innate features can be recast in emergent features, Emergent Feature Theory provides an opportunity to lend evolutionary plausibility to discoveries from the past several decades which have been cast in distinctive features..

1.5.2. Signed language features

Most work in feature theory focuses on spoken languages, and typological surveys, markedness generalizations, and hypothetical universals are generally made on the basis of only spoken language data. Sign language phonology has many implications for the notion of innate distinctive features. Substantial work has been conducted in the area of sign language features and feature organization (e.g., Stokoe 1960, Liddell 1984, Liddell and Johnson 1989, Sandler 1989, Brentari 1990, 1995, 1998, Perlmutter 1992, van der Hulst 1995, Uyechi 1996). There are obvious practical reasons for focusing on a single modality (and the survey in this dissertation only includes spoken language data). Focusing on spoken language allows modality-specific questions to be addressed (such as the role of the vocal tract and auditory system in phonology), but questions about phonological universals cannot ignore the existence of sign language phonology.

The hypothesis that there is a small set of innate distinctive features which are defined in terms of the articulation and/or audition of spoken language and which are the only features available to the phonologies of the world's languages is incompatible with signed language phonology, because signed languages involve an entirely different set of articulators and rely primarily on vision rather than on audition. Consequently, the claims about an innate feature set must be qualified with the acknowledgment that this universality is really only applicable to languages of one modality, even though UG purportedly applies to all languages.

There are a number of ways to reconcile the universalist claims with the existence of signed language phonology: (1) relax the requirement that features are defined in phonetic terms and interpret each innate feature as having both spoken language and signed language phonetic correlates, (2) posit additional innate features which apply to signed language, and claim that humans are hardwired with two sets of innate features for two different modalities, or (3) consider that features and their phonetic correlates are learned during acquisition, according to the modality of the language being acquired.

If signed and spoken languages use the same innate features but with different phonetic correlates, it is expected that there will be some evidence that they are otherwise the same features. This evidence could include feature geometries for signed languages that look like Feature Geometries for spoken language. Research in signed language features offers no such evidence (see Brentari 1995, 1998 for reviews). In fact, Liddell (1984) reports that evidence from American Sign Language suggests that signed languages have significantly larger numbers of contrastive segments than spoken languages, and many other analyses are consistent with this. Stokoe (1960, *inter alia*) produced the first phonemic analysis of signed language, using 12 distinctive places of articulation, 18 distinctive handshapes, and 24 distinctive aspects of movement. The Hold-Movement Model (Liddell and Johnson 1989 *inter alia*) involves 299 distinctive features. Brentari (1990) reorganizes Liddell and Johnson's feature system and reduces the number of features to 20, a number more comparable to that proposed for spoken languages, but Brentari's analysis achieves this only by using seven features with more than two values, in addition to other binary and privative features.

Sandler's (1989 *inter alia*) Hand Tier model was the first to incorporate a hierarchical organization of features, placing hand configuration and location on separate trees, as shown in Figures 1.6 and 1.7, and bears little resemblance to any spoken language Feature Geometry proposals. Similarly, other feature organizations such as the Dependency Phonology model (van der Hulst 1995 *inter alia*), Visual Phonology (Uyechi 1996 *inter alia*), or the Moraic Model (Perlmutter 1992 *inter alia*) do not resemble spoken language Feature Geometry.

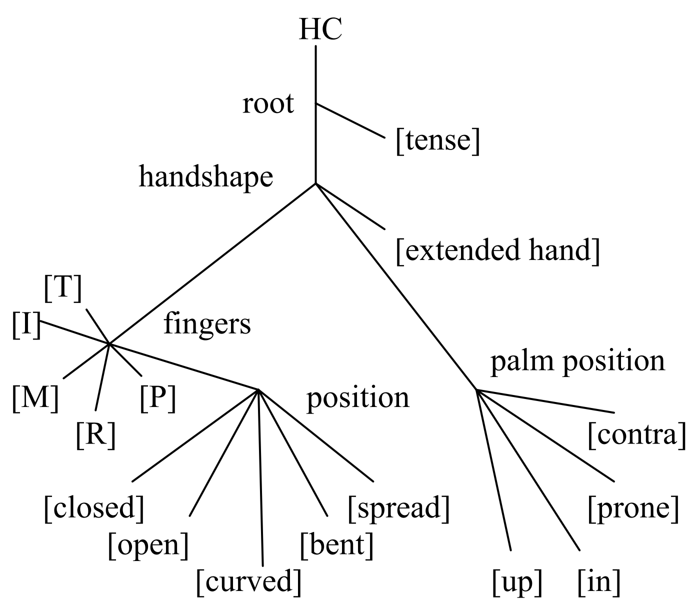


Figure 1.6. The Hand Configuration tree (Sandler 1989)

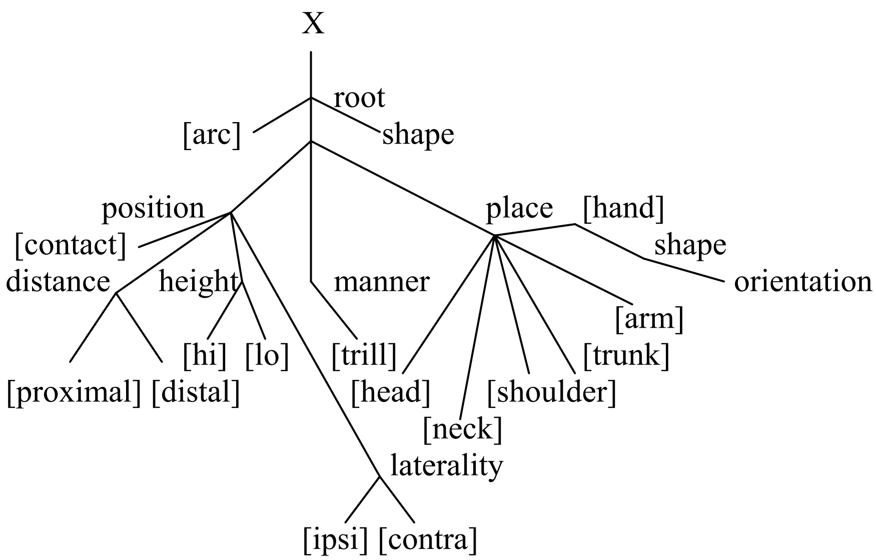


Figure 1.7. The Location tree (Sandler 1989)

The similarities between the feature organizations for different modalities are limited to very general statements, such as the observation that both have a place node. Just as spoken language feature organization reflects the physiology of the vocal tract, signed language feature organization (e.g., as seen in Figures 1.6-7) tends to reflect the anatomy that is relevant for signed language. For example, the organization of features in the Hand Configuration tree, such as the features [T], [I], [M], [R], [P], representing fingers, corresponds to the organization of body parts. Beyond the representation of physiology in feature hierarchies (as is seen in spoken language), Brentari (1998) draws parallels between the structure of signed language phonology and the human *visual* system, just as many sound patterns in spoken languages reflect the human auditory system. If features were driving phonology, and these are the same features, we would expect some evidence that is attributable only to the features and their organization, rather than to commonalities between the physiological facts they represent.

Positing separate feature sets for signed and spoken languages runs into specific problems, namely that even if spoken language features could have evolved through natural selection, it is not very plausible that signed language features did as well, because most humans are not deaf, and because deafness is rarely hereditary. It is not clear how a genetic mutation introducing an innate signed language distinctive feature could have been advantageous before Deaf communities became established in fairly recent times (e.g. the first Deaf school was established in the 1500s). This issue is discussed further in chapter 3.

In the case that phonetic correlates, and perhaps feature organization, are assigned by the language learner in acquisition, then what is shared by signed language and spoken language phonology may simply be cognitive categories. In other words, categories/features emerge as a result of contact with language data, and they naturally reflect the modality of the language being learned. A child learning a signed language will develop features associated with the production and perception of signs, and a child learning a spoken language will develop features associated with the production and perception of speech. This is essentially the position taken by Brentari (1998:313) regarding differences between signed and spoken language:

> The findings presented here support [the hypothesis] that the formal role of distinctive features, syllables, and segments as building blocks of a grammar with constraints is the same for signed and spoken languages, but that the substantive definitions in both types of languages—those that are more phonetic and less grammatical—depend on conditions of naturalness in each modality and on specifics about production and processing that grow out of experience with linguistic messages conveyed in each.

The idea that signed language features, and thus perhaps all features, must be learned, is not new. Corina and Sagey (1989) analyze phonological alternations in ASL using a feature-geometric framework. They note that the proposed Feature Geometry for signed languages is clearly related to anatomy and very different from the Feature Geometry models (e.g. Sagey 1986) proposed for spoken languages, which are also clearly related to anatomy (but different parts). Finding it implausible that signed language features are in UG, they try to reconcile the differences between the two:

> An alternative is to say that sign language hierarchies are learned or derivable from some language external facts. Since the features and the feature hierarchy are closely tied to articulation, this is not an implausible result. In fact, their being learned could explain why they are clearly tied to articulation. But we are left with a peculiar state of affairs. We posit an innate feature system for spoken language, but a derivable one for signed languages. Once again this seems inconsistent. Could it be the case that spoken language features and hierarchies too are derivable or learned constructs rather than innate? If we adopt this position that features and feature hierarchies are learnable and not given in UG, we open up the possibility that they are not completely universal. That is there could be slight differences between languages, the particular language influencing the feature set and the hierarchy. The vast differences in the feature hierarchy proposed here simply represent the extreme end of this continuum, due to the radically different mediums in which they are conveyed. The puzzle to be explained would now become why hierarchies are so similar among languages. If features are in UG, then any variations must be explained; if features are not in UG, then any universals among languages must be explained (Corina and Sagey 1989:81-82).

Over the past 50 years, phonologists have generally taken UG as the explanation for crosslinguistic similarities, and sought special explanations for apparent exceptions. Emergent Feature Theory takes the opposite approach. The fact that features and feature hierarchies appear to be so similar may not be so much a puzzle as a result of the *assumption* that features and feature hierarchies are so similar. In fact, as will be seen in later chapters, most languages do not have phonological phenomena to motivate most features. There is no reason to believe that these languages have particular features except for the assumption that all languages must have the features which are motivated by other languages. The differences between the features which are useful for analyzing signed and spoken languages demonstrate how much the similarities are dependent upon modality.

It is worth noting that the survey data presented in subsequent chapters of this dissertation is from spoken languages. In the discussion, the term “sound pattern” is generally used in contexts which for some reason do not apply to signed languages. The term “phonological pattern” is used in more general contexts where excluding signed languages is not intended.

1.5.3. No null hypothesis and no large-scale survey

The arguments in favor of particular implementations of innate feature theory generally consist of examples from a handful of languages which are dealt with in an elegant fashion by the theory being advocated. The success of a given feature theory, combined with the assumption that features are innate, is taken to support the assumption that features are innate and to validate the model in question. The fact that a variety of feature theories are able to account for different phonological phenomena using phonetically defined features is consistent with the idea that a variety of phonetic facts are relevant for accounting for phonological phenomena. It is not surprising that there are many different competing theories of innate features, since each one is valid for some set of data but lacks the ability to account for data that some other theory is better suited for. The claim that one theory in particular is innate and universal is a leap that requires the evidence that would be provided by a large-scale survey.

McCarthy (1991:29) gives two criteria for feature theories, articulating the assumptions about distinctive features in Feature Geometry. It will be seen in the survey results that all feature theories fail at least the second criterion:

> An adequate theory of phonological distinctive features must meet two criteria: (a) it must be able to describe all the distinctions made by the sound systems of any of the world's languages; and (b) it must be able to characterize the so-called natural classes of sounds in all languages. (A natural class is a set of sounds that are recurrently treated as a group by different phonological rules.) In practice, the second criterion for the adequacy of a distinctive feature theory is a good deal more important – you can always make more distinctions by adding more features, but you generally cannot add nonredundant features to define more natural classes.

Aside from the optimistic goal of accounting for everything, there is no theory of *how much* phonological patterning should be accounted for by a feature theory in order to motivate the innateness of its features. Arguments for innate feature models do not involve a theory of the extent to which phonetic factors would be expected to influence phonology *anyway*, without the existence of an innate feature set.

In addition to there being no null hypothesis with which to compare innate feature theories, there have been no large-scale typological studies examining the predictions of various models. A possibility that is generally ignored is that the successes of a given model of features can be taken as evidence that the model is correct in its choice of articulatory and acoustic facts to recapitulate, but in itself unnecessary precisely because these explanations already exist.

It is often assumed, at least in practice, that an innate feature set is the *only* available explanation for the similar patterning of speech sounds, as though the null hypothesis were that all logically possible phonological patterns (including, e.g., /car horn/ → [60 Hz hum] / __mating call of a dust mite) should be equally likely in human language. In reality, the null hypothesis must take into account the fact that the speech sounds of human spoken languages are limited by human physiology and general cognitive capacity, and that natural languages are not invented by their speakers but descended along sometimes familiar paths from earlier languages. Given this, the case for an innate feature set could be strengthened by specifying the minimum amount of similar patterning that must be found, and what its nature must be, in order to conclude that an unprecedented evolutionary leap has created an innate feature set. The same applies to the extragrammatical features of language use which are presented as arguments for an innate feature set. What would we expect language acquisition, disablement, and change to look like in a world without innate features but with the tangible constraints on possible languages described above?

This dissertation provides the results of a large-scale typological survey in order to examine the extent to which innate feature theories and the phonetic factors they are grounded in are able to account for phonological patterning in a wide range of languages.

1.5.4. No evidence that unattested = impossible

The goal of many theories of phonology is to distinguish possible phonological phenomena from impossible ones. Often the only evidence given for the impossibility of a phonological pattern is that it is unattested in the fraction of existing spoken languages which have been described, e.g.: “It should be possible to represent within the theory any phonological process or form that is possible in human language, and it should be *impossible* to represent phonological forms and processes that do not exist in human language (Sagey 1986:9, emphasis mine)."

The ability to represent all and *only* the phonologically active classes which recur is described by McCarthy (1994:191) as the most import criterion for an adequate theory of distinctive features (emphasis mine):

> An adequate theory of phonological distinctive features must meet four criteria: (i) it must have a relatively consistent and direct relation to the phonetic properties of speech sounds; (ii) it must be able to describe *all and only the distinctions* made by the sound systems of any of the world's languages; (iii) it must be able to characterize *all and only the natural classes of sounds* that recur in the phonological phenomena of different languages; and (iv) it must correctly characterize the subgroupings of features by recurrent phonological phenomena. The third criterion is the most important one and probably the hardest to achieve.

In Optimality Theory, this criterion is applied to proposed constraints (factorial typology). Every ranking of a set of constraints is expected to be an attestable language, even when no historical changes are known which could result in such a language (but see Myers 2002).

At least two questions are relevant here: First, how confident are we that phonological patterns which are unattested in today's languages are impossible? The number of languages which have been documented are a small sample of the languages which exist, and the number of languages which are currently living are just a small sample of the languages which have existed and will exist in the future. When there are so many linguistic phenomena found in only a handful of attested languages, how can we be certain that *any* phonological patterns never existed in the past, never will exist in the future, and doesn't exist currently in an understudied language?

Chomsky and Halle (1968:4) contrast linguistic universals and accidental universals. To illustrate accidental universals, they construct a hypothetical scenario in which only inhabitants of Tasmania survive a future war. In this scenario, it would be a true generalization to say that no existing language uses pitch to distinguish lexical items, but Chomsky and Halle argue that this would be useless information to linguistic theory, because this generalization is only true by virtue of the elimination of most of the world's population by a non-linguistic event.

War and genocide have already destroyed entire language families. Making it impossible to represent phonological forms that existed in these languages unbeknownst to us inevitably rules out possible forms that once existed. Theories of representations which exclude unattested patterns are valued in many approaches to Feature Geometry and phonetically-driven phonology, and it is a common assumption in Optimality Theory (factorial typology). Whether or not the phonological formalism should rule out unattested phonological patterns is a very important issue. While it is clearly important to have a theory of possible and impossible or likely and unlikely phonological phenomena, there is no reason to believe that the formalism for the cognitive representation of phonological patterns is the only venue for such a theory.

One of the reasons for positing a *small* set of innate features is to keep the theory from overgenerating, i.e., being able to represent phonological patterns which have not been observed. The languages which have been documented give a picture of what types of phonological patterns are expected; it is justified to conclude that phonological patterns which occur frequently in the sample are common crosslinguistically. However, if a pattern is unattested in documented languages, it is not justified to conclude that it is impossible. This is because there are so many phenomena which are attested only once, and which the same criteria would deem impossible if a different sample were selected. While it may be justified to conclude based on a sample that a pattern is rare, there is a major difference between rare and impossible when the issue at hand is whether the language faculty should be incapable of dealing with a given pattern.

1.5.5. New theories without new evidence

In the history of the study of phonology, new theories have often been preceded by new evidence. For example, the use of spectrography to examine the acoustic properties of speech led to Jakobson, Fant, and Halle's (1954) acoustically-defined feature system. In other cases, the connection between new theories and new evidence is less overt. The claim that distinctive features are innate is one of these. Early feature theories did not claim innateness, but innateness is now a fairly standard assumption, and it is not clear what evidence brought about this shift.

In the early years of modern phonological theory, Trubetzkoy (1939 *inter alia*) and Jakobson stressed the importance of describing languages on their own terms. Jakobson (1942:241) writes that "[t]he description of a system of values and the classification of its elements can be made only from that system's own perspective." Later, Jakobson takes more universalist views, but the evidence that leads to this conclusion is unclear. In part II of Fundamentals of Language (Jakobson and Halle 1956:39), Jakobson claims that "[t]he study of invariances within the phonemic pattern of a given language must be supplemented by a search for universal invariances in the phonemic patterning of language in general." Further, Jakobson reports implicational relationships between phonological distinctions, which are found in acquisition and in aphasia (Jakobson and Halle 1956:38). While studying aphasia and acquisition would be expected to shed light on the structure and universality of distinctive features, none of the examples of aphasia given by Jakobson provide evidence for this. This work must be taken as an explication of the *predictions* of the theory, rather than empirical evidence in support of it. It is acknowledged more recently (by proponents as well as critics of his later universalist views regarding language acquisition) that Jakobson's model of language acquisition is based on his general theory of phonology rather than on actual language acquisition data (Menn 1980, Rice and Avery 1995). What is troubling about Jakobson's change of view is that it is not accompanied by new evidence, but has nevertheless been widely accepted by phonologists who followed in his path.

Recent work on language acquisition has shown that children are highly individualistic in their order of acquisition of sounds and words (see Vihman 1993, 1996 for summaries). This is unexpected if a set of innate features is at the core of phonological acquisition. Research has shown that similarities between children acquiring language reflect the languages the children are learning, rather than universal tendencies (Ingram 1978, Pye, Ingram, and List 1987, de Boysson-Bardies and Vihman 1991, Vihman 1996, and Beckmanm, Yoneyama, and Edwards 2003).

Another theoretical development which is not accompanied by any new evidence is the criterion that simplicity of representation should reflect the phonetic naturalness of a process, and that the phonological representation "should lead to explanation, where possible, of why the facts are as they are, and of why the representation is structured as it is ” Sagey (1986:9-11). For example, the simplicity of the representation of a phonological pattern is argued to explain why it is more frequent than one with a more complex representation. This assumption that representations are explanatory in this way was not present in the bulk of early work on distinctive features (e.g., Jakobson 1942, Jakobson, Fant, and Halle 1954, Jakobson and Halle 1956, Chomsky and Halle 1968 (chapters 1-8)), but is assumed, apparently without any motivation, in many approaches to Feature Geometry. This has the effect of adding another dimension to the claim of distinctive feature universality (the need for the representation of one language to reflect markedness generalizations about language in general) without any argument for why such a representation is desirable, beyond aesthetic reasons (see Lass 1975, Hume 2004b for counterarguments). It is often assumed (see e.g. Sagey 1986) that a representation that can be explained based on factors such as vocal tract anatomy, acoustics, and knowledge of the world is more highly valued than a representation which accounts for the same phonological facts arbitrarily. Not discussed, however, is the possibility that the phonological representation does *not* need to explain the non-occurrence of non-occurring segments, such as doubly-articulated palatal/velar stops, precisely because they do *not* occur (because they are extremely difficult to produce as segments distinct from both palatal and velar stops). The hypothetical cognitive representation may be the last line of defense keeping doubly-articulated palatal/velar stops out of human languages, but it is by no means the first. If no language ever develops them (for the above reasons), then there is no need for the cognitive representation of phonological patterns to rule them out.

Sagey explicitly argues against including the Well-Formedness Condition (No Line-Crossing) in Universal Grammar, because it follows from knowledge about the world. This is interesting, because this argument could also be leveled against phonetically-grounded Feature Geometry as a whole, because the requirements it derives from are extralinguistic (physiological).

The role of features in acquisition and aphasia, and the role of representations in reflecting the naturalness and frequency of phonological patterns are both relationships that are often treated as evidence for innate features. But these, like the ability of innate features to account for most if not all phonological patterns, are hypotheses. Acquisition and aphasia are the subject of much ongoing research, and the ability of feature theories to predict the frequency or possibility of sound patterns is challenged by the results of the crosslinguistic survey reported in chapters 5-7.

1.5.6. Dogs, fish, chickens, and humans

Phonological features are sometimes treated as a uniquely human endowment which explains in part why humans acquire language, but other animals do not. On the contrary, many of the early arguments for features involved evidence from the behavior of other animals to motivate key aspects of features.

In *The Concept of Phoneme*, Jakobson (1942) treats distinctive features as a manifestation of the fundamental relationship between meaningful contrast and the ability to distinguish sounds. Evidence for this relationship is found in humans, dogs, and fish. Jakobson observes that all native speakers of a given language can accurately perceive even the most minute phonetic differences as long as they perform a discriminative role, while foreigners, even professional linguists, often have great difficulty perceiving the same differences if they do not distinguish words in their own native languages. Jakobson's point is that there is a fundamental relationship between meaningful contrast and the ability to distinguish sounds, not that this has anything to do with universality in the sense of Universal Grammar. Jakobson goes so far as to note that dogs and fish possess a similar faculty. The important distinction is between meaningful and non-meaningful differences, rather than between innately-provided and non-innately-provided differences. Jakobson gives examples of dogs being trained to recognize a particular pitch that signals the arrival of dog food, and to distinguish it from other, very similar pitches, as well as certain species of fish being trained to associate a certain acoustic signal with receiving food, and to associate another slightly different acoustic signal with "something nasty," so that the fish surface upon hearing one signal, hide upon hearing another, and ignore all other signals. Jakobson (1942:233) writes that the fish "recognize the signals according to their meanings, and only because of their meanings, because of a constant and mechanical association between signified and signifier".

Another parallel between the proposed nature of distinctive features and animal behavior is observed by Jakobson and Halle (1956:26), this time involving relational rules. The opposition [compact] vs. [diffuse] (acoustic correlates of low vs. high vowels) characterizes the relation between [æ] and [e] and also the difference between [e] and [i]. Jakobson and Halle observe that the ability to understand such relations as instances of a single property is not unique to humans. They cite experiments in which chickens were trained to pick grain from a gray field, but not from a darker one, and when presented with a gray field and a *lighter* one, the chickens transferred the relation and picked grain only from the lighter field.

Much like the hypotheses involving aphasia, acquisition, and naturalness, the notion that features are part of the uniquely human ability to acquire language arose without direct evidence. Innate distinctive features are cognitive categories with built-in phonetic correlates. As shown by Jakobson, Halle, and others, cognitive category formation is shared with other members of the animal kingdom. Meanwhile, the phonetic correlates of features are not even shared by all human languages; spoken languages lack the correlates of signed language features, and vice versa. It is hard to imagine how a uniquely human capacity for language could involve innate distinctive features, when one aspect of supposedly innate features is too widespread and the other is too restricted.

1.5.7. Innate features recapitulate independently-observable facts

Innate features have been used to account for a variety of observable facts about language. Often there are other explanations available for these facts, and it may be the case that the feature theories are simply restating what is accounted for by other factors. Two ways in which this occurs are when synchronic formulations of phonological patterns appear to recapitulate historical changes, and when the feature organization which accounts for affinities between articulators appear to repeat explanations which are available simply from observing the physical relationships between the articulators.

For example, the model proposed in SPE accounts for a very wide range of sound patterns in modern English, often drawing on diachronic changes known to have occurred in the history of English. Pinker (1999:100) criticizes Chomsky and Halle's (1968) and Halle and Mohanan's (1985) formalization of certain English sound patterns as recapitulations of historical changes rather than realistic parts of linguistic competence:

> Any theory that can tame the quintessentially unruly English irregular past-tense system with only three rules, each delicately adjusting a single feature, is undeniably brilliant. But is it true? Not necessarily. One problem comes from the assumption that every scintilla of patterning in the verb system needs an explanation in terms of the psychology of speakers, in particular that the patterns are distilled out into rules in the mind. Chomsky, Halle, and Mohanan's rule-by-rule derivations often recapitulate the history of a past-tense form in English over the centuries—deliberately—and that brings to mind an alternative explanation… that the patterns are fossils of rules that died long ago. The surviving past-tense forms, semilawful though they are, could simply be memorized by today's generation without any help from the rules.

It is in large part because phonologists have had, over the past 34 years, an opportunity to build upon the groundwork laid by Chomsky and Halle that it is possible now to look back on some of their claims and find them to be at odds with current understandings of language. A similar critical reevaluation of their assumptions about innate distinctive features would have seemed natural, but this is a path that mainstream phonological theory has not explored yet. Criticisms of the framework set forth in SPE are largely limited to Chomsky and Halle's choices of features and their organization, but not the basic assumption that there is a universal set of distinctive features. Chomsky and Halle's *assumption* that distinctive features are innate is treated in subsequent literature as if it were a *conclusion*.

While derivations often recapitulate historical changes, innate feature organization encodes information that is also independently observable. In motivating constituency among distinctive features, Clements (1985:229) observes that at least four articulatory parameters show considerable independence from each other: (1) laryngeal configuration, (2) degree of nasal cavity stricture, (3) degree and type of oral cavity stricture, (4) pairing of an active and a passive articulator. Oral tract configuration can be held constant while the state of the vocal folds or velum changes, and vice versa. However, within each category, it is difficult or impossible to vary one gesture while maintaining another. With the exception of laryngeal, which seems to be completely independent, there is limited mutual dependence between these parameters. For example, there is no nasal contrast on pharyngeals. The physical impossibility of such a contrast is a possible explanation for its absence, but this potentially important issue for the theory is generally not discussed.

In addition to external explanations for the nonexistence of phenomena, there are external explanations for affinities between features and the properties they represent. For example, the claim that features such as [anterior] and [distributed] are dominated by the [coronal] node on the basis of their patterning is an uninteresting claim unless [anterior] and [distributed] are used for segments other than coronals (such as velars), and the formalism is better able to account for the behavior of these segments by virtue of both features being dominated by [coronal]. But if these features are only used for coronals, then the generalization falls out logically from the physiology, and formally stating this again in Feature Geometry is redundant.

The incorporation of physiological information into formal phonology is taken to the extreme by Articulator Theories (Sagey 1986, Halle 1988, 1989, 1992, and Halle, Vaux, and Wolfe 2000), which directly incorporate anatomical adjacency as a criterion for feature organization:

> In Articulator Theories the groupings of features in the tree reflect aspects of the anatomy of the vocal tract. Thus… the lowest constituents (nodes) are made up of features executed by each of the six articulators, and the next highest constituents (nodes)—Place and Guttural—refer to articulator groups that are anatomically adjacent (Halle, Vaux, and Wolfe 2000:389-390).

By incorporating anatomical adjacency rather than basing the model on phonological phenomena, Articulator Theories construct a model of the physiological facts which lead, via the phonologization of phonetic effects, to articulatorily-driven phonological alternations. Drawing on physiological facts as a means of accounting for phonological patterns is not the same as including physiological facts in the representation of synchronic phonology. Including these facts in the representation is seemingly only justified if it is motivated by observed phonological patterns.

Recent phonological theory has placed emphasis on explaining phonological patterns in terms of independent observations about phonetics and other factors. While this is a worthwhile pursuit, identifying these factors does not require repeating them in Universal Grammar. It may be true that these factors really are in the grammar, but motivating this requires more than just evidence that there is a pattern, because the pattern is already predicted by the external facts.

1.5.8. Summary

As seen in this chapter, there is substantial independent evidence calling innate features into question. The fact that quite a bit of what they account for may have other explanations anyway makes abandoning them quite reasonable. The formal model of the cognitive representation of phonology is often treated as if it is the only way to account for the nonexistence of unattested phonological patterns. This issue is particularly important when ruling out unattested phenomena compromises the ability of the formalism to capture some attested phenomena (such as unnatural classes), especially when there is no independent evidence that various "marked" phenomena are treated any differently by speakers than common phenomena (see Buckley 2000, Onishi, Chambers, and Fisher 2002, and Peperkamp and Dupoux 2004 for additional discussion).

The notion of innate distinctive features would not have remained popular for so long if there were not many correlations between phonological patterns and the phonetically-grounded features that have been proposed to account for them. The question is this: "When we study sound patterns, are we looking at something that innate features do that manifests itself in sounds, or are we looking at something sounds do that can be described with features?"

The strongest position in support of innate features is one that has perhaps no proponents. This is what we might expect phonological patterns to be like if we were to take a literal interpretation of the idea that features are the building blocks of phonological patterns (7).

(7) Innate features (strong position):

- All phonological patterns in spoken and signed languages can be reduced to operations on a small set of innate features.
- The role of phonetics in phonology can be reduced to the phonetic basis of distinctive features.
- A wide range of observations about phonological patterns can be attributed to facts about features themselves (e.g., their organization in the brain), with no interpretation in phonetics, language change, or anywhere else.

The weaker position in (8) is more widely held but harder to falsify. This position is informed by the observation that some phonological patterns are not easily interpretable as the manifestation of innate features. External factors are invoked to account for problem cases.

(8) Innate features (weak position):

- Most if not all *recurrent* phonological patterns in spoken and signed languages can be reduced to operations on a small set of innate features.
- The role of phonetics in phonology can *often* be reduced to the phonetic basis of distinctive features.
- Some observations about phonological patterns may be attributed to facts about features themselves (e.g., their organization in the brain), with no interpretation in phonetics, language change, or anywhere else.

The emergent features position in (9) dispenses with innate features as a means of accounting for observations about phonological patterns, and appeals directly to influences on phonological patterns.

(9) Emergent features:

- Phonological patterns occurring with greater than chance frequency in spoken and signed languages can be accounted for in terms of external factors affecting them.
- The role of phonetics in phonology can be reduced to external factors (relating to vision, audition, articulation, etc.).
- No observations about phonological patterns may be attributed to facts about features themselves (e.g., their organization in the brain), with no interpretation in phonetics, language change, or anywhere else.

It should be clear that the strong version of the innate features position is not tenable. The purpose of this dissertation is to motivate the emergent features position over the weak version of the innate features position. There are already many widely-recognized external explanations for the existence, absence, or rarity of certain phenomena among the world's languages, and many of these are invoked in the weak version of the innate features approach. Two goals of Emergent Feature Theory are to show that when these external factors are taken seriously, there is nothing left for innate features to account for, and to formalize the role of external factors in phonological patterns without including them in Universal Grammar or otherwise building them into the cognitive representation of phonology.

1.6. Original motivations for distinctive features

There are many reasons to suspect that distinctive features are not innate, and there are also many facts which distinctive features have been used successfully to account for. The approach advocated in this dissertation focuses on reevaluating the insights of distinctive feature theory and recasting them in a framework that does not assume innateness, rather than discounting the contributions of innate feature theories to the study of phonology. Several different observations have motivated features and their hypothetical properties, such as binarity and innateness, and this section summarizes some of these motivations.

1.6.1. Motivations for features

Features were proposed as a part of phonological theory long before they were argued to be innate. Early motivations for distinctive features focused on minimizing demands on memory and perception. Based on assumptions about the correlation between meaning and strain on perception and memory, Jakobson hypothesizes about a constraint on the number of phonological contrasts in a language:

> Differences which have differentiating value are, as we have seen, more accessible to perception and to memory than differences which have no value at all, but on the other hand differences between phonemes—since they lack particular meanings—strain perception and memory and necessarily require a great deal of them. We would expect, therefore, that the number of these primordial and unmotivated values would be relatively small for any given language (1942:235).

Because Jakobson assumes that the differences between phonemes, being "unmotivated", tax perception and memory, he argues that the number of oppositions should be minimized. If binary oppositions between phonemes are taken to be the "primordial" values, then twenty-eight (7+6+5+4+3+2+1) binary relations are necessary to characterize the eight vowels of Turkish. By introducing the notion of distinctive features, Jakobson reduces twenty-eight binary relations to three, as in Figure 1.8:

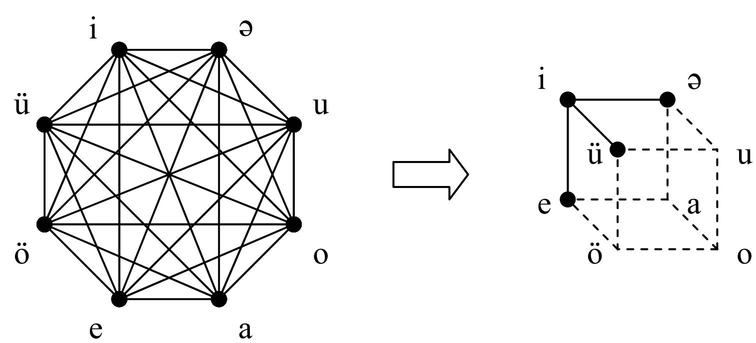


Figure 1.8. Reducing 28 binary relations to three

For Jakobson, the argument for a minimal number of distinctive features in any given language is the same as the argument for the *existence* of distinctive features: It is assumed that primitives which have no inherent meaning are costly to perception and memory, and that their numbers in any given system are therefore minimized. Universality of distinctive features is limited to the claim that features in two languages which refer to the same acoustic feature (and by transitivity, it is claimed, to the same articulatory movement) are fundamentally the same. Thus, the feature [high] in Turkish is fundamentally the same as the feature [high] in Russian. In this sense, the set of possible phonological distinctive features is limited only by acoustic and articulatory phonetics (which at this point are assumed to be related by a one-to-one mapping), and the universality of the distinctive features is a direct consequence of the universality of the human vocal tract.

1.6.2. Motivations for binarity

The conclusion that distinctive features are binary was supported by Jakobson, Fant, and Halle on the basis of the observation that the distinction between some pairs of words, such as *bill/pill* and *bill/dill*, can be characterized by a difference of one feature. Others are distinguished by more than one feature, such as pairs like *bill/fell*, which involve a duple distinction in initial segments and a minimal distinction in their middle segments. In essence, the fact that differences between words *can* be represented by a series of binary decisions is taken as evidence that this is actually how information is encoded in language. Jakobson, Fant, and Halle assert that Information Theory (e.g. Shannon and Weaver 1949) provides a sequence of binary selections as the most reasonable way to analyze communication, and that in the special case of language, this is not simply the best analysis to impose on the data, but how it is inherently structured. While there is a continuous range of possible degrees of voicing and lip-rounding and other articulatory movements, only two polar points are picked out as distinctive features. Jakobson and colleagues argue that the dichotomous scale is the optimal code, and therefore there is no reason to suppose that speakers would use a more complicated system. However, no evidence is presented to show that this is limited to language rather than more general cognitive patterns of human beings (and perhaps also dogs and fish). They report that binary relations are imprinted in children's early cognitive development (citing Wallon's (1945) study of gradual binary fissions in child development and Parsons and Bales' (1955) study of socialization). Additionally, they note that almost all distinctive features are dichotomous at the articulatory and acoustic levels, and that applying the dichotomous scale makes the analysis of phonological patterns so clear that it must be inherent in language.

1.6.3. Motivations for innateness

The assumption of innate primitives in linguistic theory did not originate in the study of phonology. Chomsky's transformational grammar program, starting in the 1950s, crucially involved a universal, innate human language faculty containing formal and substantive linguistic universals. Formal universals correspond to the formalisms of linguistic theory, which are believed to be unlearnable, and therefore innate. The central component of linguistic competence in Chomsky's (e.g. 1957, 1965) program is syntactic, and so are the arguments for formal and substantive universals. *The Sound*

Pattern of English (Chomsky and Halle 1968) represents a move to extend some of the formal universals of Chomsky's account of syntax, such as the transformational cycle, to the study of phonology. The claim set forth in Jakobson, Fant, and Halle (1954) that all the phonemes of the world's languages can be described in terms of twelve features is quite compatible with Chomsky's program.

In contrast to previous accounts by Trubetzkoy (1939), Jakobson (1942), and Jakobson, Fant, and Halle (1954), Chomsky and Halle (1968) assume a cognitive, rather than physiological, basis for the universality of distinctive features. Distinctive features are provided by Universal Grammar, rather than determined by the universal vocal tract.

While they acknowledge the role of the universal vocal tract in phonological patterns, Chomsky and Halle (1968:14) propose that a phonetic representation is "a feature matrix in which the rows correspond to a restricted set of universal phonetic categories or features (voicing, nasality, etc.) and the columns to successive segments," and that "such representations are mentally constructed by the speaker and the hearer and underlie their actual performance in speaking and 'understanding'."

Distinctive features "must be determined absolutely, within general linguistic theory, and independently of the grammar of any particular language" (Chomsky and Halle 1968:164). This argument is based on the assumption that it is necessary for the functioning of their model and therefore necessary to the extent that their model works to explain English phonology. Because conditions such as the principle of the transformational cycle and the principles of organization of grammar do not seem to be learnable, these universals are hypothesized to be innate (Chomsky and Halle 1968:43).

The motivations for Universal Grammar are discussed in more detail in chapter 3, along with recent arguments against some of the foundations of UG, and some alternatives.

1.7. Outline of the dissertation

This chapter has begun a case against innate distinctive features and in favor of Emergent Feature Theory. Emergent Feature Theory is developed further in chapter 4. The intervening chapters discuss phonetic and psycholinguistic evidence that is related to features, Universal Grammar, and emergent and functional models.

Chapter 2 discusses phonetic and psycholinguistic evidence that relates to distinctive features and/or their universality. Because innate features are generally claimed to be phonetically defined, many arguments involve phonetics, and it is often difficult to tease apart phonetic features and phonetics itself. Many different types of explanation are available to account for all the ways in which sounds may be grouped together. Chapter 3 discusses various approaches, including Universal Grammar and functionalist and emergent models.

Chapters 5 and 6 present the results of the crosslinguistic survey of phonologically active classes. Chapter 6 focuses on the ability of three feature theories (Preliminaries, SPE, and Unified Feature Theory) to account for the observed classes.

Emergent Feature Theory, laid out in more detail in chapter 4, is part of a more general model of the emergence of linguistic structure that is described in chapter 8. As is shown in chapter 4, sounds may be grouped together as a result of their shared participation in a sound change. Many groupings can be attributed to phonetically-based generalizations, and it is seen in chapter 7 that the segments which are the most fickle in their crosslinguistic patterning are those whose phonetic cues are the most ambiguous, regardless of the features traditionally used to define them.

CHAPTER 2

PHONETIC AND PSYCHOLINGUISTIC EVIDENCE

The literature contains a wide variety of experimental results which are often presented as evidence for distinctive features and their universality. Three mitigating factors are common to many examples of phonetic and psycholinguistic evidence for features. First, some of these studies *assume* that distinctive features are innate, and test the predictions of different theories of universal distinctive features without considering the possibility that distinctive features are *not* innate. Second, some studies find evidence that segments sharing distinctive features are processed similarly but do not rule out the possibility that this may result simply from phonetic similarity, which is usually positively correlated with the number of shared features. Third, some studies find evidence for abstract features but do not find evidence that these features are innate rather than learned. In short, a variety of studies produce data that is relevant for answering questions about the existence of distinctive features, but there is no experimental evidence that distinctive features are innate.

Finding evidence that distinctive features are innate would mean finding evidence that a feature for which there is no motivation in a subject's native language (and which thus could not have been learned) accounts for some aspect of their behavior that cannot be accounted for by other factors such as phonetics. For example, if it is found that subjects in a phoneme recognition task or a memory task confuse segments which are featurally similar more than they confuse segments which are phonetically similar, this would be evidence that features are somehow at the root of these errors. Further, if subjects make the same errors involving features not present in their native language (e.g. [lateral] for Japanese speakers or [constricted glottis] for Standard American English speakers), then this would be evidence that the features are innate. If there is motivation for the feature in the subject's native language, then the feature could be learned rather than innate. If what the feature seems to account for can be accounted for equally well (or better) by independently motivated facts such as the production and perception of speech, then there is no need to posit innate features as an additional/redundant source of explanation. The next section deals with some of the phonetic evidence related to distinctive features, and it will be seen that none of these studies provide the type of evidence needed to show that features are innate. Section 2.2 takes a similar look at psycholinguistic evidence.

2.1. Phonetic evidence

Phonetic evidence related to distinctive features has come from speech errors and perception errors, from quantal relations between different phonetic parameters, and from crosslinguistic variation in inventories, coarticulation, and phonetic realization. Some of this evidence has been used to argue for innate features, and some of it has been used to argue against innate features, and some of it does not bear on innateness at all.

Among the articulatory evidence which has been cited as evidence for distinctive features is the existence of speech errors which appear to involve features. Analysis of 1500 spontaneous phonetic errors by Shattuck-Hufnagel and Klatt (1975:S62), who report that consonant substitutions are significantly more likely to preserve a feature value than would be expected by chance, "suggesting that at some point in the production process, segments are represented psychologically in terms of features." Fromkin (1973) reports 55 feature errors from a corpus, but concedes that many errors are ambiguous as to whether they involve features or segments (Fromkin 1988). Fromkin (1988) argues that there would be no explanation for speech errors such as 'metaphor → menaphor' without a theory of distinctive features. But speech sounds can be similar in many ways, and features are only one of these. The fact that consonants are substituted for more similar consonants and not substituted at random is not surprising. Therefore, to conclude that features are behind these substitution errors, there would need to be evidence that featural similarity is a better predictor than, e.g., articulatory and perceptual similarity, and that gestural overlap (e.g., perseveratory nasalization in 'metaphor → menaphor') is not responsible. It will be seen below in Graham and House's (1971) study that children's errors of misidentification are better accounted for in phonetic terms than in terms of distinctive features.

In a subsequent analysis of a larger data set, Shattuck-Hufnagel and Klatt (1975) report that distinctive features and markedness appear to play little if any role in articulatory control during speech production, and that most phonetic speech errors involve manipulating segments rather than features. In the combined UCLA (Goldstein 1977) and MIT error corpora, containing 2989 substitution errors, there are fewer than a dozen examples which appear to involve a feature being exchanged between two segments.

Acoustic evidence cited for distinctive features includes evidence from the quantal relations between different parameters of speech. Stevens (1972, 1989 *inter alia*) proposes that the sound inventories of languages are determined by the nonlinear mapping between articulatory and acoustic parameters and also between acoustic and auditory parameters. The articulatory and acoustic attributes which occur within the plateau-like regions of the relations, where articulatory changes result in comparatively small acoustic changes, are the correlates of the distinctive features. When languages exploit these stable regions, variability in production results in minimal confusion, as opposed to the areas where the mapping is steeper, and minor changes have drastic acoustic consequences. The same is true of the mapping from acoustics to audition. This allows phonetic continua to be divided into two or more regions, and Stevens argues that this provides evidence for innate features with values corresponding to these regions. The features would have emerged in human evolution in response to nonlinearities in articulatory/acoustic/auditory mapping.

Others have suggested that the nonlinearities may account more directly for the nature of common phonological patterns (e.g., Beckman and Pierrehumbert 2003). In this view, the naturally occurring discretization of phonetic space is exactly why innate features are unnecessary. The human vocal tract and auditory system both favor particular regions of stability that are naturally exploited by the world's spoken languages. Speech sounds which involve stable regions are less likely to change than those which are in unstable regions, resulting in sound systems that resemble each other, because they all settle in stable regions, as defined by the anatomical parts used for spoken language, which under most circumstances are common to all humans. If the similarities between languages were caused by innate features associated with quantal regions rather than the quantal regions themselves, they would be expected to extend into sign language, a linguistic domain where the vocal tract and auditory system are largely irrelevant, but Universal Grammar ostensibly is. Not surprisingly, signed languages show no evidence of the facts that innate features corresponding to acoustic/articulatory quantal relations are intended to account for. Instead, signed language phonology reflects the anatomical parts that are used in signed languages.

Studies reported to involve perceptual evidence for distinctive features include Miller and Nicely's (1955) study, which found that different attributes of speech sounds are affected differently when the speech signal is degraded by the application of noise or high-pass or low-pass filtering. Miller and Nicely adopt voicing, nasality, affrication, duration, and place as features to distinguish the 16 consonants used in their study. Differences in the way these features of sounds are affected by signal degradation are attributed to their acoustic correlates. For example, nasality and voicing are more resistant to random masking noise than the other features because random noise across the frequency spectrum is more likely to weaken the already weaker high-frequency cues to the other features than the more robust low-frequency cues for nasality and voicing. The features imposed on the consonants by Miller and Nicely are describable in phonetic terms, and the explanations given for the clear differences in confusion rates between consonants distinguished by different features are all found in the acoustic signal. This does not motivate more abstract or innate feature representations. It simply motivates the claim that speech sounds have attributes that are affected differently by different types of noise.

Studdert-Kennedy and Shankweiler (1970) found that subjects in a dichotic listening experiment are better at identifying segments in both ears simultaneously when the segments share phonetic features. Studdert-Kennedy, Shankweiler, and Pisoni (1972) replicated the experiment with the purpose of determining whether auditory similarity is at issue rather than more abstract phonetic features. In order to vary auditory similarity without varying phonetic features, Studdert-Kennedy, Shankweiler, and Pisoni compared the identification of stop consonants (which differed in terms of voicing and place) in cases where the following vowels were identical and with cases where the following vowels were different. The formant transitions which provide cues to the place of articulation of identical consonants are acoustically different when the following vowels are different, but the abstract representations of the place of articulation of the consonants are expected to be the same.

The results show that the ability of English-speaking subjects to recognize the place of articulation and voicing of stop consonants in both ears simultaneously is no better when the following vowels are identical than when they are different. This indicates that an abstract notion of place of articulation is relevant here, rather than simple acoustic similarity. So this study, unlike many others, teases apart features and acoustic similarity. However, it does not address the question of *universality*. In order to determine whether the features are innate or learned, it would be necessary to examine features which are claimed to be innate but which are not motivated by the subjects' native languages. The study involves only voice and place distinctions among the stops [p t k b d g]. Both of these abstract distinctions are well-motivated in the phonology of English, the language spoken by the subjects in the study. Therefore, innate features and emergent features make the same predictions about these features. Thus, the study does not bear on the question of whether features are innate or emergent, and it does not claim to. Similarly, brain imaging studies which appear to show the localization of phonological features in the auditory cortex (e.g., Phillips, Pellathy, and Marantz 2000) support the existence of features, but do not support innateness unless they identify features which are not motivated by the subject's language.

While there is some phonetic evidence for distinctive features (but not for their universality), there is some phonetic evidence against the notion of innate distinctive features. Ladefoged (1984) observes that many facts of phonetic realization, while consistent within a given speech community, cannot be explained by universal principles (i.e., universal phonetics, Chomsky and Halle 1968) or a universal set of distinctive features:

> Speakers of every language have to use exactly the right vowel and consonant qualities, intonations, rhythms, etc. on pain of being wrongly labeled if they do not. There can be very subtle phonetic differences among languages resulting from this drive to be correctly identified as part of a group; but these phonetic phenomena are important to speakers and listeners. They cannot be ascribed to any general universal principles; they are due to the vagaries of local history and personal desire. But their maintenance can be regarded as ascribable to the behavior of individuals (85).

As an example, Ladefoged (1985:85) describes the similarities and differences between the vowel systems of Yoruba and Italian, based on a study by Disner (1983). The similarities between the way the vowels of Yoruba and the vowels of Italian are organized are attributable to the human drive for communicative efficiency (see, e.g.

Lindblom 1983). This accounts for why the two systems of vowels are fairly evenly spaced in articulatory and perceptual space and more fully exploit contrast along the F2 dimension in the high vowels than in the low vowels. Ladefoged attributes the *differences* between Yoruba and Italian in part to the biological drive for group identification. While both vowels systems are largely similar, the Yoruba vowels are less evenly distributed than the Italian vowels. For example, the low vowel [a] is considerably lower with respect to the low mid vowels than Italian [a] is in relation to Italian low mid vowels. These patterns are consistent across speakers of Yoruba and speakers of Italian, and they are consistent because speakers want to show their group identity, not because any universal laws of language have caused these vowels to manifest themselves in such a way. Likewise, while coarticulation can be attributed to forces acting upon speakers of all languages, it manifests itself differently in different languages.

To summarize, many phonetic facts about language can be explained in terms of universal physiological and physical constraints, but many phonetic facts cannot be explained by universal constraints, be they functional (contra Lindblom) or hardwired (contra Chomsky and Halle, etc.). A theory of innate distinctive features is consistent with many observations that can be made based on functional considerations, but neither theory can account for the subtle phonetic differences between languages, even though these subtle phonetic differences are used by language users to form contrasts. Port (1996:503) similarly reports that experimental observations show that there are “subtle context effects” (e.g., the language-specific coarticulation facts summarized by Ladefoged), most of which are language-specific and cannot be language universals, and that these subtle variables can be employed by listeners in speech perception.

Further evidence against the notion of universal phonetics and the idea that phonological categories are defined in terms of universal distinctive features comes from studies which show that phonology influences speech perception and/or that speech perception influences phonology. Huang (2001) finds that tone sandhi in Chinese Putonghua can be attributed to the perceptibility of differences between different tonal patterns, and further that the perception of similarity between tones is not universal but instead differs between Chinese and American English listeners. If phonological processes are subject to perceptual constraints, and perception is not universal, it is difficult to see how phonological processes can be explained by means of a universal set of distinctive features. Similarly, Seo (2001), Tserdanelis (2001), and Mielke (2001, 2003) find that segmental processes of assimilation, dissimilation, and deletion, respectively, can be accounted for in terms of perceptibility, and that perceptibility of segmental differences varies from language to language in accordance with language-specific phonetic and phonological patterns. Makashay (2001) finds that consonant clusters with more salient cues are more common in English than consonant clusters with less salient cues. While proposals by Chomsky and Halle (1968) were made in terms of articulatory features, the notion of distinctive features has also been invoked to account for observations that involve perceptibility (see, e.g., Flemming 2002). While the role of perception in phonology can indeed be cast in terms of distinctive features, perception has been demonstrated to be non-universal (see also Vihman 1996). Consequently, an account of perceptually-grounded phonological alternations that is laid out in terms of perceptibility or generalizations about perceptibility cannot be reduced to features which are universal.

Port (1996) claims that incomplete neutralizations also present a problem for a theory of universal distinctive features. For example, German final devoicing is generally considered by phonologists to result in phonological neutralization, but the neutralized forms are measurably different, and native speakers can distinguish them about 75% of the time. Labov (1994) discusses near mergers in more detail, including cases where speakers produce a contrast they cannot hear. The strongly-held belief that speech sounds are either the same or different has prevented partial neutralization data from being taken seriously in phonological theory (Labov 1994:367-69).

In summary, Studdert-Kennedy, Shankweiler and Pisoni's study stands out because it does point to abstract place features as being superior to acoustic cues in accounting for dichotic listening results. This means that phonological features appear to be motivated as a part of phonology that is independent of phonetics, but the study does not demonstrate or attempt to demonstrate universality. Stevens' interpretation of quantal relations as evidence for innate features would predict that the patterns observed by Studdert-Kennedy, Shankweiler and Pisoni will be found for speakers of other languages and for other features, including speakers with features that are not active in their language. Emergent Feature Theory predicts that the effects would only exist for features which would have emerged during the speaker's acquisition of language.

2.2. Psycholinguistic evidence

This section deals with evidence for and against a universal set of distinctive features from areas such as infant perception, development, and memory. Much of this evidence originally appeared to support innate distinctive features, but further research has indicated that some of the conclusions may have been premature. For example, the results of early experiments on infant speech perception (e.g., Eimas *et al.* 1971) suggested that the ability of infants to discriminate a wide range of phonetic contrasts is a part of the innate human capacity for language, and that perhaps neural atrophy during childhood is responsible for the inability of adults to distinguish many nonnative contrasts. This conclusion is very compatible with the idea of universal phonetics proposed by Chomsky and Halle (1968). However, the results of further studies (many of which are summarized in Aslin and Pisoni 1980) indicate that it is not so simple.

For example, Aslin and Pisoni (1980:71) note Kuhl and Miller's (1975, 1978) findings that chinchillas "who obviously do not make use of human voicing distinction in their own vocal repertoire" can be trained to distinguish synthetic labial stop stimuli, and the perceptual boundary of chinchillas is very close to the boundary found for the voice-voiceless stop contrast in (presumably American) English adults. If Chinchillas show human-like categorical perception, it seems less plausible that the same observations in the perception of infants can be attributed to innate linguistic processing abilities.

Aslin and Pisoni (1980:85) argue, based on their own research findings, that the ability of infants to detect Voice Onset Time (VOT) contrasts is the result of general constraints on the mammalian auditory system which cause detection of the onset of the first formant relative to higher formants to be easiest at ±20 ms, especially when the lower-frequency component begins first (positive VOT). This can also be extended to explain the crosslinguistic preference for VOT contrasts with boundaries in the region of ±20 ms (especially +20 ms).

Many of the results reported by Aslin and Pisoni support an “attunement theory” which states that infants start life much like chinchillas, with the ability to make distinctions between acoustic stimuli, and that human infants’ distinction-making abilities are “tuned” in response to exposure to linguistic stimuli. While infants may start with a vowel space that is processed most efficiently by the auditory system, it can then be rearranged to match the phonological categories in the language being learned. Aslin and Pisoni (1985) conclude that the question of how infants learn to perceive language as adults do is complicated, and can likely be best characterized by a combination of various mechanisms. Such a combination is generally incompatible with a hardwired system of “universal phonetics”.

Also casting doubt on the neural atrophy hypothesis is Werker and Tees’ (1984) finding that under the right conditions, adult subjects are able to distinguish non-native contrasts. Therefore, earlier results implicating neural atrophy can more adequately be explained in terms of different processing strategies used by adults. Adults do indeed appear to have the sensory-neural abilities to distinguish non-native contrasts, but simply do not use them to perform many tasks, such as discriminating full syllables.

Best, McRoberts, and Sithole (1988) report evidence that the apparent loss of sensitivity to contrasts which are not present in the native language is the result of assimilation to native contrasts, and that the ability to discriminate nonnative contrasts which are not perceptually similar to native phonemic categories remains into adulthood. If assimilating sounds to native categories facilitates speech perception by eliminating redundant and irrelevant information, then the differences between adult and infant perception under many circumstances is evidence of the adults’ successful acquisition of language rather than the decay of UG-endowed speech perception abilities. They essentially enhance quantal relations by warping the perceptual space according to learned phonological categories.

Among the developmental evidence sometimes cited in favor of distinctive features is a study by Graham and House (1971), who examine the ability of English-speaking girls aged 3-4½ years to perceive differences between 17 English consonants. They find that the results “fail to support the idea that the descriptive labels used to specify speech sounds (that is, linguistic descriptive features) identify the perceptual parameters used by the listener in categorizing the speech sounds” (565). While segments which differ with respect to only one SPE feature (and are somewhat similar phonetically) are more confusable to children than segments which differ with respect to more than one feature, the set of features they consider makes no more specific correct predictions about the perceptibility of contrasts. For example, the two most confusable pairs of segments ([f] vs. [θ] and [r] vs. [w]) differ in more than one feature ([coronal] & [strident] and [vocalic], [consonantal], [coronal] & [rounded], respectively). Graham and House conclude that the set of distinctive features they consider “may have no psychological reality for the group of children studied” (564), and that traditional articulatory descriptions also fail to account for their results.

Another study which is cited as providing evidence for features is Gierut (1996), although it apparently is not intended to. It assumes innate features and tests the predictions of two different versions of underspecification. The study examines the ability of monolingual English-speaking children aged 3-5 to categorize stimuli containing an assortment of English stops and fricatives, towards a goal of testing two different approaches to underspecification. According to Gierut, the children group segments according to features that they share, and the representations the children appear to use are to be less specified than those assumed for adults. Some portions of the results which are inconsistent with this premise that features are innate (e.g. the grouping of [t] with [f] instead of [s]) are simply ignored. This study provides no evidence for an innate set of distinctive features.

Studies involving the interaction of speech sounds with short-term memory have also been presented in favor of distinctive features. Wickelgren (1965, 1966) examines errors in recalling English vowels and consonants, looking for evidence of what system of features corresponds best to the way speech sounds are stored in short-term memory, assuming that individual features of sounds may be forgotten, causing sounds which are more similar to be substituted for one another more frequently. For vowels, Wickelgren (1965) finds that the features of Chomsky and Halle's (1968) systematic phonetic level (given certain assumptions), which as of 1965 were stated in acoustic terms, works as well as conventional (articulatory) phonetic analysis for predicting the rank order of replaced vowels. Chomsky and Halle's phonemic level and Jakobson, Fant, and Halle's (1954) features are both found to be less adequate.

Cole, Haber, and Sales (1973) conducted a similar experiment involving both consonants and vowels, using predictions made by Halle's (1962) feature system. They find that Halle's feature system predicts the frequency of segment substitutions quite accurately, and that consonants and vowels seem to be replaced in identical ways. However, by not considering any other feature systems or any less abstract articulatory or acoustic descriptions, this study does not demonstrate that an abstract feature system is necessary. As Wickelgren (1965, 1966) showed, Chomsky and Halle's abstract feature system does predict errors with greater than chance accuracy, but not as accurately as feature systems based on simple articulatory or acoustic descriptions.

In summary, there is no psycholinguistic evidence in support of a universal set of distinctive features. The bulk of the generally accepted arguments for features are phonological, but work in phonology has not converged on a single feature set, and the feature sets which are argued for have not been tested against a large set of data.

2.3. Summary

The past two chapters have reviewed the arguments for innate distinctive features, and if one thing is clear from this review it should be that innateness in phonological representations is by no means a conclusion, but is instead an assumption that has not been rigorously tested with a large amount of phonological data. This leaves open the question of whether phonological patterns can be learned inductively, and whether the patterns themselves are not manifestations of Universal Grammar but generalizations involving phonetic constraints and language change. These questions will be dealt with in turn in the chapters that follow. The next chapter deals with the notion of Universal Grammar more generally.

CHAPTER 3

UNIVERSAL GRAMMAR, EMERGENCE, AND FUNCTIONALISM

This chapter deals with arguments for and against Universal Grammar, drawing on areas such as language acquisition, creolization, phonetics, and phonology, with a discussion of alternatives to Universal Grammar. Phonology has never been central to the motivations for Universal Grammar, but many theories of phonology assume primitives such as innate features. Recently there have been a number of challenges to some of the more fundamental motivations for UG; both the motivations and the challenges are summarized in this chapter. The more questionable the foundations of UG as well as the relationship between these foundations and phonology become, the more precarious the innate features position becomes. This chapter reviews these issues, before subsequent chapters present evidence against innate features head-on.

3.1. Universal Grammar

3.1.1. General arguments

Early arguments for Universal Grammar were based on the conclusions that certain devices such as cyclic application and deep structure (what Chomsky (1968) calls *formal universals*) are necessary to explain language structure, and that it seems highly unlikely that children can learn them. This is reconciled by proposing that children possess an innate set of assumptions (Universal Grammar) which facilitate language learning:

> [These assumptions] form one part of the schematism that the child brings to the problem of language learning. That this schematism must be quite elaborate and highly restrictive seems fairly obvious. If it were not, language acquisition, within the empirically known limits of time, access, and variability, would be an impenetrable mystery. Considerations of the sort mentioned in the foregoing discussion are directly relevant to the problem of determining the nature of these innate mechanisms, and, therefore, deserve extremely careful study and attention (Chomsky 1968:136).
>
> [I]nsofar as principles of interpretation can be assigned to universal rather than particular grammar, there is little reason to suppose that they are learned or that they could in principle be learned (Chomsky 1968:139).

Chomsky (1968:134) observes that language-specific phonological rules seem to be learnable, but that hypothesized formal universals such as the principle of cyclic application of phonological rules seem not to be. The language learner must construct a mental grammar based on Universal Grammar and input, which takes the form of the output of the grammar of other speakers.

Steels (1997) notes several types of counterevidence to the arguments for Universal Grammar, namely that attempts to confirm studies involving grammar-specific genes have been unsuccessful (Vargha-Khadem *et al.* 1994), that empirical data suggest there is no poverty of stimulus in language acquisition (Pullum 1996), that more powerful learning procedures have been discovered (Daelmans, Durieux, and Gillis 1994), that creole formation has more to do with language contact than with a bioprogram (Thomason and Kaufman 1988), that the genetic evolution of a language faculty is incompatible with what is known about the speed of evolution (Worden 1995), and that the nature of the Language Acquisition Device remains to be discovered.

Pullum (1996) demonstrates that the premise of the central argument for the Poverty of Stimulus does not hold up under scrutiny. The English rule of auxiliary fronting (“You are happy.” and “Are you happy?”) is held to be based on a structural rather than linear relation: the main clause auxiliary is fronted, as opposed to the leftmost auxiliary (see e.g., Chomsky 1965). Chomsky (1975, 1980) argues that children learn to employ a structure-dependent generalization about auxiliary fronting even though they may never be exposed to the relevant evidence, and so a language learner must innately know only to use structure-dependent relations. Pullum’s (1996) corpus search reveals that in just the first 500 interrogatives in an excerpt from the Wall Street Journal, five cases of crucial evidence for the structure-based rule over the linear rule occur. Pullum concludes that the claim that there is insufficient evidence to learn the rule from data is completely unfounded. Not only is there sufficient evidence to learn a structure-based rule, experimental research indicates that language comprehension involves simple processing heuristics and shallow processing anyway (Ferreira 2003).

Much of the evidence commonly presented in support of Universal Grammar involves language acquisition and creolization. White (1998:2) explains the motivation for UG in terms of language acquisition:

> What is the motivation for UG in the first place? It is the claim that, at least in the case of first languages, there is a logical problem of language acquisition, a mismatch between what goes in, (namely, the primary linguistic data) and what comes out (a grammar). In other words, the input underdetermines the output.

An argument could also be made that if proposed formal properties of language are unlearnable, then perhaps they are the wrong formal properties. Another possibility is that they are the right formal properties but the explanation for their existence can be found in constraints on language processing. Culicover and Nowak (2003) offer two alternative explanations. The universal tendencies (such as the correlation between left-branching structure and Subject-Object-Verb word order, and between right-branching structure and Subject-Verb-Object word order) can be due to social forces, or the result of the interaction between social forces and processing complexity: i.e., UG does not rule out any logical possibilities, but more complex possibilities are eliminated over time as they lose out to less complex competitors, leading eventually to a situation where it appears that Universal Grammar has ruled out some logically possible constructions. This would explain the existence of universals or near-universals, but not the speed and predictability with which language acquisition occurs.

Culicover and Nowak propose that syntactic universals may be explained as an emergent property of the interaction between social forces and processing constraints. A computer simulation models the interaction between eight "languages" which represent the eight logically possible combinations of three binary features. Invariably, some of the possibilities cease to be represented, such that after 2000 repetitions, generally only three to five of the original eight logically possible languages remain. Culicover and Nowak's simulation assumes that the initial state represents all logical possibilities, and this was not necessarily the case for the genesis of human language. Particularly if the world's languages can be traced back to a small number of original proto-languages, it is unlikely that very many of the logically possible grammars were available to begin with. Thus, explaining the observation that far fewer grammars exist than are logically possible does not require Universal Grammar. Further, processing complexity may explain why certain grammatical structures lose out over time. Culicover and Nowak argue that complexity of mapping between surface strings and conceptual structure may cause certain grammatical structures to be dispreferred.[1]

While the poverty of stimulus argument was an early motivation for Universal Grammar, some generativists have recently relied more heavily on other arguments. Newmeyer (1998:88) (following Hawkins 1985 *inter alia*) acknowledges that the arguments from the poverty of stimulus are only convincing if we know that language cannot be learned from positive evidence, and there is presently no theory of what is learnable from positive evidence. Citing work by Brent (1993) and Schütze (1997), he recognizes that data-driven learning algorithms have been shown to be able to induce complex syntactic generalizations from raw text. Of course, as he points out, this does not mean this is how the brain works, only that it is a logical possibility that language acquisition could be the result of "some sophisticated general cognitive faculty or some more specific faculty not restricted to language."

However, even if the poverty of stimulus argument is less compelling now than it was forty or fifty years ago (see below for further discussion), more recent research, particularly in the area of hereditary language impairments (e.g., Gopnik 1994, Gopnik *et al.* 1997) has provided evidence that there are language-specific genes and specific parts of the brain which facilitate language learning, and when they are impaired by hereditary conditions, the ability to acquire a native language is impaired, to the exclusion of all

[1] See also Culicover and Nowak (2004)

other cognitive processes. On the other hand, researchers attempting to confirm these findings have been unable to provide evidence to support the existence of grammar-specific genes (Vargha-Khadem *et al.* 1994:930). Further, it is relevant to the question of whether phonological features are provided by UG that studies of this type are generally limited to syntax.

Another salient body of evidence for Universal Grammar comes from creolization. It is argued (particularly by Bickerton, e.g., 1974, 1981, 1984, 1990, 1999) that similarities between creoles are the result of a *bioprogram* that determines language structure when the child is presented with a pre-pidgin that lacks crucial grammatical structure. Similarities between creole languages, crucially not just between Atlantic creoles, it is argued, demonstrate that the default parameter settings of Universal Grammar emerge in situations where the input is impoverished to the point where no settings for particular parameters are evident from the adult interlanguage.

Further, children who are in the process of acquiring English make errors which are reminiscent of grammatical constructions in various English-based creoles. Children's errors would be expected to betray default parameter settings in the same way that creole grammar supposedly does. For example, English-learning children often achieve negation by placing *no* in front of the verb phrase (e.g., *He no bite you, I no want envelope*, Bellugi 1968), as is often observed in creoles (Bickerton 1999:54). Before English-learning children acquire *to*, dependent clauses are assumed to be finite (e.g., *D'you want he walk,* Brown 1973, Limber 1973, Bickerton 1999), and this is also found in creoles. Many types of embedded clauses which are nonfinite in English are finite in English-based creoles (Bickerton 1999).

Despite the claim that this is evidence for a default parameter setting in Universal Grammar, an alternative explanation is possible based on frequency rather than default parameter settings. As children acquire English or create a creole in an environment where English is spoken, every sentence they hear contains a matrix clause, while only some contain an embedded clause. So the majority of the clauses heard by children in these situations are finite. The observation that children in both situations prefer finite clauses may be a direct result of this rather than a default parameter setting. Bybee (2001) reports that main clauses tend to be innovative and subordinate clauses tend to be comparatively conservative due to their relative infrequency.

Further evidence for the bioprogram hypothesis involves the tense-mood-aspect (TMA) system of creoles. In the bioprogram view, (Bickerton 1974, 1981), the prototypical creole TMA system has an invariant ordering of three categories (an anterior tense, an irrealis mood, and a non-punctual aspect). Consequently, ensuing descriptions of creole verb complexes have focused on the extent to which a given creole's system matches this prototype. Winford (2000:385) argues that the prototype is based on questionable analyses of the TMA systems of only a few creoles, and more recent studies of languages such as Guyanese Creole and Sranan show that the prototype claims are incorrect. For example, Winford shows that the interpretation of the Sranan TMA system which forms the basis for the claim that creoles possess a common simple TMA system, is overly simplistic.

To motivate the influence of Universal Grammar in creole genesis, it must also be demonstrated that the observed similarities between creoles cannot be explained based on similarities between substrate languages. Indeed, there are common features between

Atlantic creoles and Hawaii Creole English (which had different substrate languages) Bickerton (1999:51), but Thomason and Kaufman (1988:159-60) argue that this does not necessarily implicate a bioprogram, because different sets of substrate languages (e.g. West African and East Asian languages) may have similar shared features. Thomason and Kaufman (1988:162) report that a number of features of Atlantic creoles, such as preverbal tense/aspect markers, specific uses of and variations in the copula, serial verbs, and reduplicated numerals functioning as distributives, are also found in the Niger-Congo substrate languages. Likewise, Siegel (2000) shows that many of the theoretically significant features of Hawaii Creole English may be attributed to substrate languages such as Cantonese and Portuguese.

3.1.2. Universal Grammar and phonology

Phonology has never been central to the arguments for Universal Grammar, but the concept of Universal Grammar has been extended to phonology, most notably in the form of innate features and other innate primitives. This section examines the connections between arguments for Universal Grammar and the application of Universal Grammar in phonology. Many of the arguments for UG in other domains do not hold for phonology. For example, there is little evidence of a learnability problem in phonology (see Blevins 2004 for discussion).

In 1968, Chomsky (1968:124) considered the theory of universal phonetics to be much more fully established than the theory of universal semantics. This asymmetry could have been the result of the large amount of crosslinguistic work in phonetics and phonology (e.g., Trubetzkoy 1939, Jakobson, Fant, and Halle 1952, Chomsky and Halle 1968, and many others). Another possibility is that language sound systems seemed much more straightforwardly restricted in a way that could be attributed to Universal Grammar. Phonetics is well-known to be constrained by physiology, and Jakobson found that a large number of sound systems can be described with a very small number of distinctive features. If the former is assumed not to be the cause of the latter, then Jakobson's distinctive features look like evidence for Universal Grammar. But if physiology is what constrains phonetics in such a way that it can be described with a small set of features, then neither observation is suggestive of Universal Grammar. The fact that phonetics observations can be expressed with a small set of features has nothing to do with language-specific capabilities of the human brain, except perhaps that the human brain is usually in close proximity to the human vocal tract.

Jakobson observes that no language uses both labialization and velarization for distinguishing words, and that these could be variants of one abstract feature, and Chomsky (1968:123) claims that such generalization can be proposed as laws of universal phonetics. Abstract generalizations are consistent with the notion of Universal Grammar as proposed for syntax, but the abstractness of the labialization/velarization feature is less clear when acoustics is considered in addition to articulatory phonetics. The acoustic correlate of both gestures is a lowering of F3, and the antagonistic relationship between labialization and velarization can be explained by the fact that they are perceptually indistinct. Invoking Universal Grammar is not necessary to explain Jakobson's observation.

The notion of universal phonetics can be stated in two ways, as a set of cognitive constraints in Universal Grammar, or as observations about the human vocal apparatus. The approach which would most strengthen Chomsky's (1968) position in general is the former, exemplified by the reference to an abstract feature responsible for labialization and velarization. But universal phonetics is often defined in the more trivial way, as in Chomsky and Halle (1968:294-95) where it is the set of "phonetic properties that can in principle be controlled in speech." This definition is unassailable, but entails no cognitive explanation whatsoever for phonetic universals. The phonetic motivation for Universal Grammar is extremely weak. Perhaps the most compelling case that can be made is that phonetics, like semantics, is part of the grammar, and that there is an implicit assumption that if syntax is rooted in Universal Grammar, the rest should be too. Most of the evidence for UG is not related to phonology, and phonology instead has something of a guilt-by-association status with respect to innateness, which grows less and less convincing as many of its alleged collaborators gradually become exonerated.

3.2. Emergent models and functionalism

If a particular phenomenon is not attributable to Universal Grammar, another explanation should be provided, particularly when the phenomenon is widely considered to be explained by UG. Among the alternatives is functionalism, whose proponents claim that explanation for linguistic patterns is found in the communicative functions they perform rather than in a formal structure that may or may not be innate. Emergent models of language claim that linguistic structure emerges from the interaction of many smaller patterns. There is considerable overlap between functional approaches and emergent models. Many functional approaches involve emergent models and many emergent models are functional.

The term "emergent" carries a lot of baggage. While it is probably uncontroversial that distinctive features are emergent, the question is whether they emerge from language change or from genetic change. The use of the term "emergent" often evokes images of the former and carries negative connotations. As used in linguistics, "emergent" has a narrow definition. One appropriate definition for "emergent" comes from the Oxford English Dictionary (Simpson 2004):

(10) 3. Science. An effect produced by a combination of several causes, but not capable of being regarded as the sum of their individual effects. Opposed to resultant.

A Google® search for "emergent definition" turns up the 19th, 20th, and 21st century definitions in (11):

(11) emergent:
(a) an effect that is not the sums of the effects of each causal conjunct (Mill 1843).
(b) the phenomenon wherein complex, interesting high-level function is produced as a result of combining simple low-level mechanisms in simple ways (Chalmers 1990).
(c) a phenomenon for which the optimal means of prediction is simulation (Darley 1994).
(d) behavior by something that is not a scaling up or adaptation of anything its parts do (Thornley 1997)

(e) One set of variables, A, emerges from another, B if (1) A is a function of B, i.e., at a higher level of abstraction, and (2) the higher-level variables can be predicted more efficiently than the lower-level ones, where "efficiency of prediction" is defined using information theory (Shalizi 2001).

(f) Properties of a complex physical system are emergent just in case they are neither (i) properties had by any parts of the system taken in isolation nor (ii) resultant of a mere summation of properties of parts of the system (Terravecchia 2002).

If being interesting is taken to be an optional feature of an emergent property, the definitions (11a-b) and (11d-f) can perhaps be reduced to the definition in (11f). Given this definition, it may well be that the optimal means of prediction of an emergent phenomenon is prediction (11c), but that is beyond the scope of this question. Two more definitions are provided in the description of two emergentist models of language.

(12) Bybee (1998:215) "Usage-based Phonology":

> Emergentist and connectionist views of language take substance (or the perception and memory of experience with substance) to be directly represented, while structure is considered emergent from the way substance is categorized in storage, which in turn is based on patterns of actual language use. Under this view, phonological and morphosyntactic regularities are emergent. This means that such patterns are not basic but a secondary result of aspects of speaking and thinking: they are not necessarily categorical, symmetrical or economical, but vary according to the nature of the substance involved, and the demands of communication

MacWhinney (1998:362) "Emergent language":

> According to this new view of language learning and processing, the behaviors that we tend to characterize in terms of rules and symbols are in fact emergent patterns that arise from the interactions of other less complex or more stable underlying systems. I will refer to this new viewpoint on language learning and processing as 'emergentism.'

These definitions are consistent with the definitions in (11a-b, d-f). An emergent property is not basic, but a secondary result of the interactions of other less complex or more stable underlying systems. In functional linguistics, such systems may be speaking and thinking. The definition used by MacWhinney is broader and can apply to the emergence of a wider variety of linguistic phenomena. For example, hypothesizing that the existence of phonological distinctive features is not a basic, inherent property of speech sounds or of Universal Grammar, but rather a property that results from the interaction of the speech production apparatus, the auditory system, the perceptual system, and the tendency of the human mind to form generalizations about data is to say that phonological distinctive features are emergent.

There is little argument over whether the structure of language is emergent. The controversy is over when linguistic structure emerged, or rather, when various elements of linguistic structure emerged. According to the Universal Grammar view, this structure is innate in the brain of every human, which means that it emerged in the course of human evolution. Any bit of linguistic competence that is not specified in the genome must either be emergent from functional factors related to the use of language or be learned when the child acquires her native language. The structure of the language, insofar as it is not accounted for by these other two sources of structure, is emergent from the evolution of the language itself, as an entity apart from (but dependent on) humans.

Contrary to a popular perception, emergent models can be more restrictive than innate models, because they only permit elements which have motivation in the ambient language. For example, Pulleyblank (2003) argues that a theory of emergent features is more restrictive than a theory of innate features in accounting for covert feature effects in

Nuu-chah-nulth and Oowekyala. In these cases a feature that is not active in an inventory plays a role in phonological patterning. Pulleyblank finds that covert feature effects appear only to involve features which are already evidenced in the language, and takes this as evidence that a theory of emergent features is more restrictive than a theory of innate features, because these effects seem to be limited to features which would be expected to have emerged in language acquisition, and fail to exploit features argued to be provided by Universal Grammar that are not phonetically recoverable in the language:

> To the extent that cases of covert contrast involve phonetically recoverable properties…, the most restrictive hypothesis is that features are emergent. If cases can be found that are comparable to the cases presented here but involve features that are completely absent phonetically, then such cases would be compelling evidence for the UG theory (Pulleyblank 2003:421).

The rest of this section reviews different approaches to the emergence of linguistic structure, as background for Emergent Feature Theory, which is proposed in more detail in the next chapter. A variety of emergent theories of language structure have been proposed, and here they are divided into non-teleological models, which do not attribute optimization to the speaker, discussed in 3.2.1, and teleological models, discussed in 3.2.2, which do attribute optimization (e.g., in terms of perceptual distinctiveness or ease of articulation) to the speaker.

3.2.1. Non-teleological models

Many models of phonology involve the emergence of linguistic structure without attributing anything to optimization on the part of the language user. Ohala (1989) interprets sound changes which occur independently in different languages to be phonetically-based, with new forms being drawn from the set of synchronic variants of existing forms. Phonetic variation is widespread, but the conventionalization of variation as a change in pronunciation norms is rarer. Further, these changes serve no particular purpose:

> [S]ound change, at least at its very initiation, is not teleological. It does not serve any purpose at all. It does not improve speech in any way. It does not make speech easier to pronounce, easier to hear, or easier to process or store in the speaker's brain. It is simply the result of an inadvertent error on the part of the listener. Sound change thus is similar to manuscript copyists' errors and presumably entirely unintended. I leave unaddressed the separate question of whether, after its initiation, the success of a sound change's transmission and spread may be influenced by teleological factors… (Ohala 2003)

Ohala suggests that all the evidence of teleology in speech production and perception seems to be directed towards *preserving* pronunciation norms rather than changing them.

If sound changes emerge from the pool of phonetic variation, then by this fact alone, the synchronic patterns they leave behind will be expected to tend toward phonetic naturalness. Demonstrating that there are additional synchronic constraints or universal grammatical primitives (such as universal distinctive features) mandating naturalness requires more than just noting that phonological patterns tend to be "natural" or tend to resemble each other.

Chang, Plauché, and Ohala (2001) provide an account of asymmetries in sound change based on asymmetries in perception. The observed asymmetries are shown in (13a). In sound change, [ki] changes to [tʃi] more often than [tʃi] changes to [ki]. In laboratory speech perception experiments, many of the same asymmetrical relationships hold, so Chang *et al.* attribute the patterns of sound change (and the resulting synchronic patterns) to the perceptual asymmetry. (13b) shows asymmetries in confusion of visual stimuli (as found by Gilmore, Hersh, Caramazza, and Griffin 1979).

(13) Asymmetries (from Chang, Plauché, and Ohala (2001:80)

(a) in sound change (and auditory confusion)

ki	>	tʃi	(e.g., Slavic, Indo-Iranian, Bantu)
pi	>	ti	(Czech dial. var: pĭ:vo [pʲiːvɔ] ~ [tiːvɔ] 'beer')
ku	>	pu	(PIE ekʷōs 'horse' Gk hippos)

(b) in visual confusion

E	>	F	Q	>	O
R	>	P	W	>	V

The visual asymmetries are attributable to the fact that the symbols on the left in each pair have an additional feature. Subjects are more likely to miss a feature that is present than to hallucinate one that is not there. Chang, Plauché, and Ohala argue that it is the same with the asymmetries in (13a). The CV sequence on the left in each pair has an auditory feature that the one on the right lacks. For example, Plauché, Delogu, and Ohala (1997) found that the stop burst in [ki] has a compact mid-frequency spectral peak (essentially F3), that is not observed in [ti]. Listeners are more likely to fail to hear the spectral peak than to imagine it when it is not there. Thus, these directional asymmetries of sound change can be explained in terms of the acoustic properties of the sounds themselves in a manner consistent with Ohala's (1981) model of the listener as a source of sound change, without recourse to distinct "markedness" effects, which are invoked in order to account for asymmetries and crosslinguistic tendencies in frameworks such as Optimality Theory.

In Optimality Theory (Prince and Smolensky 1993), specific phonological patterns emerge from the interaction of more general constraints. Optimality Theory (OT) treatments of consonant epenthesis assume that epenthetic consonants will be those which are least marked, i.e., those which are least disfavored by markedness constraints. Vaux (2002) shows that contrary to OT approaches which predict that only certain unmarked segments are likely to be epenthesized (e.g., some combination of [t], [ʔ], [n], [r], or [h]), a wide variety of epenthetic consonants are actually observed crosslinguistically, i.e., [ʔ], [h], [ɣ], [t], [d], [n], [ŋ], [r], [l], [j], [w], [v], [b], [ʃ], [ʒ], [g], [s/z], [x], and [k] (Vaux 2002:3). Many of these cases of epenthesis are accompanied or preceded historically by processes which delete the same segment. For example, [r] insertion in Boston English is accompanied by [r] deletion, and reanalysis of deletion as insertion has been argued to be its historic origin (Jones 1928). Vaux argues that processes such as these are synchronically arbitrary, and need not and should not be synchronically motivated:

> The primary problem for OT and AP [Articulatory Phonology] is that a grammar arises from the confrontation of the human language acquisition device with the arbitrary linguistic data to which it is exposed; since these data encode layers of historical change, the resulting phonological grammar will be 'unnatural' (Vaux 2002:1).

While the version of derivational phonology Vaux argues for focuses on the synchronic formalism which receives arbitrary phonological patterns from diachronic change, other models deal directly with the factors which produce these phonological patterns. Hume and Johnson (2001c) develop a model of the interplay between external factors and phonology. External forces such as perception, production, generalization, and conformity influence the cognitive representation of phonology, which may in turn influence the external factors. Production, perception, generalization, and conformity are filters on language change rather than components of the phonology. Similarly, Pierrehumbert (2003) argues that the effects of treating adaptive dispersion as a direct pressure on production can be obtained from diachronic change, in many cycles of the production-perception loop. See also Dolbey and Hansson (1999), Buckley (2000), and Blevins (2004).

The promise of such non-optimizing approaches to the emergence of linguistic patterns is increased by de Boer's (2000) computer simulation, which shows that characteristic tendencies of human vowel systems emerge as a result of nothing more than local interactions between agents who try to imitate each other's vowel systems while being subjected to constraints on perception, production, and learning. The types of optimization such as symmetry and perceptual distance which have been argued in teleological approaches to be deliberate, or to be a component of the synchronic grammar, emerge from unsupervised local interactions between agents which individually do no optimizing at all.

Accounts of phonological patterning which rely on diachronic explanation are generally stated in terms of likely paths of change. Consequently, it is difficult to rule anything out. However, it may not be realistic or particularly meaningful to divide phenomena into possible and impossible categories. Beddor (1991:102) observes that existing phonetic models of possible sound systems fail to predict the sound systems which occur:

> Of the models presented in the literature, neither those interpreted as generating default settings [e.g., Lindblom, 1983, 1986; Westbury and Keating, 1986] nor those viewed as imposing physical limits [e.g., Ohala, 1981, 1983] derive exceptionless predictions for phonological systems. It would appear that only constraints of the type ‘the human vocal mechanism cannot produce the sound X’ or ‘the human auditory system cannot differentiate between the sounds X and Y’ would yield such predictions. Yet to the extent that such constraints are known [see, e.g., Catford, 1977], they fall considerably short of characterizing the vowel or consonant space utilized by the world’s languages [Lindblom, 1983, 1990a; Ladefoged, 1985]

Beddor concludes that the predictive power of current models may be limited to claims that there is a greater than chance tendency that the constraints of a given model will be reflected in the world’s languages. This situation can be illustrated as in Figure 3.1 (following Hume 2002). Certain forms are predicted to occur with greater than chance frequency by models of speech production, and others are predicted to occur with greater than chance frequency by models of speech perception. Formal phonological theories attempt to capture as many attested phonological patterns as possible while rejecting as many unattested phonological patterns as possible.

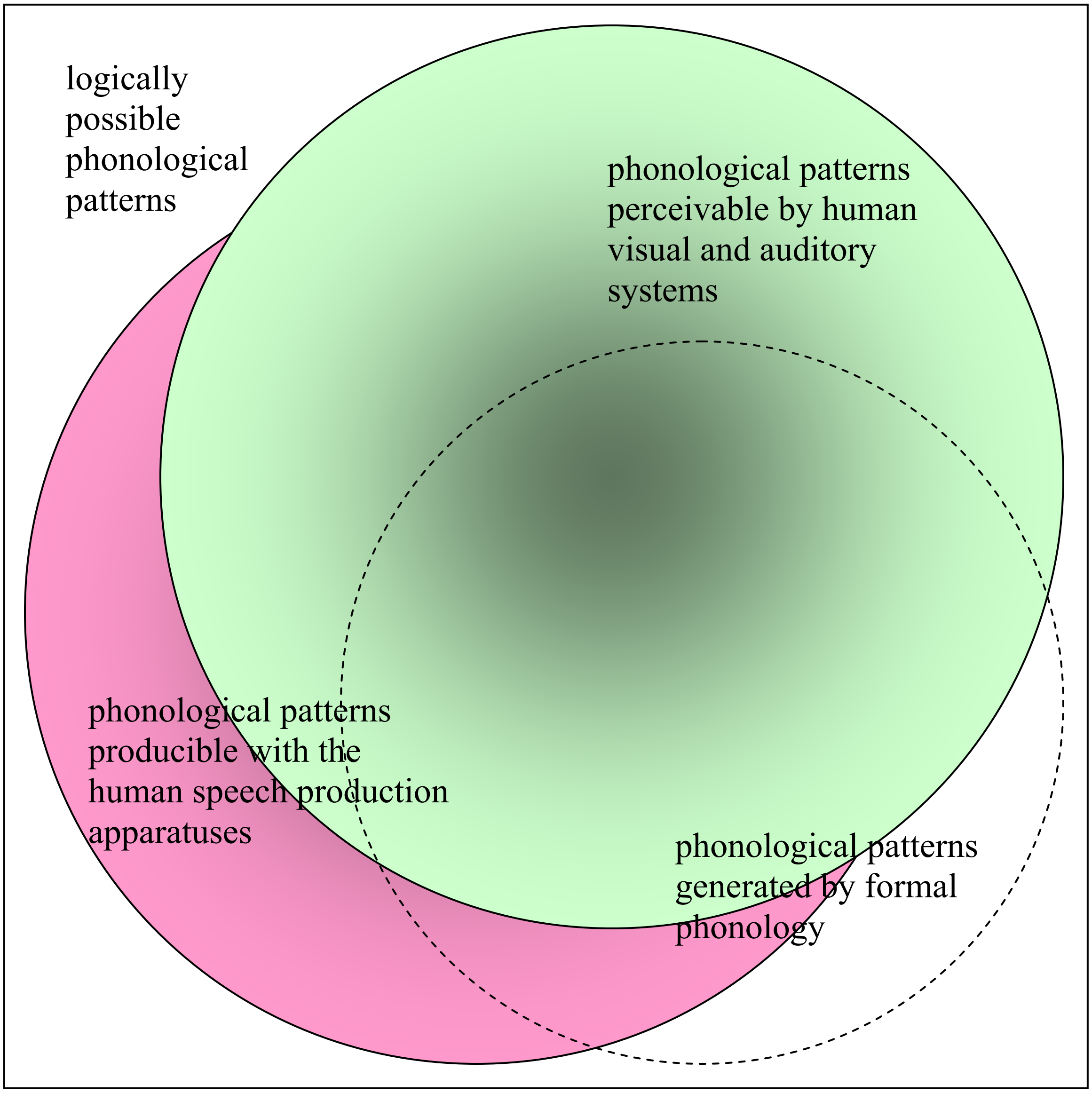


Figure 3.1. Phonological patterns expected to occur with greater than chance frequency

As seen in this section, non-teleological emergentist models seek to account for the preference for certain recurrent linguistic patterns in terms of many interacting forces acting upon languages. Contrary to teleological models, which are discussed in the next section, the language user is not claimed to be optimizing her language with respect to external factors, and contrary to innatist models, these patterns are not attributed to biological evolution.

3.2.2. Teleological models

Teleological models attribute optimization to the language user, contrary to the non-teleological emergentist accounts of linguistic structure. Lindblom proposes that speech sounds emerge from the interaction of phonetic variation and a selection mechanism, much like Darwinian evolution of biological organisms:

> The ontogeny of phonemic coding seems to be a case that clearly calls for a self-organizing model since children proceed from holistic vocalizations to adult segment-based speech as a result of circumstances that they have no direct conscious control over (Lindblom 1984:70).

Lindblom assumes the syllable as an axiomatically given primitive, justifying this by stating that it is simply a gesture starting from a closed configuration and ending in an open one. The theory states that the first syllable (maybe it will be [ba]) is chosen at random, and subsequent syllables are chosen so as be optimized with respect to performance constraints. The performance constraints Lindblom envisions are along the lines of maximizing contrast and minimizing effort, and as expected, computer simulations with these constraints converge on what appear to be segments. A growing inventory of syllables begins with a small set of closed configurations that look like familiar consonants and a small set of open configurations that look like familiar vowels. It is linguistic analysis that generates discrete units such as segments and features (1984:75). As evidence that the notion of consonants and vowels can emerge from acoustic signals, Lindblom (1999) cites results from Kluender, Diehl, and Killeen (1987), who trained Japanese quail to peck when they heard syllables starting with /d/ but not when they heard syllables starting with /b/ and /g/. Although the quail were trained using a small set of vowels, they were able to generalize to syllables containing different vowels than the ones they were trained on.

Lindblom (1999:8) elaborates the performance constraints in terms of minimization of energy cost in opening and closing the jaw, and finds that the jaw movement which requires minimum effort, combined with phonation, would resemble [bababa], which resembles canonical babbling. Reuse of gestures (and thus the emergence of consonants and vowels) is promoted by a theory of memory storage which charges a higher cost for storing novel memories. It is more efficient to compose syllables that reuse components that are already used (this has many parallels with Clements' (2001, 2003) notion of feature economy).

The observations that synchronically unmotivated or "crazy" phonological patterns are problematic for a synchronic notion of naturalness echo the arguments made by Bach and Harms (1972), who argue that the prevalence of natural or "plausible" rules results from naturalness constraints on the initiation of phonetic rules and that naturalness constraints are essentially diachronic, although they view these diachronic constraints as an "apparent historical striving toward more optimal segments [that] is most likely to find explanation as a consequence of some kind of marking theory…" (Bach and Harms 1972:18)

Bach and Harms argue that phonological systems may contain "crazy" rules because synchronic phonology does not have constraints on naturalness. The preference for natural rules is a result of the type of phonetic patterns which are available to be phonologized. However, their suggestion that this is a result of "marking theory" is at odds with other work on this topic, which argues that the processes of language acquisition and language change, rather than any substantive constraints, account for the observed array of natural and unnatural phonological patterns (e.g., Lass 1975, Blevins 2004, to appear)

Lindblom (2000 inter alia), like Martinet (1968), suggests that phonological units emerge from children's language processing, that children "initially explore their vocal resources in an energetically low-cost mode" and that "sound patterns have adapted to reward this behavior". Children are actively optimizing the movements they use to produce speech, in order to arrive at the most efficient gestures which sound like the adult pronunciation norms, which are already optimized as the result of being acquired repeatedly by generations of children. Lindblom draws on two means for accounting for the observation that phonological patterns tend to conform to some expectation of phonetic naturalness: (1) language learners are actively optimizing their language, and (2) languages are already quite optimized. These are essentially two sides of the same explanation, since optimization performed by an individual learner is assumed to be part of the reason why the adult norms are generally not in need of much optimization. This approach differs from Ohala's in two ways: first, it gives more importance to the role of the individual language learner, who would be expected to iron out accidental non-optimal patterns which may exist in the adult grammar, and second, the types of common language changes which are observed over time are attributed to active optimization by many generations rather than to arbitrary conventionalization of arbitrary phonetic variation over the course of many generations (Ohala 2003:20):

> Any of several aspects of language can be cited as showing some improvement due to a given change: the size of the phoneme inventory, the symmetry of the inventory (or lack of it), the phonotactics, the canonical shape of syllables, morphemes, or words, the opacity of morphologically related forms, the loss or addition of inflectional affixes, the structure of the lexicon, the functional load of certain elements, etc., etc. With so many 'degrees of freedom' to invoke, where is the rigor in finding some area of alleged improvement following a specific change? What is the null hypothesis which the improvement arguments are competing against? I suspect it is not possible to fail to find some feature which one can subjectively evaluate as an 'improvement' following a given sound change. But the lack of rigor in marshaling the evidence makes such accounts less interesting

Another teleological model of linguistic structure is the P-map (Steriade 2001, 2004) which is a model of the generic listener's perceptual abilities and biases. It is proposed in order to provide a synchronic explanation for directional asymmetries in phonological processes. For example, the generalization that disallowed biconsonantal clusters are more likely to be repaired by alteration of the postvocalic consonant than by alteration of the prevocalic consonant is explained first by the observation that this is generally a less perceptible change, and second by the claim that this perceptual knowledge is available to the speaker. The P-map is hypothesized to be psychologically real, and to be used by speakers to determine when articulatory simplifications can be made without the listener noticing a deviation from accepted norms of pronunciation.

Thus, knowledge of the perceptibility of contrasts is directly encoded in the phonology, i.e., rankings of correspondence constraints are indexed to the perceived similarity of the output differences they refer to. Similarity is crucial because the repair strategies which are most likely to go unnoticed by the listener are those which involve surface forms which are perceptually very similar to faithful forms.

The P-map hypothesis is firmly seated in a concept of phonology that is both explanatory and phonetically grounded. Specifically, it seeks to explain why the logically possible number of repair strategies that can apply in a given situation exceeds the number of attested repair strategies. This “Too-Many-Solutions” problem is solved, via perceptual metaconstraints, by restricting the possible rankings of correspondence constraints to those which are commonly observed. For example, to repair a prohibited sequence in a language which disallows word-final voiced stops, a variety of repair strategies are logically possible, such as devoicing, nasalization, lenition, deletion, vowel insertion, and metathesis, but only one, devoicing, is attested, according to Steriade, ostensibly because only minimal departures from UR are allowed, and devoicing is the least salient change.

The P-map is hypothesized to be computed from factors relevant to similarity, or else either deduced or induced from speaker’s observations of confusability rates, and the information contained in the P-map is translated into correspondence constraint rankings (Steriade 2004). For example, a perceptual basis is offered for the observation that unlike major place assimilation, apical (alveolar/retroflex) assimilation is usually progressive: changes in apical values are more noticeable in *postvocalic* position than in prevocalic position. In the P-map proposal, this perceptibility information is encoded in the phonology.

The knowledge contained in the P-map is translated into the correspondence constraint ranking. The constraints are ranked in order of increasing perceptual similarity of apical pairs in the contexts they refer to. The correspondence constraints relevant to consonant place assimilation are in a constraint ranking with an antagonistic markedness constraint, which prohibits heterorganic consonant clusters. Constraints that prohibit changing the apical specifications of stops in postvocalic and prevocalic positions receive their relative ranking from the P-map, and this, according to Steriade, is precisely why phonological systems reflect speech perception patterns.

In standard Optimality Theory (Prince and Smolensky 1993), the relative ranking of the two IDENT constraints is arbitrary. The thrust of the P-map proposal is that the constraint against changing postvocalic apical specifications will outrank the constraint against changing prevocalic apical specifications as long as retroflexion is more perceptible postvocalically than prevocalically. As a result, whenever apical assimilation occurs in clusters with alveolar and retroflex consonants, the prevocalic consonant changes, because this change is least perceptible.

Flemming (2002, etc.) similarly builds phonetics into the synchronic phonology, pitting constraints maximizing the perceptual distinctiveness of contrasts against constraints which maximize the number of contrasts. The result is an evenly-spaced segment inventory. This approach arrives at the same result as de Boer's (2000) simulation, but by incorporating perceptual and articulatory optimization directly into the synchronic grammar, whereas in de Boer's approach, dispersion emerges as the result of the interaction of non-optimizing agents. This is a good illustration of how teleological and non-teleological models are often very similar except for their stance on optimization.

3.3. Discussion

There are a wide variety of models which are designed to account for phonological patterns. From among the formalist and functionalist accounts, and the innatist and emergentist accounts (of teleological and non-teleological varieties), it is not necessary to choose just one. The idea that a single monolithic theory will account for everything is also an assumption rather than a conclusion. For example, Pinker (1999:118) discusses the advantages and disadvantages of Chomsky and Halle's generative phonology and Rumelhart and McClelland's (1986) connectionist model in handling the English past tense system, and concludes that a hybrid model is best. Pinker and Prince (1994) argue that regular verb morphology is best handled with rules, while irregular verb morphology is best handled by analogy.

Pursuing an approach in which morphology is separated into a rule- (and maybe Universal Grammar-) governed component and a component that is composed of memorized items results in a model of the language faculty in which a component which by many accounts is atomic (e.g. morphology) is divided into two different types of processing, only one of which may depend on Universal Grammar. Taking this a step further, we can imagine a scenario in which phonology is like irregular morphology, and not governed by Universal Grammar, while regular morphology and syntax may be best accounted for with UG. Heavy influence of UG in one part of the grammar does not entail influence in another part. As we have seen, most of the evidence for Universal Grammar comes from areas other than phonology, and even if UG *is* necessary to account for some properties of language, it is not necessarily playing a role in all properties.

Suppose that language is like the hand. The hand has four fingers and a thumb, units that are superficially independent and distinct. Possible constituents appear to be the hand itself and perhaps the four fingers together. Neurologically, the picture is slightly different: The median nerve serves the thumb, index finger, middle finger, and the side of the ring finger closest to the middle finger (Figures 3.2 and 3.3), while the ulnar nerve serves the little finger and the side of the ring finger closest to the little finger. The hand is a unit, but in at least one respect, it is divided. Incidentally, if distinctive features are innate, and signed language Feature Geometry models which incorporate these neurological facts are correct, then these neurological facts are in the phonological component of Universal Grammar….

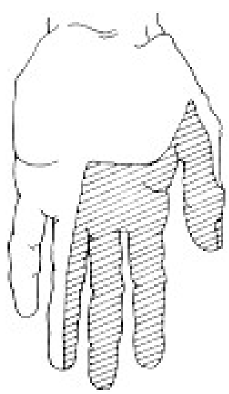


Figure 3.2. Parts of the hand served by the median nerve (Pestronk 2004)

The ring finger, which on the surface appears autonomous and distinct, is also divided. Where the ulnar nerve crosses the elbow is known as the funny bone. Hitting it against something makes the neurological division of labor apparent in the same way as when brain lesions impair some aspect of linguistic competence (regular morphology, perhaps) and leave another (e.g., irregular morphology) intact.

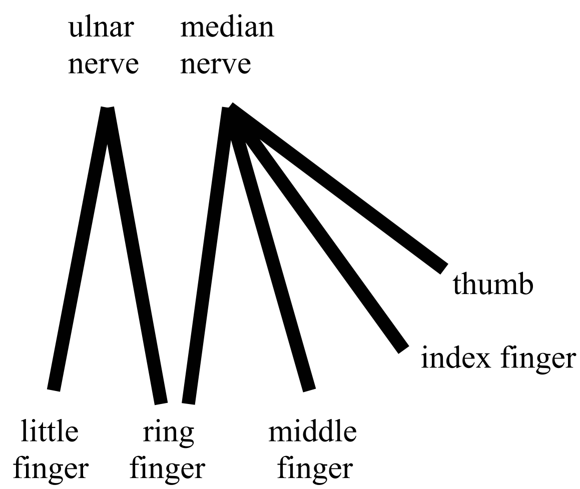


Figure 3.3. How the hand is wired

Just as the hand, a superficially unified entity, is divided below the surface, language could be divided between parts that are more or less relevant to Universal Grammar, as in the hypothetical illustration in Figure 3.4.

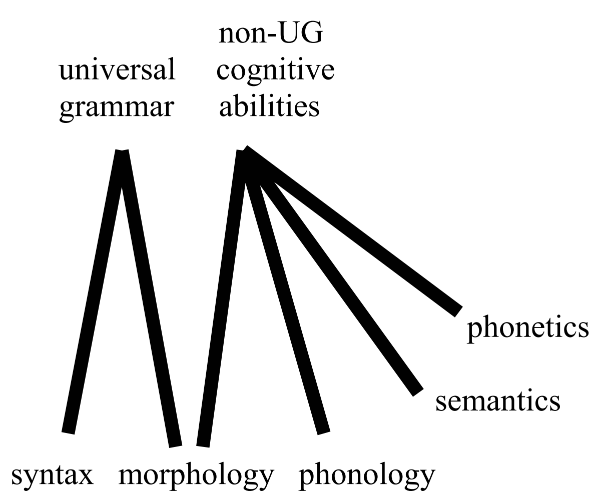


Figure 3.4. How language could be wired

If the part of language that is governed by Universal Grammar does not include phonology, or does not include significant parts of phonology, the phonological phenomena which have traditionally been explained in terms of a set of distinctive features specified by Universal Grammar are still interesting, but call for a different explanation. It is therefore worthwhile to consider alternatives that do not assume a universal set of distinctive features, and see how far such an approach can go. Lindblom (1984:78) writes:

> Claiming that language is special as Ladefoged and Chomsky do prejudges the issue. For any given phenomenon, it should be preceded by an exhaustive search for preadaptations. Before giving up that search and joining the 'formalist' camp we should make sure that, for example, we have not underestimated the structure-forming power of principles operating in the *self-organizing systems* subserving language. Although clearly untrue (e.g. speciation) the formulation of Linnaeus remains an efficient null hypothesis of biological inquiry: *Natura non facit saltum*[2].

And so, considering the long-standing assumption that universal distinctive features explain phonological patterns, and given the evidence that this is at least not totally the right answer, and while remaining agnostic with respect to the role of Universal Grammar in other domains of linguistic competence, it is a worthwhile pursuit to consider the extent to which phonological patterns can be explained in terms of self-organizing systems rather than innate systems, as summarized by Bybee (1998:235):

> The moral to this story is that cross-linguistic generalizations are observations that we can make about language but they are not necessarily the same as the innate cognitive system that is used for language. Some universals come from phonetic factors, others arise because of the external context in which language is used, others from cognitive and perceptual factors that are independent of language. Only if language is viewed in the more general context of real usage by real language users will it become clear how to describe and explain crosslinguistic patterns.

[2] "Nature doesn't make a jump."

This chapter has addressed some of the arguments for and against Universal Grammar and phonology's involvement in it, and surveyed some of the models which do not rely heavily on Universal Grammar. The next chapter introduces one such model, Emergent Feature Theory.

CHAPTER 4

EMERGENT FEATURE THEORY

This chapter proposes Emergent Feature Theory, which is intended to account for crosslinguistic generalizations about phonological patterns without assuming innate features. Phonetically defined features are one way to describe classes of phonetically similar segments, but there are other ways to describe such classes and to predict common and rare ones. As will be shown, by exploiting factors such as phonetic similarity and the nature of sound change, Emergent Feature Theory can account for data that is beyond the reach of innate features.

In Emergent Feature Theory, features emerge from phonological patterns rather than the other way around. This is illustrated in Figure 4.1. Instead of being grounded directly in phonetics, the features reflect phonetics *via* phonetically-grounded phonological patterns they are motivated by. This is consistent with exemplar models in phonological categories emerge from the phonetics through experience (see Pierrehumbert 2003). The phonological patterns result not from features, but from various external factors which influence language over time. Both of these approaches posit relationships between phonetic substance, abstract features, and the phonological patterns found in human languages. The difference lies in the nature of these relationships. For innate features (Figure 4.1a), abstract features are grounded directly in phonetics, and phonological patterns reflect both the features and the phonetic substance because features are the building blocks of phonological patterns. The relationship between phonological patterns and phonetics (bypassing features) is less direct, but necessary in order to provide the phonetic or historical accounts for "idiosyncratic" phenomena which are difficult or impossible to analyze with features.

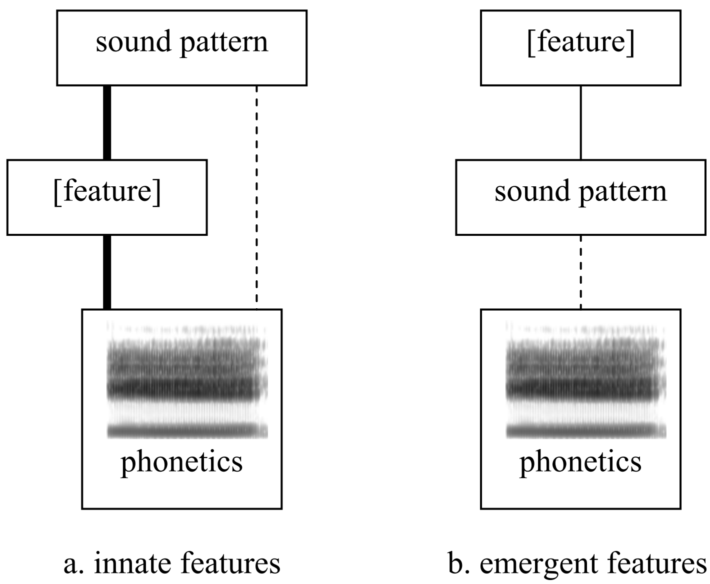


Figure 4.1. Relationships between phonetics, features, and phonological patterns

For emergent features (Figure 4.1b), this loose relationship between phonetics and phonological patterns is the sole connection between phonological patterns and phonetic tendencies. Just as phonetics (and other grammar-external factors) can be used to account for idiosyncratic phenomena in an approach which otherwise depends on innate features, phonetics can account for these unusual phonological patterns, and *also* for more common ones, which also tend to reflect more common phonetic tendencies. In this way, Emergent Feature Theory employs a single mechanism to account for common and rare phonological patterns, in contrast with innate feature theory, which requires two. Features are abstract generalizations made by language learners on the basis of the phonological patterns found in the language they are learning. As will be seen below, this abstraction facilitates analogical change.

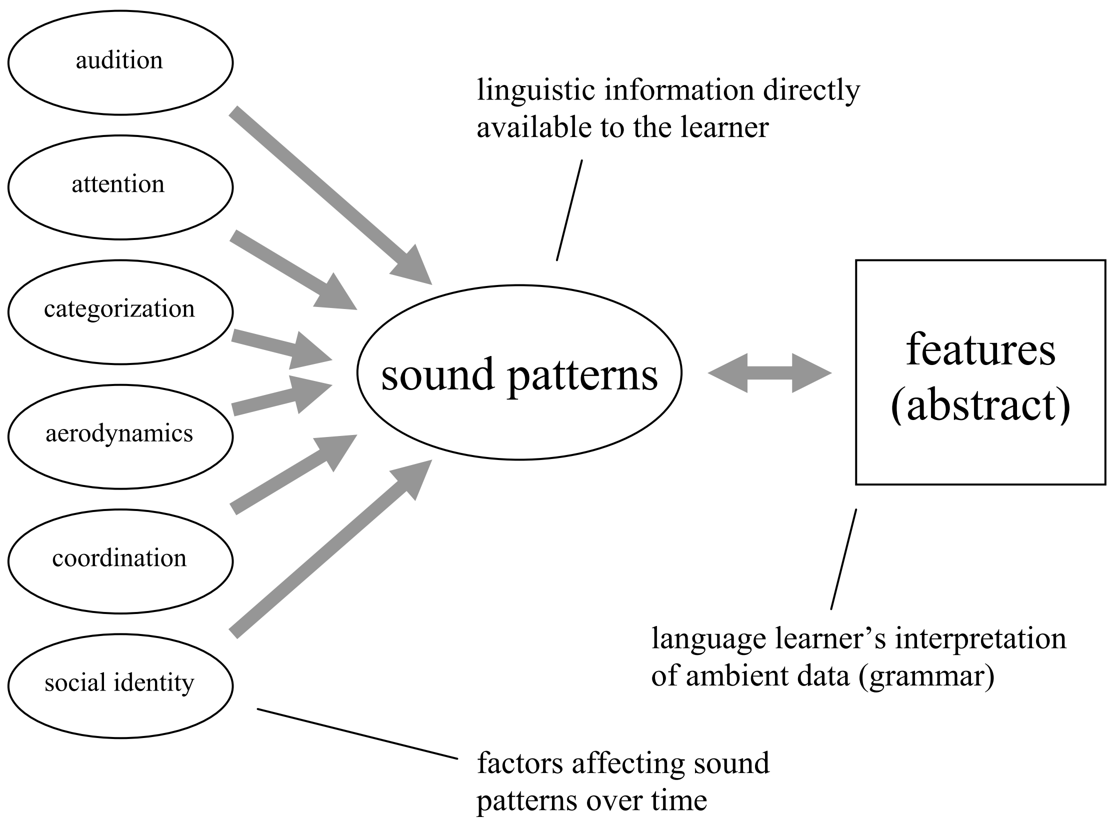


Figure 4.2. Abstract features from concrete external factors

A more detailed view of the relationship between features, phonological patterns, and external factors is given in Figure 4.2. The environment in which language is used includes the anatomy used to produce and perceive speech, the laws of physics they are governed by, the social context in which language is used, and the cognitive mechanisms employed in learning and using language. These factors contribute to the development of the phonological patterns found in language, making some patterns more common than others. The role of speech production and perception is not to be interpreted as simply ease of articulation and ease of perception, but as the physiological and cognitive realities in which language exists. The six factors audition, attention, categorization, aerodynamics, coordination, and social identity will be discussed in more detail in chapter 8, in a more general model of the emergence of linguistic structure.

The phonological patterns which exist in a particular language are internalized by speakers in terms of features which are necessary to describe them, rather than in terms of predetermined innate features. Using language and abstracting from the available data necessarily involves all of the factors pictured on the left, and the process of abstraction may cause the output of the learner's grammar to differ from the ambient language, which is why the arrow between abstract features and phonological patterns is bidirectional. This relationship may be viewed as an instance of the relationship between phonological patterns and external factors depicted on the left side of the figure.

4.1. A typographical metaphor for change with external pressures

It should be emphasized that the influence of production, perception, and other factors is not simply a matter of ease of articulation or ease of perception. These external factors do not represent pressure phonology to be more optimal or more natural, but the reality of what kinds of perception and production errors and what kind of variability tends to occur under the circumstances in which language is used, and what types of errors and variability are most likely to become conventionalized. Consider the following typographical metaphor.

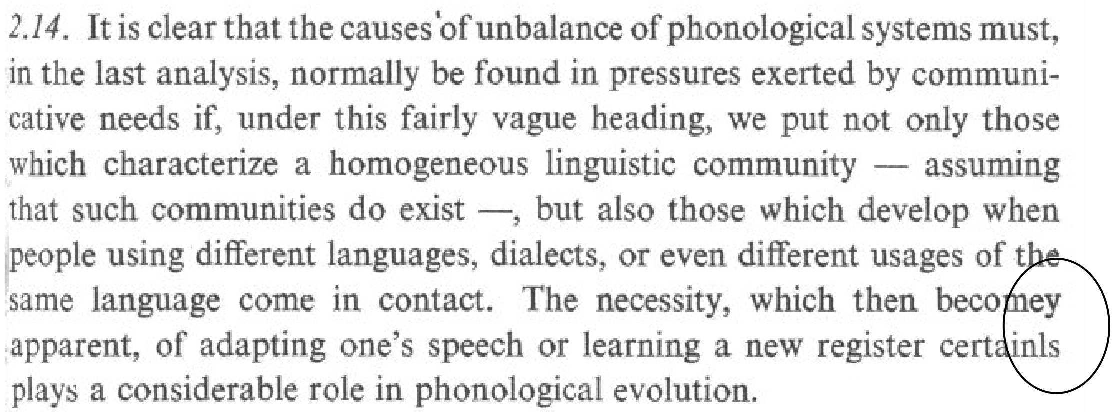
Due to the layout of the qwerty keyboard, some typographical errors are more likely than others. <d> is more likely to be mistyped as <e>, <r>, <s>, <f>, <x>, or <c> than as a letter it does not neighbor. Acknowledging the role of the layout of the keyboard (or vocal tract) in what types of deviations from a target are most likely does not amount to saying that the result of these errors are more natural or optimal than the intended target, <d>. In speech production, [d] has a different set of neighbors, including [n], [t], and [ɾ]. [d] would naturally be expected to be accidentally realized as one of them more frequently than as an articulatorily more distant segment such as [ɣ].

While <d> has six equally distant neighbors on the keyboard, the six errors are not equally likely to be committed without being noticed. Of the following six ways to mistype <noticed>, (14c) has a distinct advantage in going unnoticed:

(14) Some easy ways to mistype <noticed>
 a. noticee
 b. noticer
 c. notices
 d. noticef
 e. noticex
 f. noticec

<notices> is the only error in (14) which can pass a spell check, and consequently it is more likely to persist in a document than the other errors, and possibly more likely to be typed in error, because it is a word in English. Similarly, a production error which results in an actual word may be more likely to go unnoticed and to become conventionalized.

Although it is hard to predict when a typing error will be committed, considering the layout of the keyboard and the content of the spell checker makes it possible to predict which deviations from the target are likely to occur, and which of those are likely to persist. Taking into account the reality in which typing (or language use) occurs does not require any sense of optimization or naturalness in order to be useful. A different reality, which could involve a different keyboard layout or a different modality or language system, would make different predictions. Consider the following typographical error on page 475 of Martinet's (1968) article in Manual of Phonetics (Malmberg 1968) (Figure 4.3).



2.14. It is clear that the causes of unbalance of phonological systems must, in the last analysis, normally be found in pressures exerted by communicative needs if, under this fairly vague heading, we put not only those which characterize a homogeneous linguistic community — assuming that such communities do exist —, but also those which develop when people using different languages, dialects, or even different usages of the same language come in contact. The necessity, which then becomey apparent, of adapting one's speech or learning a new register certainls plays a considerable role in phonological evolution.

Figure 4.3. Typographical error from a different reality

This type of error (substitution of <y> for <s> and <s> for <y> on different lines) would appear to be a random coincidence if this were the output of word processing software, where there is no single mechanism by which this transposition could occur. It is surprising both for the coincidence of the complementarity of the errors and for the failure of a spell checker to catch these two nonwords. In the alternate reality of typesetting, this error is not surprising, given the opportunity for two letters at the edge of a page to get knocked out and then accidentally switched as they are replaced.

If the goal is to understand why certain phonological patterns exist and why some are more common than others, it makes quite a lot of sense to consider the reality in which language is used. This enables us to determine which observations are explainable on the basis of external factors, before adding hypothetical new components to the reality (such as innate features) in order to explain the same observations. The following sections discuss some of the factors which lead to phonological patterns from which many familiar types of features may emerge. We will return to the specific factors illustrated in Figure 4.2 in chapter 8.

4.2. Relevant factors for phonologically active class formation

There are many ways in which recurrent phonologically active classes may be predicted. As outlined below, members of phonologically active classes may be related by their participation together in regular sound change, or they may be related by generalization, by virtue of shared phonetic or non-phonetic properties. Social differences between societies may also play a role in determining what classes are likely, as may cognitive factors such as those claimed to be part of Universal Grammar. The extent to which language-specific cognitive categories of sounds are necessary to predict phonologically active classes depends on what predictions can be made on the basis of other factors.

4.2.1. Sound change

Some recurrent phonologically active classes can be accounted for directly from sound change, as some types of recurrent sound change may affect multiple segments from the very beginning. These cases would occur when a phonetic effect is widespread before it becomes phonologized. For example, vowel nasalization can affect all vowels at once, if every vowel is phonetically nasalized and allophonic nasalization is reinterpreted as contrastive. A resulting alternation would affect all vowels by virtue of the fact that they were the segments which were phonetically nasalized before nasalization became phonologized. It would also likely involve all nasals consonants, if they were the only segments capable of inducing substantial phonetic nasalization in vowels. Thus, the phonological pattern that results would refer to the natural class of vowels and the natural class of nasals, in line with an observation made by Janda (2001:305):

> It could thus be said that sound-change tends to be regular, not due to persistent influence from some kind of articulatory or auditory/acoustic phonetic naturalness, but instead because exaggerations and misperceptions of phonetic tendencies tend to involve stepwise generalizations based on the natural classes of phonology (i.e., … coronals, nasals, obstruents, and the like).

While the phonological patterns that result from phonetic tendencies (such as vowel nasalization) can certainly be described using features such as [vocalic], [consonantal], and [nasal], this is simply a description. Treating the features as the explanation obscures the chain of events which led to the creation of the phonological patterns.

Other types of sound change which may affect multiple segments at once include final devoicing (results seen in Russian, German, Turkish, etc.) and postnasal voicing (results seen in Greek, many Bantu languages, etc.). In both cases, by the time phonetic voicing or devoicing is reinterpreted as a phonological distinction, several segments are already affected—voiced obstruents or voiced consonants generally are devoiced in the former case, and voiceless obstruents are voiced in the latter. The results of these changes could be described using features such as [voice] and [sonorant], but again, the features themselves do not account for the sound change. The sound change allows for the descriptive use of the features.

All of these types of sound change are fairly common, and the classes of segments which participate in the resulting alternations are fairly common phonologically active classes. Not surprisingly, the features used to describe them are also fairly commonly-used features. Just by looking at a few common types of sound change, it is apparent that some common classes and features emerge readily as the result of sound change.

While there is reason to speculate that these types of sound change could involve multiple segments right from the start, there is no way to know for sure what happened at the inception of each change. An alternative chain of events which produces the same result is one in which a phonetic tendency initially was phonologized for only a single segment, and then spread analogically to other segments. For example, when vowels are phonetically nasalized, lower vowels tend to be nasalized more profoundly than higher vowels, since tongue lowering facilitates velum lowering due to their connection via the palatoglossus muscle (Johnson 1997, Moll 1962, Lubker 1968). Phonemic vowel nasalization in Old French has been claimed (not uncontroversially) to have started with /a/ around the turn of the 11^{th} century and spread essentially one vowel at a time to ultimately affect /a e aj ej o oj i u/ in the 14^{th} century (Chen 1973, see Hajek 1997 for discussion). If it is true that all vowel nasalization starts with one segment rather than a wide range, it is not difficult to see how it could then spread very easily to include all vowels, if the other vowels share the phonetic property (nasalization) that has been phonologized, even if it is to a lesser degree.

Sound changes that appear to affect multiple phonetically similar segments constitute one source for emergent classes and features. If it can be shown that these changes all begin with one segment and spread to others, this is not a problem for the theory. In each case, the phonetic property that is phonologized in one segment is robustly present in other segments, making generalization to the larger class a straightforward process. Whether classes and features emerge from multi-segment sound change or from single-segment sound change followed by generalization, it is clear that common sound changes are a plentiful source for the features and classes of synchronic phonology, without reference to an innate feature set.

As described thus far, generalization of a phonological pattern involves segments sharing a phonetic property that was fundamental to the initial sound change. In the next section, we will see examples in which shared phonetic properties form the basis for generalization, even though the properties were not relevant for the original sound change.

It is very difficult to know exactly what happened at the initiation of a sound change. Depending on one's comfort level with sound change effecting multiple segments from the start, generalization may or may not be required to produce the phonologically active classes resulting from common sound changes such as vowel nasalization, postnasal voicing, and final devoicing. If generalization does play a role, then these are special cases of a more general situation in which the result of sound change is extended to similar segments. While the similarity is closely tied to the original change in cases like vowel nasalization, there are other cases where a change is generalized according to a completely independent phonetic property.

4.2.2. Phonetically-based generalization

As it is used in this dissertation, generalization is a process by which two or more entities which share certain properties are treated as equivalent in some way. One way for phonologically active classes to form is for a set of speech sounds which share a phonetic property to be treated as though they are phonologically similar, even if there is not direct phonological evidence in the ambient language, or if the sounds have other phonetic properties which differ.

A hypothetical illustration of the role of generalization in the development of a phonologically active class is shown in Figure 4.4. Given evidence that [g] undergoes a phonological process (perhaps spirantization) and that voiceless stops do not, and no clear evidence either way about [b] or [d] (perhaps because they are infrequent segments), a language learner may learn or mislearn this pattern in various ways. She could treat all stops the same, and reverse the spirantization process (Figure 4.4a), given that the majority of stops do not exhibit phonetic spirantization, or she could infer that spirantization applies only to segments produced with closure voicing and a constriction between the tongue and velum ([g]) (Figure 4.4b), or that it applies to any stop produced with closure voicing (Figure 4.4c). Closure voicing and velar constriction both involve sets of phonetic properties which are recognizable by speakers with or without a cognitive entity [+voice]. The result of the latter case (generalization to other voiced stops) is the 'natural' class of voiced stops. The outcomes illustrated in Figure 4.4 may be expected to be the most likely, but if the generalization were to occur slightly differently, the result might be termed an 'unnatural' class. In this dissertation, it is been proposed that phonetically natural classes are the result of common phonetically-based generalizations, while phonetically unnatural classes are the result of less common generalizations or sequences of evence.

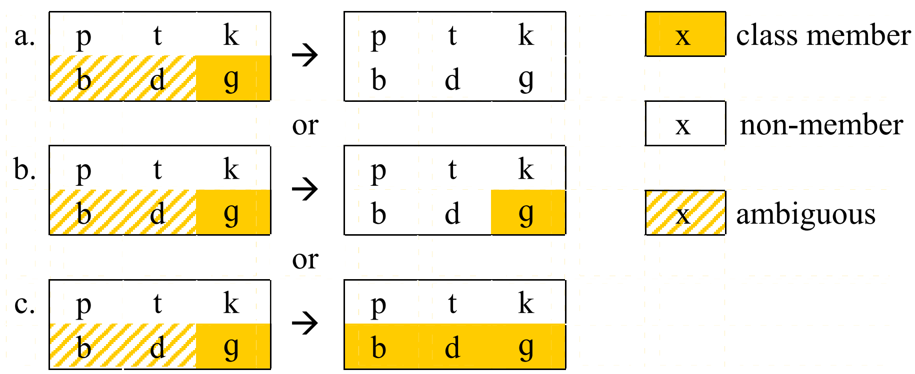


Figure 4.4. Generalization of a phonetic effect

The process of linguistic generalization is also seen in cases such as the way different speech communities have generalized the use of the English verbal inflectional suffix *-s*, as shown in Figure 4.5. It is a 3rd person present singular marker in most varieties Indian, British, and American English, a present singular marker in some varieties of Northern British English, (Pyles and Algeo 1993) and absent from some varieties of African-American Vernacular English (Green 1998). In both of the innovative cases, the presence or absence of the suffix corresponds to semantically-coherent sets of person-number combinations. The absence of the suffix in AAVE may be an undergeneralization or may also be attributed entirely or in part to phonological loss.

I digitize.	We digitize.
You digitize.	You digitize.
She digitizes.	They digitize.

Many English varieties

I digitizes.	We digitize.
You digitizes.	You digitize.
She digitizes.	They digitize.

Some varieties of Northern British English

I digitize.	We digitize.
You digitize.	Y'all digitize.
She digitize.	They digitize.

Some varieties of AAVE

Figure 4.5. Generalization in English morphology

The three hypothetical outcomes above in Figure 4.4 are analogous to the three English –s suffix examples here, only here it is semantically similar person-number combinations, rather than phonetically similar consonants, which are being treated similarly.

Beyond its role in linguistics, generalization is a general cognitive process which is widely-attested in other domains. Generalization occurs when an individual infers a class from available positive evidence. In their work on memory phenomena and principles, Spear and Riccio (1987:152) describe generalization as "a fundamental and very robust learning phenomenon":

> Basically, generalization refers to the tendency of subjects (human and animal) that have been conditioned to one stimulus to respond to new stimuli which are similar to the training stimulus. Generally speaking, the strength or probability of responding decreases as the novel stimuli become more dissimilar to the original. In effect, stimulus generalization means that subjects will respond to stimuli to which they have never been trained, albeit less to these stimuli than to the training stimulus.

Further, generalization is a necessary adaptive strategy (Spear and Riccio 1987:153):

> In most instances stimulus generalization is adaptive for an organism. Just as we 'never step into the same river twice,' stimuli are seldom exactly the same from moment to moment. If generalization did not occur, every perceptibly different variation on a stimulus theme would constitute a new situation requiring further conditioning to acquire new properties. Generalization permits responding to occur despite 'slop' in the stimulus situation; learning transfers to related stimuli.

Phonetically-based generalization (phonetic analogy) is an old and well-documented concept in linguistics, its modern exponents including Vennemann (1972), Andersen (1972, 1973), Anttila (1977, 2003), and Hock (2003). Analogical change (e.g. proportional analogy and paradigm leveling) depends on the cognitive process of generalization, and has been central to diachronic linguistics since the Neogrammarians (e.g. Whitney 1867, 1875, Scherer 1868). Whitney writes that "[t]he force of analogy is, in fact, one of the most potent in all language-history; as it makes whole classes of forms, so it has power to change their limits" (Whitney 1875 (p. 75 of 1887 ed., cited in Anttila and Brewer 1977). In their bibliography of analogy, Anttila and Brewer (1977) trace the study of analogy to pre-Neogrammarian times, starting with Duponceau in 1816.

Analogy has had a stormy relationship with phonological theory, having been rejected (e.g. Kiparsky 1965) and ignored (various) by practitioners of Generative Grammar. Part of the reason why phonetic generalization has not played a role in Generative Phonology is that generalizations about sounds are intended to be provided by innate features, so that there is no role for analogical reasoning in accounting for patterns in synchronic and diachronic phonology. In recent times, analogy has been accepted back into the study of phonology, in Correspondence Theory (McCarthy and Prince 1995), Paradigm Uniformity (Steriade 1997), and other approaches.

Generalization is also invoked in the phonological learning algorithms of Clements (2001) and Dresher (e.g., 2003). Hume and Johnson (2001c) include it as one of four diachronic filters on phonological systems. According to Hume and Johnson, phonological systems are constantly filtered by external forces, and this can result in the filtering out or alteration of forms which are difficult to produce or perceive, which are not used by members of a speakers community or which do not fit an existing or apparent generalization over the available phonological data.

Generalization is necessary for the ability of learners to acquire phonology at all, but it yields particularly interesting results when a language learner arrives at the 'wrong' generalization, by forming an undergeneralization or overgeneralization of the prevailing pattern. In addition to an overwhelming number of correct generalizations, undergeneralizations and overgeneralizations are commonly observed in language-learning children (e.g. Vihman 1996, Pinker 1994 and references cited). The "wrong" generalization becomes *right* if it catches on and spreads.

One place where the role of generalization in forming new phonologically active classes can be observed is in differences between dialects. In Tigrinya (Pam 1973:16), noncoronal stops spirantize intervocalically, as shown in (15). Pam (1973) reports that while Leslau (1941) found that spirantization was limited to velars (no data is given on glottal stop), his informants have generalized the target class to include bilabials as well, i.e., it is now the class of grave stops. This is a good illustration of the role of generalization to phonetically similar segments (acoustically similar, in this case) as a source of phonologically active classes.

(15) Tigrinya spirantization

a. Noncoronal nonlabial stops spirantize in both varieties

[kʌlbíː]	‘dog (sg.)’	[ʔaxaːlɨbtíː]	‘dog (pl.)’
[gʌnʔíː]	‘pitcher (sg.)’	[ʔaɣaːnɨʔ]	‘pitcher (pl.)’

b. Labial stops spirantize in one variety

[ʔádːiːs ʔábʌbʌ]	‘Addis Ababa’ (Leslau 1941)
[ʔádːiːs ʔáβʌβʌ]	‘Addis Ababa’ (Pam 1973)

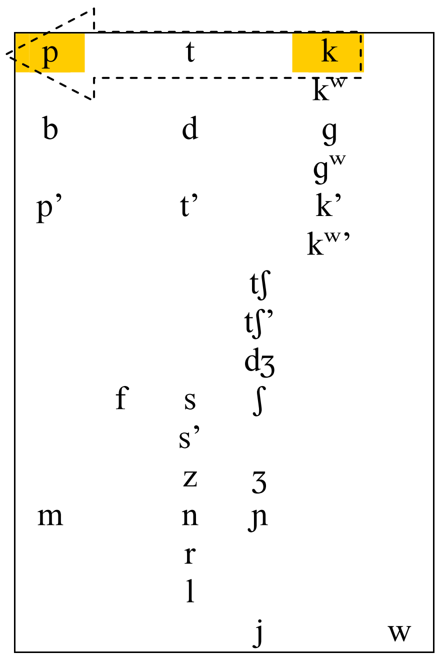


Figure 4.6. A phonologically active class in Tigrinya (circa 1973)

Another clear example is /o/ lowering in northeastern varieties of Swiss German. As reconstructed, the original sound change only involved one conditioning segment, but as seen in variation among modern Swiss German varieties, different sets of consonants which do not cause phonetic lowering now condition lowering phonologically in different varieties. In northeastern Swiss German, /o/ is lowered to [ɔ] before certain consonants (Keel 1982). In and around the city of Schaffhausen, four different versions of /o/ lowering are observed, in which different classes of sounds condition lowering. Some of this variation is illustrated in (16). /o/ lowering originally occurred only before /r/, but it has been generalized differently in different communities (Keel 1982, Janda and Joseph 2001), as shown in Figure 4.7.

(16) Schaffhausen /o/ lowering

a. /o/ is lowered before /r/ throughout Schaffhausen

[bɔrə]	'to bore'
[fɔrə]	'fir tree'
[hɔrn]	'horn'
[tɔrn]	'thorn'
[kwɔrffə]	'thrown. pp.'
[ʃpɔrə]	'spur'

b. /o/ is lowered before coronal obstruents elsewhere in the canton, but not in the city of Schaffhausen itself

Cantonal dialects	City of Schaffhausen	
[ʃtɔtsə]	[ʃtotsə]	'to push down'
[lɔsə]	[losə]	'to listen'
[rɔss]	[ross]	'horse'
[xrɔttə]	[xrottə]	'toad'
[gɔt]	[got]	'god'
[ʃnɔdərə]	[ʃnodərə]	'to stir, pp.'
[pɔttə]	[pottə]	'offered, pp.'
[ksɔttə]	[ksottə]	'boiled, pp.'
[tnɔssə]	[tnossə]	'enjoyed, pp.'
[kʃɔssə]	[kʃossə]	'shot, pp.'

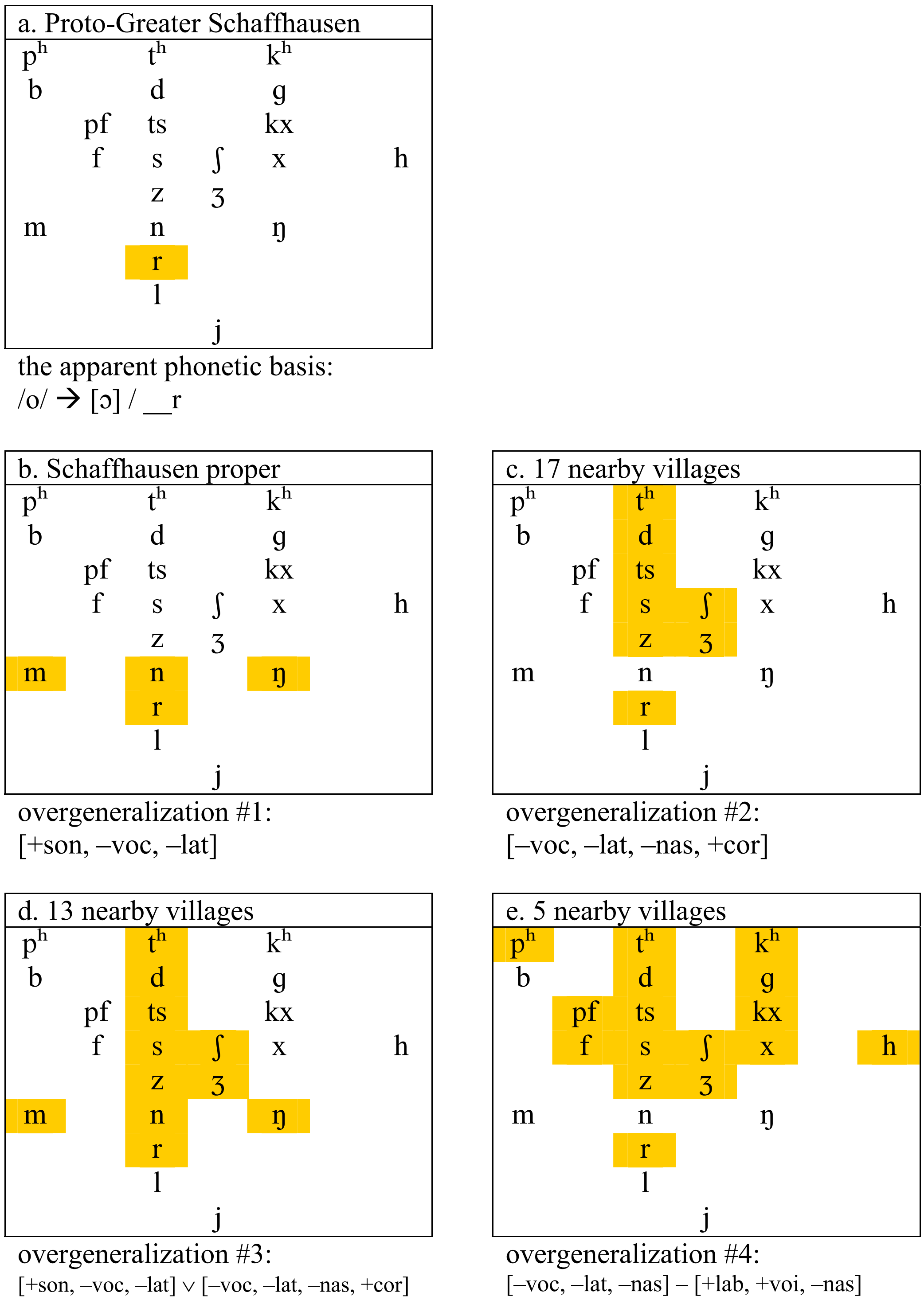


Figure 4.7. Generalization of the conditioning environment for a sound pattern in Schaffhausen Swiss German

In the city of Schaffhausen, the conditioning environment for lowering has been generalized to include nasals (i.e., other nonlateral sonorants) (Figure 4.7b), while in 17 nearby villages, the environments have been generalized to include other nonnasal, nonlateral coronal consonants (Figure 4.7c). In 13 other villages, the generalization includes nasals and coronal obstruents (i.e., segments which are similar to /r/ in one of two ways: sonorance and coronality) (Figure 4.7d). In five villages, the conditioning environment has generalized to include all obstruents except /b/ (Figure 4.7e) (see Janda and Joseph 2001, Janda 2003). /b/ is less similar to /r/ in some ways than most of the segments which *do* participate, e.g., most of them are lingual consonants. On the other hand, /b/ is certainly more similar to /r/ than /p^h/ is, but it is similarity to the segments already participating which is relevant, not just similarity to /r/. Because generalization from /r/ likely occurred in more than one step, similarity to /r/ would have been most critical only at the stage before other segments began participating. Perhaps the development of the class in Figure 4.7e involved an intermediate stage where the class was /r/ and lingual obstruents, and this was futher extended to other fricatives and affricates, including /pf f/. Since there are no voiced labiodentals in the language, /p^h/ is more similar to the participating segments than /b/ is at this hypothetical stage. /b/ is also rather similar to /m/, another segment which does not cause /o/ lowering.

The last two generalizations resulted in classes which are not characterizable with a conjunction of distinctive features. The overgeneralization in (Figure 4.7d) require the union of natural classes, while (Figure 4.7e) requires subtracting one class from another, or else the union of a larger number of classes. This suggests that speakers simply learn the set of environments where /o/ lowering occurs in the speech of members of their community, regardless of whether or not the set of environments is expressible as a conjunction of distinctive features within any particular theory.

Cases like Schaffhausen /o/-lowering differ from the examples in the previous section in that phonologically active classes are produced by a generalization unrelated to the initial motivation. Nonetheless, in both types of cases, phonetically similar segments take on similar phonological behavior. In multisegment sound change (or sound change + related generalization), the segments are united by a phonetic property that is at the heart of the resulting phonological patterns. In sound change + unrelated generalization, a phonological pattern is analogically extended to segments which are similar in some way that has nothing to do with the original phonetic motivation for the phonological pattern. While Schaffhausen /o/-lowering is conditioned by segments that do not necessarily share the property of /r/ which originally had the phonetic effect of lowering /o/, the extreme case is found in Zina Kotoko, where a class of depressor consonants appears to have been generalized to segments which have the *opposite* phonetic effect.

The classes of consonants involved in consonant-tone interactions tend to be similar across languages. Typically, voiced consonants act as depressors, lowering the tone of adjacent vowels, often from H to L (see e.g., Bradshaw 1999, for a survey of consonant-tone interaction and a formal account employing a single feature for voice and low tone). All known cases include at least voiced obstruents among the class of depressor consonants (Bradshaw 1999). This is consistent with the observation that voiced obstruents have a phonetic lowering effect on the F0 of a following vowel (Hyman and Schuh 1974), shown in Figure 4.8.

Lowering ◄				► *Raising*	
breathy voice	voiced obstruent	sonorant	voiceless unaspirated	voiceless aspirated	implosive

Figure 4.8. Hyman and Schuh's (1974) hierarchy of phonetic F0 lowering

Consonant-tone interactions arise when this phonetic lowering is reanalyzed as phonological tone. Sometimes sonorants also function as depressor consonants (in Nupe, Ngizim, Ewe, and Kanazawa Japanese) (Odden 2002a). This is not surprising considering that sonorants do lower F0, although not as much as voiced obstruents, and that voiced sonorants are phonetically similar (in voicing) to other voiced segments.

Zina Kotoko features a variety of tone-lowering processes, one of which occurs in the recent past verbal inflection. In this case, an underlying mid tone in the first syllable is realized as mid after [h] and voiceless obstruents (17), but lowered to low after voiced obstruents (18a), sonorants (18b), glottal stop (18c), and most interestingly, implosives (18d) (Odden 2002a,b).

(17) An underlying mid tone surfaces in the first syllable.

a.	hēr-ə́m	'bite'	hērtʃ-ə́m	'slice'
	hwāt-ə́m	'inflate'	hə̄l-ə́m	'steal'
b.	skāl-ə́m	'pay back'	sāp-ə́m	'chase'
	pāj-ə́m	'bury'	kāh-ə́m	'take a handful'
	kāɗ-ə́m	'cross'	sə̄k-ə́m	'send'
	tām-ə́m	'touch'	tʃə̄nh-ə́m	'be sated'

(18) An underlying mid tone surfaces as low after a depressor consonant.

a.	ɣàg-ə́m	‘close’	gàh-ə́m	‘pour’
	zə̀gl-ə́m	‘carry’	bgwàr-ə́m	‘jump pl.’
	gə̀ɓ-ə́m	‘answer’	gə̀ɗ-ə́m	‘open’
	gùlm-ə́m	‘twist’	vàlf-ə́m	‘give back’
	dùnk-ə́m	‘throw’	zàk-ə́m	‘beat’
	vìt-ə́m	‘blow a fire’	dʒìk-ə́m	‘begin’
b.	jèj-ə́m	‘call’	wèh-ə́m	‘be tired’
	làb-ə́m	‘tell’	ràɗ-ə́m	‘pull’
	màr-ə́m	‘die’	làkf-ə́m	‘bring’
c.	ʔə̀kf-ə́m	‘approach’	ʔə̀k-ə́m	‘snatch’
d.	ɗə̀v-ə́m	‘put’	ɗə̀h-ə́m	‘write’
	ɓàl-ə́m	‘dance’	ɗàm-ə́m	‘eat’

It is of particular interest that implosives act as phonological depressors in Zina Kotoko, because implosives have the phonetic effect of *raising* F0. Like many other consonant-tone interactions, the phonetic basis for this phonological patterns probably was the F0 lowering caused by voiced obstruents (see e.g. Hombert, Ohala, and Ewan 1979). However, speakers apparently generalized this category along the phonetic dimension of *voicing* to include segments such as sonorants and implosives, even though F0 lowering, not vocal fold vibration, is the phonetic effect likely responsible for the phonological pattern in the first place. As in Schaffhausen Swiss German, groups of phonetically-similar segments participate together in phonological patterns, regardless of the original phonetic motivation. Discrete events can result in classes that may appear phonetically natural or unnatural, but children learn them regardless of their historical origins.

It should be clear at this point that shared phonetic properties may lead to shared phonological behavior, regardless of whether they are the phonetic properties fundamentally related to the original motivation for a phonological pattern. While it is not possible to predict when generalization will occur, when it does occur, there is a good change that it will involve segments which are similar to segments already in the class. For example, if the class /b d/ is extended to include one more segment, the inclusion of /g/ is more likely than the inclusion of /l/. Chapter 6 introduces a model of generalization which takes phonetic similarity into account in order to predict the most likely generalizations

4.2.3. Frequency

While all of the examples given above involve generalization according to phonetic properties, other properties may also lead to a particular group of sounds patterning together as a class. Nonphonetic properties such as phoneme frequency may also be relevant. For example, Hume (2004b) argues that high frequency is responsible for /m/ and /ŋ/ patterning together as a class, to the exclusion of /n/, in Sri Lankan Portuguese Creole. Sri Lankan Portuguese Creole (SLPC) has an assimilation pattern whereby the labial and velar nasals assimilate in place across morpheme (19a) and word boundaries (19c), while the coronal nasal does not (19b) (Smith 1978, Hume and Tserdanelis 2002).

(19) Place assimilation in Sri Lankan Portuguese Creole

	Nom. sg.	*Gen. sg.*	*Dative sg.*	*Verbal noun*	*gloss*
a.	ma:m	ma:nsu	ma:mpə	ma:ŋki-	‘hand’
	cf. [eli ma:m ebe:rtu]		‘he + hand open = He is a spendthrift’		
	va:rzim	va:rzinsu	va:rzimpə	va:rziŋki-	‘harvest’
	reza:m	reza:nsu	reza:mpə	reza:ŋki-	‘reason’
	mi:tiŋ	mi:tinsu	mi:timpə	mi:tiŋki-	‘meeting’
b.	silo:n	silo:n	silo:npə	silo:nki-	‘Sri Lanka’
	cf. [silo:n avara taantu defre:nsa teem] /silo:n avara…/ ‘Sri Lanka is now very different’				
	bataan	bataansu	bataanpə	bataanki-	‘button’
	si:n	si:nsu	si:npə	si:nki-	‘bell’
	tavn	tavnsu	tavnpə	tavnki-	‘town’
	kəlkun	kəlku:nsu	kəlku:npə	kəlku:nki-	‘turkey’

c. perim + təsuwa: [pərin təsuwa:] ‘me + sweat = I am sweating’
   cf. [perim uŋ ga:rfu ta:n tri:ja] /perim uŋ ga:rfu ta:m tri:ja/
   ‘me-DAT a fork also bring = Bring me a fork too’
   pikini:m + ka:zə [pikiniŋ ka:zə] ‘small + house = small house’
   reza:m + lej [reza:n lej] ‘reason + like = reasonably’
   uŋ + fa:kə [um fa:kə] ‘one knife’ cf. [uŋ a:nu] ‘one year’
   uŋ + di:j [un di:j] ‘one day’

Place assimilation is often treated as a diagnostic of markedness, with unmarked places of articulation undergoing assimilation to more marked places. The pattern of assimilation in SLPC is surprising, because coronals are generally treated as unmarked relative to labials and dorsals. Hume (2004b) reinterprets markedness observations in terms of expectation, which is based in part on frequency. Hume and Tserdanelis (2002) observe the labial is the most common nasal in SLPC, occurring in twice as many words as the coronal nasal. The velar nasal occurs finally in only three words, but one of these is the definite article /uŋ/ (Hume 2004b), which is a very frequent word. Thus, as Hume argues, it is the high token frequency of the labial and velar nasals which causes them to behave together as a phonologically active class. Further, the high frequency of coronal consonants can be invoked to account for cases where coronals act as though they are unmarked. For example, /t d/, which are frequently and famously flapped, deleted and otherwise altered in American English, are by far the most frequent consonants as well, occurring in 40% of all words in the Buckeye corpus of conversation Central Ohio English (Pitt *et al.* 2004, Hume 2004b, Raymond, Dautricourt, and Hume, to appear).

It is an empirical question whether nonphonetic parameters such as phoneme frequency can account for a wide range of phonologically active classes, particularly the classes which have no apparent phonetic motivation, some of which are discussed in chapter 5. Invoking frequency is more complicated than invoking phonetic facts, because frequency is necessarily language-specific. While many phonetic facts are also language-specific, there are enough commonalities between languages (within a given modality) to allow phonetic generalizations to be made about a relatively unfamiliar language. Using phoneme frequency to account for a phonological pattern requires language-specific information like word frequency. Unfortunately, many of the languages with the most unexpected phonologically active classes have little or no readily available frequency data at this time.

4.2.4. Social considerations

Frequency is not the only nonphonetic factor that may play a role in accounting for the emergence and maintenance of phonological patterns. Social factors have also been argued to be relevant. Janda (1999, 2003) attributes phonemic split to socially-motivated phonetic exaggeration perpetrated by successive generations. Trudgill (2002) discusses the role of dense social networks in supporting complex alternations and unusual sound changes. For example, working-class speakers of Belfast English have a more complex system of vowel allophones than middle-class speakers, and they also have denser social networks (Milroy 1980). For middle-class speakers, the vowel phoneme in *trap* has only the allophone [a]. For working-class speakers, this vowel has allophones including [ɛ], [æ], [a], [ɑ], and [ɒ], with further complexity added by the fact that front [ɛ] occurs before back consonants and back [ɒ] occurs before alveolar nasals. Trudgill (2002:723) argues that small, tightly-knit communities are more able "to encourage continued adherence to norms from one generation to another, however complex they may be," and that complex and unusual phonological patterns may consequently be favored in small, closely-knit and/or isolated communities (see also Chambers 1995).

If this correlation is correct, then Emergent Feature Theory makes the interesting prediction that large communities with sparse social networks should display more phonologically active classes that are phonetically natural. These classes should be similar to the classes predicted by many feature theories. Smaller communities with denser social networks are more likely to support more unexpected "unnatural" classes that are less compatible with many feature theories. This is empirically testable, although the issue is complicated somewhat by the fact that for much of its history, linguistic theory has been focused largely on standard languages spoken by large and diverse groups of speakers. These languages would already be expected to conform most willingly to the linguistic theories crafted by their speakers. Counterexamples are most likely to occur in languages spoken in isolated small and closely-knit communities. And these are precisely the communities in which Trudgill and others predict complex and unusual phonological patterns to be most prevalent anyway. So there are two very different factors at play here. Not only are small, closely-knit, and isolated communities potentially more able to sustain unexpected and complex phonological patterns, they are more likely to be more foreign to linguists. Therefore, the phonological patterns that they do have will be even more unexpected simply due to lack of exposure.

4.3. The abstractness of emergent features

In Emergent Feature Theory, phonetic substance and language use are more fundamental to the explanation of recurrent phonological patterns than they are in the innate features theory. However, the features themselves are, if anything, more abstract than the phonetically-defined innate features are argued to be. In Emergent Feature Theory, phonologically active classes (which form the basis for features) are learned as the result of observations about the phonological patterns which exist in the adult language, and as a result of generalizations about the properties of the speech sounds. There is no direct connection between the features and the external factors which led to the phonological patterns. For the speaker, the phonological pattern is an abstract generalization over sounds, and the original basis for the phonological pattern is of little importance. The phonological pattern is related to the factors which caused it to emerge historically, as well as to each speaker's mental representation of it.

For example, vowel harmony is distinct from vowel-to-vowel coarticulation in that it is generally treated as a symbolic operation, although it bears a striking resemblance to coarticulation. The connection between the two phenomena as well as the fundamental difference between the abstractness of a phonological process and the relative concreteness of a phonetic effect is captured by Emergent Feature Theory. A vowel harmony process can emerge over time via the external factors audition, attention, categorization, aerodynamics, coordination, and social identity (Figure 4.2, above). Coarticulation between vowels occurs as a result of gesture mistiming (coordination), resulting in phonetically rounded vowels which are perceptually similar to contrastively rounded vowels (audition and attention). These phonetically rounded vowels are recategorized as rounded vowels by some speakers (categorization). Then rounding harmony takes on social significance and spreads throughout a community (social identity). Learners of the language are exposed to a situation in which rounded vowels are only ever followed within a single word by another rounded vowel. They perceive that high-amplitude intervals produced with lip rounding and minimal obstruction in the oral cavity and featuring low F2 and F3 share some abstract property that they do not share with other segments (even segments which have some properties in common with them, such as labial consonants, or other vowels). For the speaker, all that is important is that these segments share an abstract property. Labeling the property is a task primarily for linguists. Since these segments share a clear phonetic property, linguists may refer to this abstract property as something like [flat], [+round] or [Labial] in order to reflect the phonetic similarity. However, since the phonetic similarity is secondary to the fact that the grouping is phonologically significant, the class could just as easily be thought of as “the segments that do X” and the abstract property that connects them could just as easily be called “z”. This is the conclusion reached by Anderson (1981) and others.

Phonological features and phonologically active classes are potentially isomorphic. No feature needs to be learned that is not motivated by the presence of a phonologically active class. Treating phonological patterns as primary and features as secondary (see Figure 4.1, above) may seem backwards because it is often thought that innate features facilitate the acquisition of phonological patterns by narrowing the search space and providing an alphabet with which to construct phonological patterns. This is a line of thinking that has leaked over from syntactic theory. While syntax is recursive and generates infinitely many utterances, phonology is finite, and a comparatively easy problem for the language learner to tackle. See Blevins (2004) for more discussion on this topic.

Emergent features also raise questions about contrast. In innate feature theories, contrastive segments in inventories are built out of distinctive features. If only the features which are motivated by phonological patterns emerge, then there is no guarantee that all segments will be contrastive. Jakobson (1942) motivated features on the basis of the assumptions that unmotivated oppositions, such as those between phonemes, are taxing to memory and processing; reducing the number of oppositions by introducing features reduces the cognitive load. However, memory capacity is not as scarce as it was thought to be during most of the last century. For example, Wang, Liu, and Wang (2003) report that the memory capacity of the human brain is something along the lines of 10^{8432} bits of information. Further, there is evidence that a wide array of details of spoken and written language are stored. Listeners remember details of voice quality which relate to information about age, sex, emotional state, region of origin, and social status, and readers remember fonts and the location of words on a page. Both of these types of memories have been demonstrated in the laboratory (see Goldinger 1997 and references cited).

In accordance with these advancements in the study of memory and its relationship with language, most modern psychological models of phonology involve the storage of chunks larger than segments, such as whole words and even multiple exemplars of whole phonemes and words. It is an open question, then, whether speech sounds need to be contrastive in terms of features that are not relevant for phonological alternations, or whether they can simply contrast as whole segments or words. If the former turns out to be true, and this is suggested by Pulleyblank's (2003) study of covert feature effects, it is straightforward to include in Emergent Feature Theory the emergence of features which are necessary to distinguish contrasting sounds but are not necessary to formulate any rules or constraints. This is empirically testable. If phonological features are important for phonological patterns but not for contrast, then speakers are expected to be more sensitive to native contrasts that are involved in a phonological pattern than to those that are not.

4.4. Reinterpreting formal phonology

At the end of chapter 1 was a discussion of some of the insights of innate feature theories which need to be carried over to Emergent Feature Theory. This section describes some of the correspondences between the two approaches, and how they are adapted.

In most innate distinctive feature theories (Chomsky and Halle 1968, etc.), the features are universal cognitive entities specified in Universal Grammar which are directly related to their phonetic correlates, and which are the building blocks of phonological patterns. In Emergent Feature Theory, features exist only as needed by a given language. As in the innate feature theory, they correspond to phonological patterns. Phonetically grounded features are indirectly related to their phonetic correlates via the phonetically-driven sound changes or analogical changes that produced the phonological patterns they refer to (Figure 4.1, above). In innate feature theories, features are innately tied to their phonetic correlates, and phonological patterns are built directly out of features. The relationship between phonetics and phonological patterns is not direct, and is usually only invoked to account for things that cannot be accounted for with features as the sole intermediary. In Emergent Feature Theory, phonological patterns emerge from sound change and analogical change, shaped by a range of external factors (Figure 4.2, above) which are necessary anyway to account for exceptions to innate feature theories. The language user's internalization of the phonological pattern that arose this way uses features which are needed to describe the pattern. The phonetic content of the features is mediated by the phonological pattern, which may reflect its phonetic origins.

The "discovery" of distinctive features in the 20th century was interpreted by many linguists as a discovery about Universal Grammar, about the nature of the innately-determined building blocks of phonological patterns. This discovery is reinterpreted in Emergent Feature Theory as a discovery about common and uncommon phonological patterns, which is in turn related to common and uncommon diachronic changes. Features which have often been thought to be innate and explanatory are created by learners in response to a phonological pattern. What were once universal features are now properties of sounds which are likely to be grouped in sound change or likely to be generalized to. The study of emergent features can continue right where innate features left off. Arguments for innate features are directly translatable into arguments for why certain phonological patterns are likely to emerge.

Interpreting feature organization in Emergent Feature Theory is similar. As discussed above, the organization of features in most versions of Feature Geometry mimics the organizations of the vocal tract. As Clements (1985) argued in the original Feature Geometry proposal, the features which are grouped together are articulatorily dependent on one another, and the features which are under separate nodes (e.g. place features and laryngeal features) are articulatorily independent. By including this as part of Universal Grammar, these articulatory dependencies were given two opportunities to manifest themselves: first, by virtue of the fact that articulatorily independent parameters are far less likely to be involved in the same phonological patterns than articulatorily dependent ones, and second, because the same facts, in abstract form, are in Universal Grammar as the framework in which the resulting rules are stated. Moving from innate features to emergent features eliminates the second opportunity but not the first. In this view, including the articulatory organization in Universal Grammar is redundant. The interdependency of articulatory parameters would be expected to influence which phonological patterns are most common regardless of whether it is repeated in UG. If an innate feature organization imposed structure on phonological patterns above and beyond what is explainable on the basis of physiology, we would expect two things to be true. First, spoken and sign language phonology would both show evidence of the same abstract feature organization, instead of only showing evidence of feature organization which is directly motivated by the modality of each language. Second, acoustic and auditory features would show evidence of feature organization. Since these are generally not observed, we can conclude that feature organization is limited to explaining facts which are already explained by modality-specific articulatory facts.[1]

That being said, there is nothing wrong with describing assimilatory processes using articulatorily-motivated feature hierarchies. Indeed, this is what Feature Geometry was designed for, and modeling the many naturally-occurring phonological patterns which reflect human physiology is something it is well suited to doing. But the assumption that there is a single feature organization to handle all phonological phenomena is not supported. In fact, there is evidence for the many of the models that have been proposed. There are many different ways to generalize across difference segments, and different models capture different possible generalizations. The mistake is to treat these models as mutually exclusive. For example, competing approaches to place of articulation are compared in chapter 6, and it is seen that the subgroupings predicted by different approaches are all observed, and what is not seen is any evidence of a prohibition against

[1] One exception is the use of a Peripheral node in Feature Geometry (e.g. Rice 1999) for labial and dorsal segments. These are clearly not an articulatory natural class, but they do have acoustical similarities (the basis for the feature [grave]). However, Peripheral is used in Rice's theory not for phonetic reasons, or even necessarily in the interest of forming natural classes, but rather to facilitate the correlation of structure with markedness. Indeed, velars (the unmarked counterpart of marked dorsals), which share the acoustic properties represented by [grave], do not bear the Peripheral node, because they do not behave as marked. Consequently, Peripheral should not be interpreted as an instance of acoustic or auditory facts playing a role in feature organization

subgroupings not predicted by a particular model. It is useful to construct models, but they are just models, as Chomsky (2000:29) points out:

> It is perfectly proper to develop the subject of rational mechanics, a branch of mathematics abstracted from physics that treats planets as mass points obeying certain laws, or to develop theories that consider aspects of I-language in abstraction from their physical realization or other properties; indeed, that is the standard practice... But one is not misled thereby into believing that the subject matter of rational mechanics is an entity in a Platonic heaven, and there is no more reason to suppose that that is true in the study of language.

	Innate feature theory	Emergent Feature Theory
Features…	…are universal cognitive entities specified in Universal Grammar.	…are properties of sounds which are likely to be grouped in sound change or generalization.
	…are innate and explanatory	…are created by learners in response to phonological patterns.
The discovery of features…	…is a discovery about Universal Grammar.	…is a discovery about common and uncommon phonological patterns, in turn related to common and uncommon diachronic changes.
Phonetic correlates…	…are directly and innately tied to features.	…are indirectly related to features via the phonetically-driven changes.
Phonological patterns…	…are built directly out of features.	…are the basis for abstract generalizations (features).
Phonetics and phonological patterns…	…are related through features, but may also be related through diachronic changes (when necessary).	…are related through diachronic changes.
Interdependency of articulatory parameters…	…is stated in Universal Grammar (as feature organization).	…is part of the reality of speech production, directly affecting the development of phonological patterns.

Table 4.1. Summary of main points of innate feature theory and Emergent Feature Theory

The representation often works because the articulatory facts it represents may have been involved in the diachronic changes which created the phonological pattern, not because the feature organization model represents language processing or is more explanatory than the articulatory basis for it, or because assimilatory phonological patterns are in any way limited to those which are expressible in this framework. Table 4.1 summarizes the main points of innate feature theory and Emergent Feature Theory.

Many issues that have been analyzed in innate features are directly translatable to an account involving emergent features. At the beginning of this chapter it was seen that certain features readily emerge as the result of common sound changes. While features such as [nasal] are frequently observed spreading in synchronic phonology, others, such as [consonantal], are seldom if ever seen spreading. This has caused some phonologists to argue that it is not a feature (see Hume and Odden 1996, cf. Kaisse 1992). While [consonantal] is not prone to spreading, it is used frequently to describe classes. Formal models of innate features do not account for why a feature might define classes but never spread, but this is straightforward in Emergent Feature Theory. While the phonetic properties associated with [consonantal] may be salient enough to be involved in generalizations (and therefore define natural classes), there are no sound changes which involve the phonologization of phonetic effects related just to the correlates of the feature [consonantal]. In Emergent Feature Theory, there is no contradiction in saying that [consonantal] is useful for defining classes but seldom if ever spreads, because features involved in spreading and features involved mostly in defining natural classes emerge in different ways (coarticulation and generalization, respectively). The distribution of commonly-emerging features in these two scenarios is an interesting question for future research.

4.5. Formalization

4.5.1. Accounting for language data

Emergent Feature Theory abandons many of the assumptions of recent mainstream phonological theory, but adopting it does not radically change the approach to phonological analysis. Decades of work has resulted in a list of common phonological features. It only makes sense for these features to be the starting point for a formal analysis of phonological phenomena. But there is no sense in forcing the features on a set of data for which it is clearly ill-suited.

Studying phonology is like studying birds. Years of research has produced an inventory of recognized bird species. There are common birds and there are rare birds, and undoubtedly there are species which have yet to be discovered. It would be absurd to approach ornithology with a list of the twenty-five most common species and force every bird encountered into one of these categories. It would be equally absurd to ignore the existing taxonomy and start anew with each specimen encountered. The balanced strategy is to expect birds to fall into one of the many categories already identified, but to allow for the possibility that new species will be discovered.

Similarly, in phonology it is reasonable to suspect that new phonological patterns will resemble the ones we already know about, but it is important to be ready to describe phenomena in their own terms if they do not fit the existing taxonomy, which is of course based on incomplete data – the data did not include the new phenomenon being studied. While phonetic factors are expected to be applicable in many different languages, there are other factors which may be very relevant to a particular language's sound system, such as high frequency, which do not translate at all to universally preferred phonological patterns. Accounting for the phonological patterns within a language is primary, and can be informed by expectations gleaned from crosslinguistic studies, but these expectations should never override language-internal evidence. This approach is a return to Jakobson's (1942:241) view that "[t]he description of a system of values and the classification of its elements can be made only from that system's own perspective" (Jakobson 1942:241).

Naming phonological features is not necessary for creating an analysis of a particular language, and implicitly acknowledges features as independent entities. In the innate features approach, using named features has explanatory value. In Emergent Feature Theory, names are a descriptive convention rather than a source of explanation, which comes from outside. Understanding why a particular type of phonological pattern is common or rare or why it interacts with other phonological patterns in certain ways is still very important, but by removing it from the cognitive representation, the cognitive representation is left relatively unencumbered and better able to deal with things like variation. Below is an illustration of how a phonological pattern can be analyzed in Emergent Feature Theory, compared with how it would be analyzed with innate features.

In the Dravidian language Tulu (Bright 1972), the high unrounded central or back vowel [ɨ] is labialized if the preceding syllable contains either a labial consonant or a rounded vowel, as in (20).

(20)	a.	naːḍɨː	‘country’	b.	bolpu	‘whiteness’
		kaṭṭɨː	‘bond’		kappu	‘blackness’
		pudarɨː	‘name’		uccu	[kind of snake]
		ugarɨː	‘brackish’		moroḍu	‘empty’
		ari-n-ɨː	‘rice’ (acc.)		uːru-n-u	‘country village’ (acc.)

One of the breakthroughs enabled by Unified Feature Theory was the nonarbitrary representation of consonant-vowel interactions involving corresponding places of articulation. Intuitively, it does not seem coincidental that labial consonants and round (labial) vowels both condition rounding (labialization) of a vowel. In SPE, labiality in consonants is represented by [+anterior, –coronal], while labiality in vowels is represented by [+round]. Consequently, the SPE formalization of Tulu vowel rounding does not express the fact that round vowels and labial consonants both involve labiality, and there is no natural class of labial consonants and round vowels. The formulation of the clas requires the disjunction of two feature bundles to achieve the union of two natural classes, as in Figure 4.9.

$$\text{ɨ} \rightarrow [+\text{round}] \;/\; \left\{ \begin{bmatrix} +\text{voc} \\ +\text{ant} \\ -\text{cor} \end{bmatrix} \atop \begin{bmatrix} -\text{cons} \\ +\text{rnd} \end{bmatrix} \right\} C_0 \;\text{—}$$

Figure 4.9. Tulu rounding in SPE

In Unified Feature Theory, this sound pattern is treated as a single process conditioned by all labial segments (labial consonants and round vowels). This is made possible by positing that consonants and vowels possess the same innate features for place of articulation. The formalization in Unified Feature Theory (based on Clements 1990:84 and Clements and Hume 1995) is simple, and does not treat the involvement of labial consonants and round vowels as a coincidence (Figure 4.10).

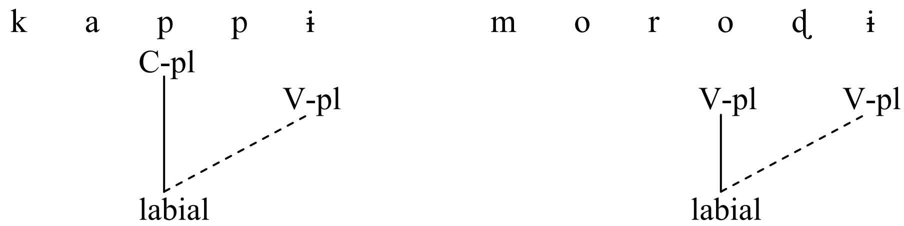


Figure 4.10. Tulu rounding in Unified Feature Theory

The Unified Feature Theory account also leaves something to be desired, too. While it allows the more elegant representation of many assimilatory phonological patterns, and captures insights overlooked by previous feature theories, and treats the rounding triggers in Tulu as a natural class (which SPE cannot do), it is actually able to represent fewer phonologically active classes than SPE, as shown in chapter 6 (63.71% as opposed to 70.98%). An example of an unrepresentable class is /s n l/ in Onti Koraga (segments which are retroflexed before retroflex stops), which cannot be represented in Unified Feature Theory, SPE, or Preliminaries. In the case of Unified Feature Theory, this is because /r/ is excluded, and the only ways to include /l/ and exclude /r/ are to specify a class either [+lateral] or [–continuant]. The former would exclude /s n/, and the latter would exclude /s/. These issues will be addressed in much more detail in the next two chapters. The inability to represent naturally-occurring classes is a serious problem with innate feature theories. While allowing elegant and explanatory formalizations of certain phenomena, theories which limit the features available to formulate rules render many other naturally occurring phonological patterns inexpressible. These theories require recourse to other mechanisms such as feature disjunction and direct historical explanation to account for these cases.

Stampe's (1979) *Natural Phonology* makes this a distinction between two formally-recognized components of phonological systems: processes and rules. Processes are innate phonological patterns which are grounded in limitations on speech production, and rules are non-innate idiosyncratic processes. Processes are "constraints which the speaker brings to the language", and rules are "constraints which the language brings to the speaker" (Stampe 1979:47). Despite the sharp distinction drawn in this and other theories of phonology, there is little evidence beyond crosslinguistic frequency of occurrence to support a distinction. As will be seen in the next two chapters, some classes are indeed much more common than others, but there is no boundary at which to draw a distinction between core and marginal classes.

In Emergent Feature Theory, the crosslinguistic preference for phonetically natural phonological patterns has a historical explanation, namely that the language has been spoken by humans with similar limitations, and has evolved to reflect that. In the terms of *Natural Phonology,* Emergent Feature Theory asserts that *all* of the rules of the language are "brought to the speaker". It is just that some of the rules are particularly well-suited to the speaker's physiology, because the language has been spoken for millennia by physiologically-similar humans. The random changes which have been conventionalized tend to reflect that.

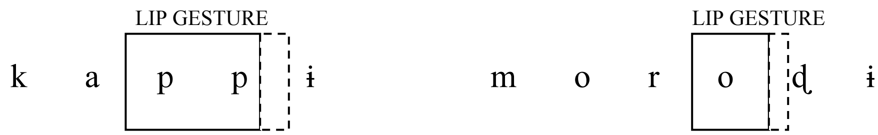
By incorporating the natural/unnatural distinction into the synchronic formalization/cognitive representation, innate feature theories prevent the representation of less common processes, or at the very least make the unsupported prediction that rarer phenomena should be dispreferred synchronically (see e.g., Buckley 2000, Onishi, Chambers, and Fisher 2002, and Peperkamp and Dupoux 2004 for evidence against this dispreference). So while the SPE account fails to express that the grouping of labial consonants and vowels is nonarbitrary, the Unified Feature Theory account does not express that the grouping of labial consonants and vowels *is* largely arbitrary synchronically (and is not intended to express this).[2] Whether there are important differences in the way that phonetically natural and unnatural classes are learned and/or processed is an interesting question. The occurrence of generalization to phonetically natural classes would indicate that at least on a large scale, there is a preference for phonetically natural classes. There is some evidence that phonetically natural processes are easier to learn in a laboratory setting (Wilson 2003). However, differences between phonetically natural and unnatural classes may not persist after both have been fully acquired. So the preference for natural classes which is motivated by typology and some experiments may ultimately be irrelevant at the level of individual linguistic competence.

A goal of Emergent Feature Theory is to permit the recognition of facts such as the crosslinguistic preference for phonetically natural classes (such as the class of labial segments) without letting this interfere with description of the synchronic grammar, e.g. by ruling out attested phonological patterns, making unsupported predictions about the processing of rare phenomena, or by having difficulty dealing with variation.

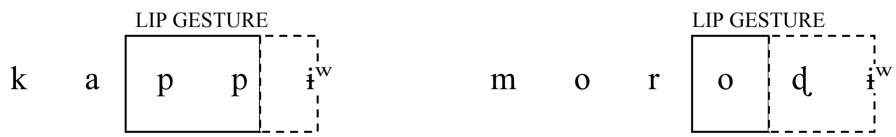
[2] The failure to recognize synchronic arbitrariness, and therefore the failure to represent less common sound patterns, is the basis of Vaux's (2002) critique of Optimality Theory (Prince and Smolensky 1993) and Articulatory Phonology (Browman and Goldstein 1992).

Emergent Feature Theory makes use of the external factors listed in Figure 4.2, and the model in which these factors participate is described in more detail in chapter 8. Each of the external factors is viewed as a filter/prism, which filters and distorts language data in the production/perception cycle and presents the opportunity for a change driven by one or more filter to become conventionalized. This model is able to account for the fact that the class of rounding triggers in Tulu is phonetically natural in a way that is related to the phonological pattern. It is hypothesized that the sound change emerged in the following way, illustrated in Figure 4.11. Prior to the diachronic changes that gave rise to the rounding pattern, the labial articulation of labial consonants and round vowels for the most part did not overlap with the unrounded high vowel (Stage 1). Later, gestural overlap, represented in the model by the COORDINATION Filter/Prism, causes some rounding on the vowel in some instances when it is near a segment with a labial gesture (Stage 2). It can spread past nonlabial segments because the labial gesture does not interfer with their production. For unrelated social reasons, represented by the SOCIAL IDENTITY Filter/Prism, this pattern catches on. The social factors are crucial, although unpredictable. Gestural overlap is very common and usually does not result in a widespread change in linguistic norms (see e.g. Ohala 2003). Next, this slightly rounded [ɨ^w] is reinterpreted as [u] (Stage 3).

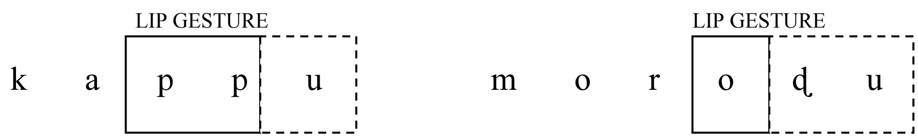
Stage 1: lip gesture generally does not overlap with [ɨ]



Stage 2: COORDINATION causes coarticulation, reinforced by SOCIAL IDENTITY.



Stage 3: AUDITION, ATTENTION, and/or CATEGORIZATION cause reinterpretation of [ɨ^w] as [u], reinforced by SOCIAL IDENTITY.



Stage 4: High back vowel is always [u] after when preceding syllable contains a labial segment.

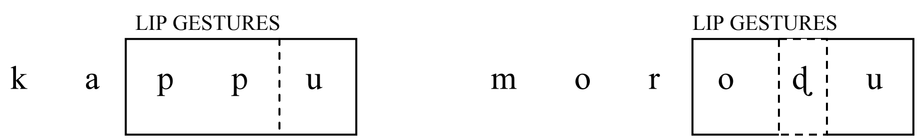
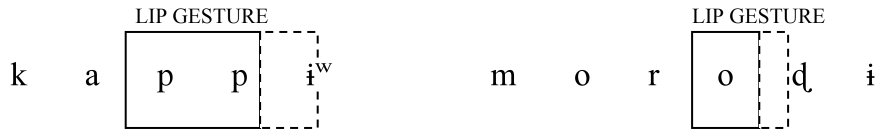


Figure 4.11. Hypothetical developments in Tulu

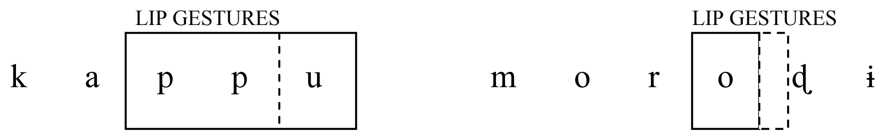
Coarticulatory rounding presumably affects other vowels as well, such as the high front vowel [i]. The fact that only the back vowel rounding was phonologized can be attributed to [ɨ^w] vs. [u] being less perceptually distinct than [i^w] vs. [y], or to the presence of a phoneme /u/ in the language and absence of /y/. In the latter case, [u] is more *expected* than [y], and so it is more likely that an ambiguous vowel will be categorized as /u/ than as /y/, since /u/ is an existing category and /y/ is not (see Hume 2004 for a much more complete discussion). The AUDITION/ATTENTION, and CATEGORIZATION Filter/Prisms are all inclined to favor reinterpretation of [ɨ^w] as [u], subject to the approval of the SOCIAL IDENTITY Filter/Prism. Finally, the language has a phonological pattern in which /ɨ/ is [u] when preceded in the previous syllable by a labial segment (Stage 4). If rounding is also seen in new words or derivations, this is the result of analogy to existing forms, not coarticulation.

Alternatively, this type of phonological pattern could start on a more limited scale, either in terms of adjacency or in terms of the size of the trigger class, before being generalized to something like the modern Tulu pattern. An alternative in which only adjacent coarticulation is phonologized is shown in Figure 4.12. This leads to a phonological pattern in which [u] occurs instead of [ɨ] only *immediately* after labial segments. The situations in which [u] occurs include some but not all situations in which the preceding syllable contains a labial segment, and may be generalized to include all cases where the preceding syllable contains a labial segment, formalized with the CATEGORIZATION and SOCIAL IDENTITY Filter/Prisms. The end result is the same as the end result in Figure 4.11, although the nonadjacent vowel never went through a coarticulation stage, but was included by analogy to the already phonologized adjacent vowel.

Stage 2: Conventionalized coarticulation only affects adjacent vowels.



Stage 4: High back vowel is always [u] after when preceding *segment* is labial.



Stage 5: Adjacent assimilation is reinterpreted to include nonadjacent preceding segments as triggers (an generalization represented by the CATEGORIZATION).

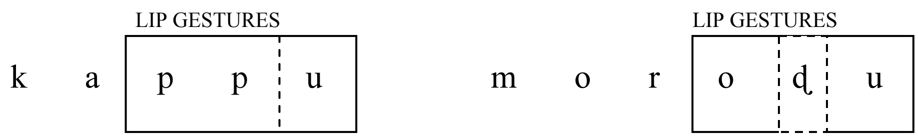
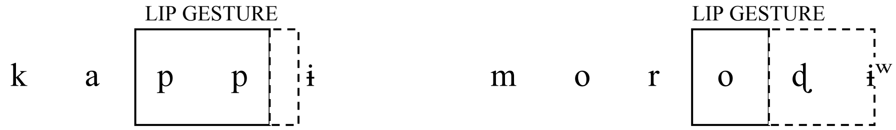


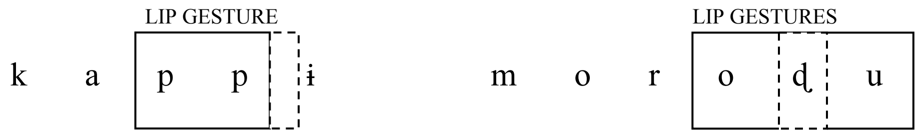
Figure 4.12. Hypothetical developments in Tulu: Alternate Reality A

Another possibility is for coarticulation only to be conventionalized in the case of preceding labial vowels but not labial consonants (Figure 4.12), resulting in the corresponding phonological pattern. The situations in which [u] occurs includes some but not all situations in which the preceding syllable contains a labial segment (only the ones in which the segment is a vowel), and may be generalized to include all cases where the preceding syllable contains any labial segment, formalized with the CATEGORIZATION and SOCIAL IDENTITY Filter/Prisms. The end result is the same as the end results in Figures 4.11 and 4.12, although the words containing a labial consonant but no labial vowel never went through a coarticulation stage, but were generalized directly.

Stage 2: Coarticulation conventionalized only after vowels.



Stage 4: High back vowel is always [u] after when preceding syllable contains a labial *vowel*.



Stage 5: Assimilation triggered by labial vowels is reinterpreted to include labial consonants too (another generalization represented by CATEGORIZATION).

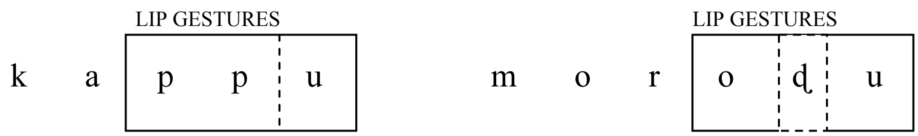


Figure 4.13. Hypothetical developments in Tulu: Alternate Reality B

All three of these scenarios result in the same synchronic pattern, and the language learner is not concerned with the trajectory of the changes that led to the present language. Hypothesizing about the origins of phonological patterns as in Figures 4.11-13 is no substitute for actual historical reconstruction, but neither is the use of synchronic formalisms that usurp historical explanation. The true scenario is an empirical question, and different languages may have similar patterns as a result of different historical developments. Synchronic formalisms which make phonetically natural phonological patterns simpler to represent are similar to those which recapitulate historical change. These formalisms are perhaps not ideal as a model of cognitive representation, because they collapse information into the synchronic grammar that already exists elsewhere and is not motivated by any aspect of performance. The stages in between 1 and 4 are important for accounting for why such a pattern exists, but they are not relevant for describing the synchronic pattern or accounting for how a language user processes it. These are different questions which require different kinds of evidence. If the diachronic changes had been different, and coarticulation involving a different set of consonants (e.g. labial consonants and high round vowels but not mid round vowels) had been conventionalized, the synchronic phonological pattern would involve a different set of segments. Certainly the sequence of diachronic changes would be expected to be more complicated, but incorporating this into the synchronic grammar would require evidence that this situation is more complicated for the language user. In Tulu, the language user knows that high back vowels following syllables that contain /p b v m u uː o oː/ are round. From a synchronic perspective, it could just as easily be /p b v m u uː/ or /p b m u uː o oː/. As shown in the survey results, languages are able to handle rules which refer to very strange sets of segments. In Emergent Feature Theory, this historical information is formalized as historical information, and the synchronic grammar reflects only synchronically-available information, where it does not belong. How the phonological patterns are represented in the mind of the language user is an interesting question, and one that is likely easier to address when historical explanations are removed from the synchronic grammar.

4.5.2. Towards a cognitive representation of phonology

In generative phonology, the explanation for recurrent phonological patterns and the cognitive representation of phonological patterns have generally been treated as one and the same. In Emergent Feature Theory, as in some other frameworks (see Hume and Johnson 2001c, Blevins 2004, etc.), much of the explanation resides elsewhere. While the language learner must construct a grammar based on language data, acquisition does not involve eliminating phonological patterns which are inexpressible in any innate feature framework. Instead, phonological patterns already exist in the language before the learner learns them, and at the extreme, phonological acquisition maybe as trivial as learning all of the words in the language. We know that some data compression does occur (i.e. every single utterance is not stored independently), evidenced by under- and over-generalizations seen frequently in language acquisition and occasionally in language change.

Since the typology of phonological patterns can be accounted for by factors that are largely external, typology is less relevant for understanding the cognitive representation of language. There is no shortage of competing models of cognitive representation of phonology, such as rule-based derivational phonology, Optimality Theory, and lexicon-based phonology. The first two, especially Optimality Theory, have relied heavily on typology for insight into the cognitive representation (but cf. Myers 2002). If explanation for typology is removed from the cognitive representation, a move that is supported here, then this approach to understanding the cognitive representation with typology can be viewed as wrong-headed.

History is history and typology is typology. If it is typology that we wish to explain, then the mental representation of phonology is somewhat tangential, although it may hold some clues as to why phonological patterns are as they are. If it is the mental representation we wish to explain, then there are better places to look than typology, because typology is the result of so many different factors. Phonological variation provides insight into how phonological patterns are stored and used. Experimental evidence may also tap into the mental representation of phonology. In order to understand the cognitive representation of phonology, these two approaches should be pursued.

4.6. Summary

Emergent Feature Theory separates explanation from cognitive representation, and draws upon different sources of explanation for typological observations. Features and classes emerge from phonetically-driven sound change and from generalization along different dimensions. As has been shown, description of phonological phenomena in Emergent Feature Theory is very similar to description with innate features. While explanation is located outside the speaker in many cases (contrary to innate feature theory), many of the insights of innate feature theory exist independent of innate features, and are available to account for the emergence of features. By abandoning innate features as a source of explanation, Emergent Feature Theory opens up new sources of explanation in formal phonology, without losing most of the insights of innate feature theory. Emergent Feature Theory is not a rejection of the work of Jakobson, Halle, Clements, and so many others, but a continuation of it.

CHAPTER 5

A CROSSLINGUISTIC SURVEY OF PHONOLOGICALLY ACTIVE CLASSES

Despite the evidence against innate distinctive features, the claim that features are innate and able to describe most if not all phonologically active classes has been reinforced by phenomena reported in the phonology literature. The phonology literature is not the best way to find a random sample and to assess the ability of phonological features to account for phonological data, however, because data which are difficult or impossible to analyze in innate feature theories tend not to get analyzed and therefore tend not to end up in publications. Assessing the ability of features to account for data requires a survey of a large sample of classes which are not selected according to their compatibility with any particular theory. However, no large-scale survey of phonologically active classes has been available to determine whether or not assumptions about innate features are valid, or to answer many different questions about distinctive features and their universality. This chapter describes a survey of phonologically active classes in 561 languages.

Models with universal distinctive features predict that the phonological behavior of segments is predicted by their features, while emergent models predict that generalization provides the opportunity for segments to be grouped with sounds that are similar along some dimension, and therefore the behavior (and feature specification) of a segment can only be determined by observing the behavior. Innate features and emergent features make very different predictions about the survey results, and it will be seen below that the results generally support emergent features over innate ones.

5.1. Predictions of different models

Innate and emergent feature models make different predictions about what types of phonological patterns are expected. The innate features approach predicts that certain classes of sounds (those which are expressible with the features of a given theory) may recur (Figure 5.1, boxy shape), and other classes occur only as historical accidents. In Emergent Feature Theory, all classes are historical accidents, and some accidents are more likely than others. Emergent Feature Theory predicts that some classes are more likely than others to arise through language change, but none are explicitly ruled out (Figure 5.1, curve). The shape of the distribution predicted by the innate features approach is not uncontroversial among theorists who have discussed it. The stepped box shape corresponds to Sagey's (1986) proposal that the simplicity of the representation predicts the frequency of the phonological pattern, i.e., that classes defined by few features should be more frequent than classes requiring many features. Other approaches which do not include Sagey's prediction simply assert that some classes are possible and some are not. In this case a rectangle is a more appropriate representation. This approach still requires a theory such as Emergent Feature Theory to predict which of these classes are expected to be common, as it is clear that all possible classes are not equally frequent.

Emergent Feature Theory makes such a prediction based on phonetic facts, but also holds that given these predictions, a separate innate feature theory is no longer needed. As will be seen below, the distribution of classes in the database, when analyzed in three different feature theories, matches the prediction of Emergent Feature Theory each time.

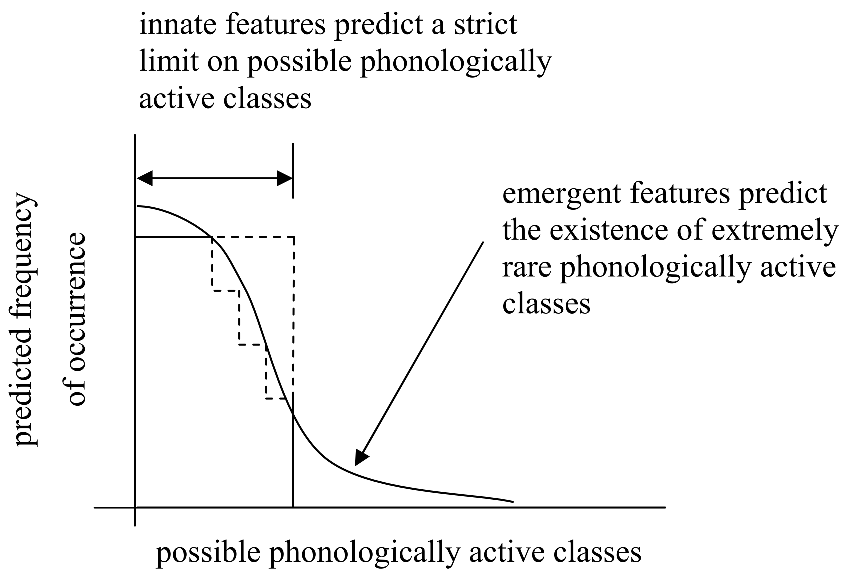


Figure 5.1. Predicted phonologically active classes

Many approaches to innate features allow for the existence of unnatural classes as idiosyncrasies or historical oddities. If so, it is expected that there should be an identifiable boundary between the "natural" classes that are predicted by features and the idiosyncratic "unnatural" classes that are not. Innate feature theories also predict the occurrence of some apparent natural classes which are actually the union of two or more classes (formalized as a disjunction of feature bundles). In the event that two natural classes are affected by the same type of process, it would appear that the union of those two classes, perhaps an unnatural one, would be acting as a class. These cases are expected to be uncommon, and if they are recurrent, to involve the union of fairly common natural classes. The unnatural classes allowed by innate feature theory require generally receive a historical explanation which is very similar to Emergent Feature Theory. Instead of two separate methods for accounting for common and rare classes, Emergent Feature Theory accounts for both with the same mechanism.

Optimality Theory predicts unnatural-looking classes as a result of constraint interaction. This would occur when a constraint referring to a natural class is dominated by an antagonistic constraint referring to a natural class which partially overlaps the first class. By preventing segments in the overlap region from participating in the phonological pattern mandated by the lower-ranked constraint, the higher ranked constraint causes an L-shaped class to emerge, one which may not be specifiable with a conjunction of features, but which can be specified by subtracting one natural class from another. Similar to the case of unions, if these classes can be attributed to constraint interaction, it is expected that the component classes of recurring L-shaped unnatural classes will be very common ones.

While innate feature theory predicts that the classes which can recur are those which are specifiable with a conjunction of innate features, Emergent Feature Theory predicts that the most common classes will be those with identifiable phonetic similarities between the members. This may result from phonetically-conditioned sound change or from generalization to phonetically similar segments. It also predicts that other factors such as phoneme frequency could select which segments participate in a class, but because phoneme frequency depends on word frequency within a specific language system, it is not easy to make crosslinguistic predictions on the basis of frequency. But individual cases where frequency is relevant are expected. Similarly, it is expected that individual cases with complicated historical sources (which obscure phonetic similarity) will also be seen.

Innate feature theories predict different possible subgroupings of segments, depending on what features or feature organizations are posited. For example, *Preliminaries* (Jakobson, Fant, and Halle 1954) predicts that labials and velars will pattern together as a result of the acoustic similarities represented by the feature [grave]. Unified Feature Theory (Clements 1990, Hume 1994, Clements and Hume 1995) does not make this prediction, because there is no node in the feature hierarchy which dominates [Labial] and [Dorsal] but not [Coronal]. But if a Lingual node is posited, it is predicted that coronals and velars will pattern together to the exclusion of labials. Likewise, SPE (Chomsky and Halle 1968) predicts that labials and anterior coronals will pattern together, due to the feature [+anterior], which covers labials as well as dentals and alveolars. All three of these subgroupings have clear phonetic correlates. Innate feature theories predict that only the subgroupings which have features or nodes associated with them will occur with greater than chance frequency. Emergent Feature Theory predicts all three, because all three have clear phonetic correlates. Other subgroupings if places of articulation sharing acoustic or articulatory properties are also expected to occur more often than chance.

Finally, Emergent Feature Theory predicts that segments which are not prototypical examples of either value of a feature will be more prone to patterning ambivalently, i.e. patterning as if specified for one value in some languages, and the other value in other languages. Innate feature theories do not predict this type of behavior, because the explanation for the classes is the feature system itself, rather than the phonetic properties (of varying degrees of gradience). The predictions made by the two approaches to features are summarized in Table 5.1. It will be seen below that the predictions of Emergent Feature Theory are generally borne out in the survey results.

	Innate feature theory	Emergent Feature Theory
Common classes…	…can be specified by a conjunction of features in a particular theory.	....involve segments with clear phonetic similarities.
Uncommon classes…	…result from historical oddities, *or* from the union of more common classes, *or* from the subtraction of one more common class from another.	…involve segments with *less* clear similarities.
The common-uncommon boundary…	…is clear, because common and uncommon classes have very different sources.	…does not exist, because common and uncommon classes have the same source.
Subgroupings (of place)…	…which correspond to features or nodes in a particular theory may recur. Others may not.	…involving segments with clear phonetic similarities are more common than others.
Ambivalent segments…	…are not predicted by phonetic ambiguity and should be equally common with all segments.	…are those which are not prototypical examples of either value of a feature.

Table 5.1. Summary of predictions of innate feature theory and Emergent Feature Theory

5.2. Methods

5.2.1. Data collection

The survey is based on the language grammars (written in English) available in the Ohio State University and Michigan State University library systems. These grammars were found in Library of Congress subclasses PA (Greek and Latin), PB (Celtic), PC (Romance), PD (Germanic), PE (English), PF (West Germanic), PG (Slavic, Baltic, and Albanian), PH (Uralic and Basque), PJ (Near Eastern languages), PK (Indo-Iranian), PL (other languages of East Asia, Africa, and Oceania), and PM (languages of the Arctic and North and South America, and pidgins and creoles), for a total of 561 languages (581 dialects).[1] Grammars were located by manually checking the shelves, in order to avoid any potential bias related to the questions the survey is intended to address. For this reason no attempt was made to seek out any particular language or languages for theoretical reasons. This sampling method favored the better studied languages families, but if anything, this bias favors the universal feature approach, because the features which have been argued to be universal are based in large part on Indo-European languages and other well-studied families.

The survey was limited to living spoken languages and languages which have died recently (as long as the grammar of the language is based on data collected while the language was still living). The 561 languages of the survey constitute 7.86% of the world's languages, based on the 7139 listed in *Ethnologue* (Grimes, Grimes, and Pittman 2000). Considering that *Ethnologue* lists dead languages, the percentage of living language listed in *Ethnologue* represented in the survey is slightly larger. The 561 languages include unclassified (1), isolate (3), and creole (20) languages, and members of 51 language families: Niger-Congo (109), Austronesian (55), Afro-Asiatic (53), Indo-European (50), Australian (31), Sino-Tibetan (21), Trans-New Guinea (19), Dravidian (17), Nilo-Saharan (17), Uto-Aztecan (15), Algic (10), Altaic (10), Mayan (9), Austro-

[1] For the purposes of this survey, two dialects belong to the same language if they share an entry in *Ethnologue*.

Asiatic (8), Chibchan, (8), North Caucasian (8), Quechuan (8), Hokan (6), Mixe-Zoque (6), Na-Dene (6), Uralic (6), Penutian (5), Salishan (5), Eskimo-Aleut (4), Iroquoian (4), Oto-Manguean (4), Arawakan (3), Carib (3), Muskogean (3), Siouan (3), Tacanan (3), Tucanoan (3), Aymaran (2), Caddoan (2), South Caucasian (2), Tai-Kadai (2), Torricelli (2), West Papuan (2), Barbacoan (1), East Papuan (1), Hmong-Mien (1), Japanese (1), Khoisan (1), Kiowa Tanoan (1), Lower Mamberambo (1), Mataco-Guaicuru (1), Panoan (1), Sepik-Ramu (1), Totonacan (1), Wakashan (1), and Yanomam (1).

Of the 49 spoken language families reported in *Ethnologue* and not represented in the survey, only seven contain enough languages that a random sampling of 7.86% would be more likely than not to include one of them: Tupi, Geelvink Bay, Macro-Ge, Choco, Arauan, Left May, and Sko. The fact that some families are better represented in the survey than others is not expected to skew the results in any way that is related to the predictions being tested. Indo-European is somewhat overrepresented (11.29%), but less so than 31 other (smaller) families. The complete list of languages can be found in the appendix, and language references not cited in the text can be found in the bibliography.

The grammars of all of these languages were mined for what are referred to here as phonologically active classes. The term "phonologically active class" is used instead of "natural class" in order to exclude the assumption that classes are inherently "natural" either phonetically or according to any particular feature theory, because this is an assumption that the survey is designed to test. A phonologically active class is defined as any group of sounds which, to the exclusion of all other sounds, do at least one of the following:

- undergo a phonological process,
- trigger a phonological process, or
- exemplify a static distributional restriction.

Classes were notated as a proper subset of the phoneme inventory of each language. The phoneme inventories were arranged in two-dimensional arrays by place and manner of articulation. Classes with only one member and classes including all of the phonemes in the language were omitted.

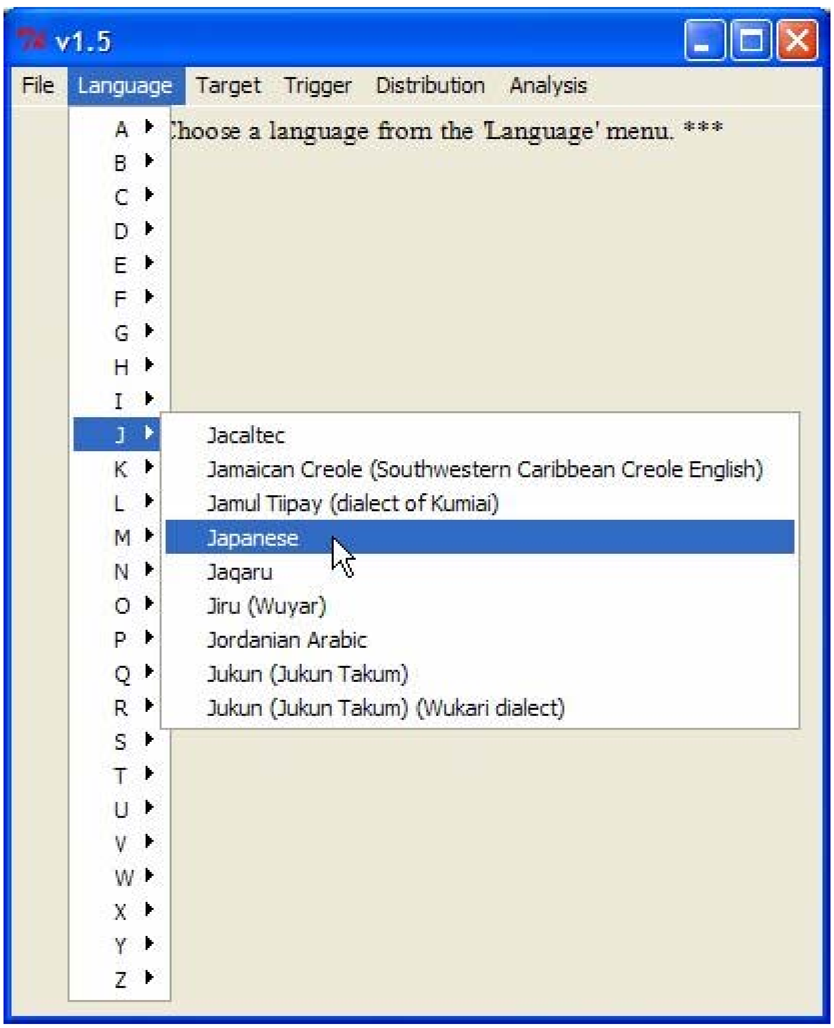


Figure 5.2. Choosing a language from the database (database view)

A program was written in Python 2.3 with Tcl/Tk to display and analyze the information in the database. The user selects a language from among 586 varieties of 561 languages listed in the "Language" menu (Figure 5.2), and then chooses a sound pattern from the "Target", "Trigger", or "Distribution" menu (Figure 5.3). The classes of sounds involved in any of 17,000 sound patterns can be displayed in the context of the segment inventory of the language in which it occurs, along with a description of the sound pattern. As an example, the class of segments that trigger high vowel devoicing in Japanese is shown in Figure 5.4.

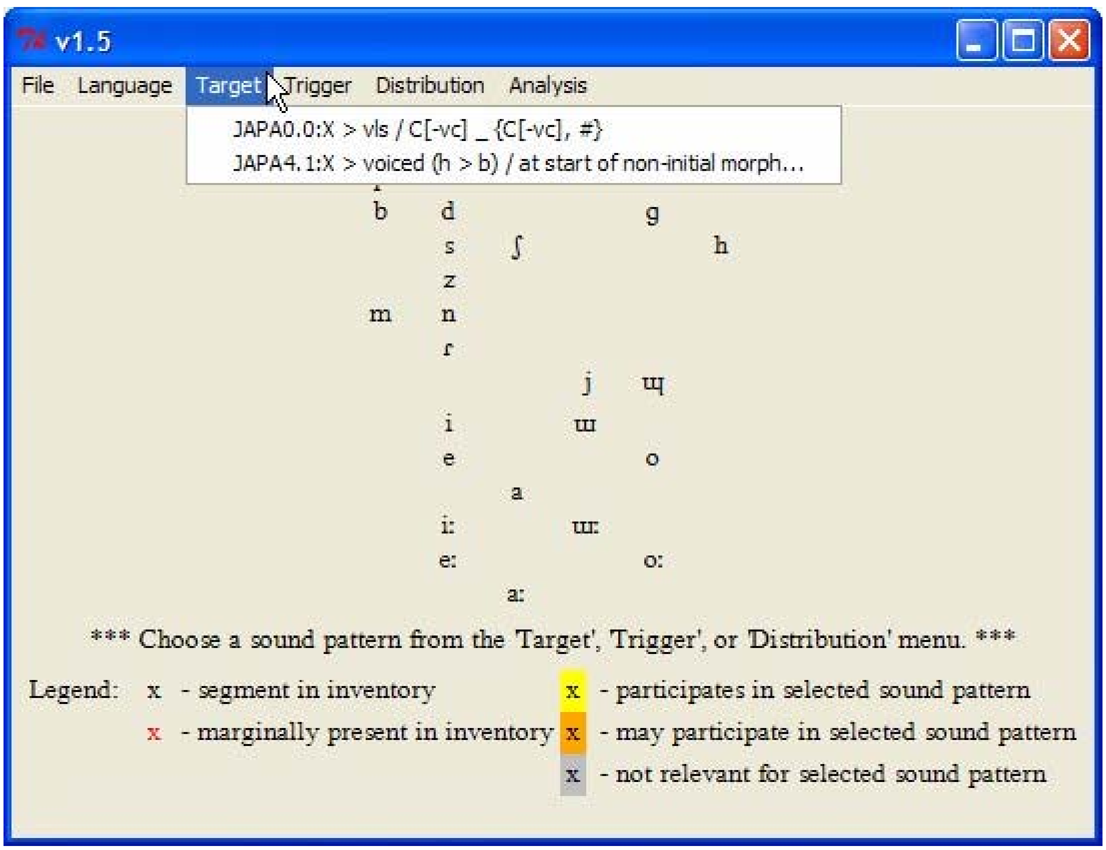


Figure 5.3. Choosing a sound pattern to display (database view)

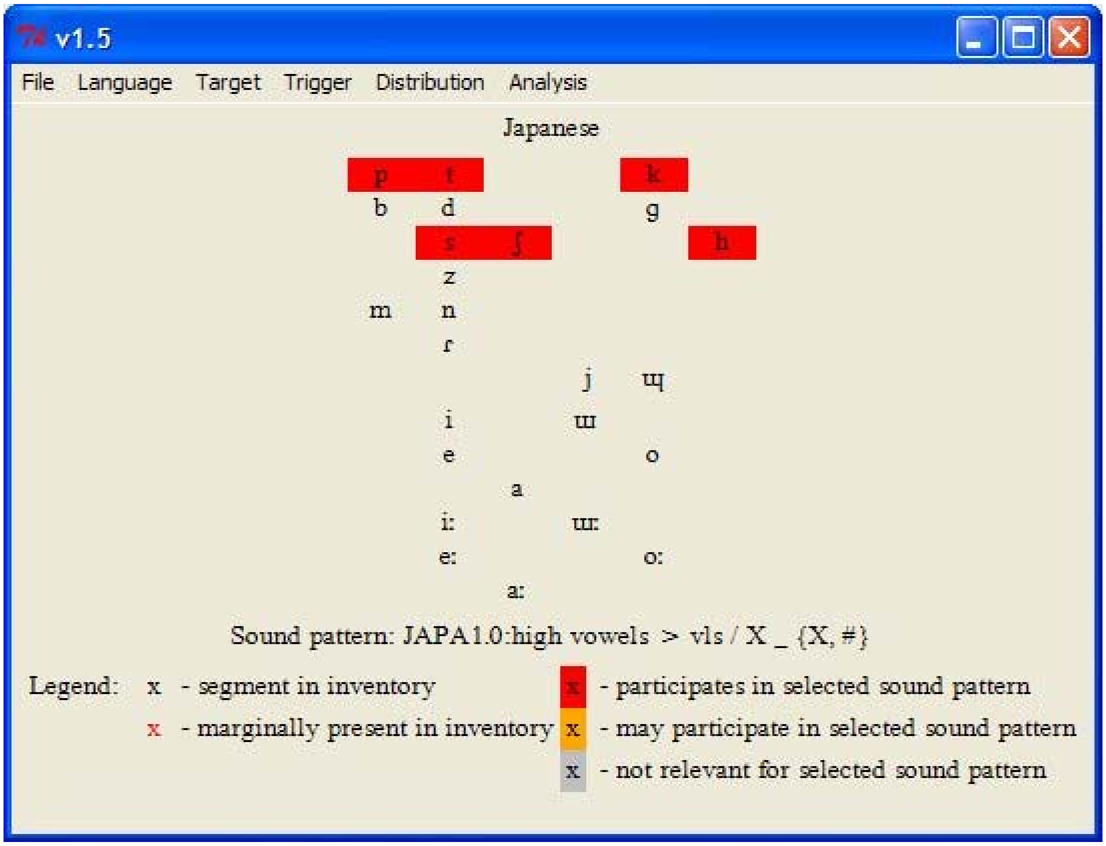


Figure 5.4. A phonologically active class in Japanese (database view)

Assumptions about phonology were minimized where possible, but certain assumptions were necessary in order to make the survey more feasible. These assumptions include the existence of phonemes and an *a priori* distinction between consonants and vowels. To the extent possible, these assumptions will be taken into account during the analysis, and if any of these assumptions should prove problematic, this survey lays the groundwork for follow-up work which abandons them.

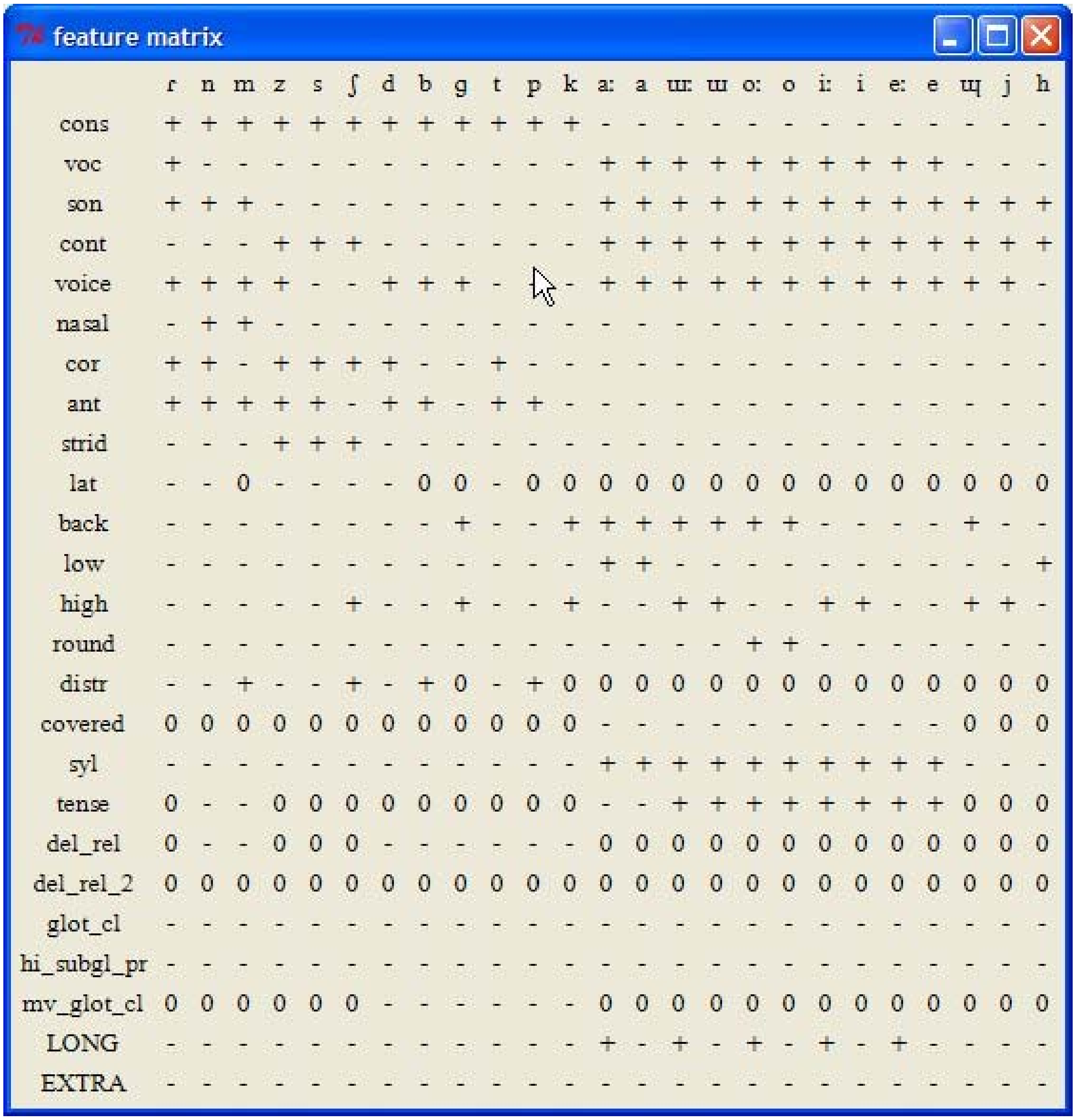
5.2.2. Analysis

Each of the classes in the database is given a characterization in the feature systems of *Preliminaries to Speech Analysis* (Jakobson, Fant, and Halle 1954), *The Sound Pattern of English* (Chomsky and Halle 1968), and Unified Feature Theory (Clements 1990, Hume 1994, Clements and Hume 1995), if such a feature specification is possible. The features assumed for each of these theories are shown in Table 5.2. These feature systems were selected to be representative of distinctive feature theory in general. The feature system of *Preliminaries* is rooted in the acoustic properties of speech sounds, and the feature system of *SPE* is rooted in articulatory properties. Unified Feature Theory is also rooted in the articulatory properties of speech sounds which builds upon previous articulatorily-based feature theories dating back to *The Sound Pattern of English* (Chomsky and Halle 1968), and differs from *SPE* in many important respects. Dispersion Theory (Flemming 2002) is a more recent proposal involving auditory features, but the *Preliminaries* system was selected only because it makes more explicit predictions about possible natural classes. Additional features were provided in order to make distinctions which theories intend to be beyond the scope of features, i.e., length in all three, and syllabicity in Unified Feature Theory.

Theory	Features
Preliminaries to Speech Analysis (Jakobson, Fant, and Halle 1954)	10 binary acoustically-defined features: (1) vocalic/non-vocalic, (2) consonantal/non-consonantal, (3) interrupted/continuant, (4) checked/unchecked, (5) strident/mellow, (6) voiced/unvoiced, (7) flat/sharp, (8) grave/acute, (9) tense/lax, (10) nasal/oral 1 equipollent acoustically-defined feature: (11) compact/diffuse
The Sound Pattern of English (Chomsky and Halle 1968)	23 binary articulatorily-defined features: (1) consonantal, (2) vocalic, (3) sonorant, (4) continuant, (5) voice, (6) nasal, (7) coronal, (8) anterior, (9) strident, (10) lateral, (11) back, (12) low, (13) high, (14) round, (15) distributed, (16) covered, (17) syllabic, (18) tense, (19) delayed primary release, (20) delayed release of secondary closure, (21) glottal (tertiary) closure, (22) heightened subglottal pressure, (23) movement of glottal closure
Unified Feature Theory (Clements 1990, Hume 1994, Clements and Hume 1995)	17 binary features (effectively): (1) sonorant, (2) approximant, (3) vocoid, (4) nasal, (5) ATR, (6) strident, (7) spread, (8) constricted, (9) voice, (10) continuant, (11) lateral, (12-14) anterior (C-place/ V-place/either), (15-17) distributed (C-place/ V-place/either) 18 unary features: (18) C-place, (19) vocalic, (20) V-place, (21-23) pharyngeal (C-place/ V-place/either), (24-26) labial (C-place/ V-place/either), (27-29) lingual (C-place/ V-place/either), (30-32) dorsal (C-place/ V-place/either), (33-35) coronal (C-place/ V-place/either) potentially unlimited binary aperture features: (36) open1, [(37) open2…]

Table 5.2. Primary feature systems

The languages in the database contained a total of 1067 distinct segments. Each of these segments was assigned a feature specification according to each of the feature theories, resulting in a large feature matrix. Not all of the features were possible to specify outside the context of the inventories in which the segments occur. [ATR], [tense] and [open] features were assigned as needed in order to maximize contrast in each inventory. For example, SPE's [tense] feature was assigned reactively in languages with tense or lenis consonants. Plain consonants were specified as [+tense] in languages such as Ibilo which contrast plain and lenis consonants, and specified as [–tense] in languages such as Korean which contrast plain and tense consonants. Language-specific feature specification was performed only in the interest of contrast. No features were assigned according to phonological patterning.



	ɾ	n	m	z	s	ʃ	d	b	g	t	p	k	aː	a	ɯː	ɯ	oː	o	iː	i	eː	e	ɰ	j	h
cons	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
voc	+	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	-	-	-
son	+	+	+	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
cont	-	-	-	+	+	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+
voice	+	+	+	+	-	-	+	+	+	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-
nasal	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cor	+	+	-	+	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ant	+	+	+	+	+	-	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
strid	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lat	-	-	0	-	-	-	-	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
back	-	-	-	-	-	-	-	-	+	-	-	+	+	+	+	+	+	+	-	-	-	-	+	-	-
low	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	+
high	-	-	-	-	-	+	-	-	+	-	-	+	-	-	+	+	-	-	+	+	-	-	+	+	-
round	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
distr	-	-	+	-	-	+	-	+	0	-	+	0	0	0	0	0	0	0	0	0	0	0	0	0	0
covered	0	0	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-	0	0	0
syl	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	-	-	-
tense	0	-	-	0	0	0	0	0	0	0	0	0	-	-	+	+	+	+	+	+	+	+	0	0	0
del_rel	0	-	-	0	0	0	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0
del_rel_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
glot_cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
hi_subgl_pr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
mv_glot_cl	0	0	0	0	0	0	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0
LONG	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	-	-	-
EXTRA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 5.5. An SPE feature matrix for Japanese (database view)

For each language, a feature matrix was built, containing all of the segments in the inventory. This can also be displayed, as shown in Figure 5.5 for Japanese. The user selects an analysis to perform from a list of possible analyses, as shown in Figure 5.6, either for the selected language, displaying to the screen, or as a batch operation, outputting to a text file. Most of the analyses reported in this chapter and chapter 6 are of the “try disjunction” category, which tries various alternatives in order to analyze classes which are not natural for the theory in question.

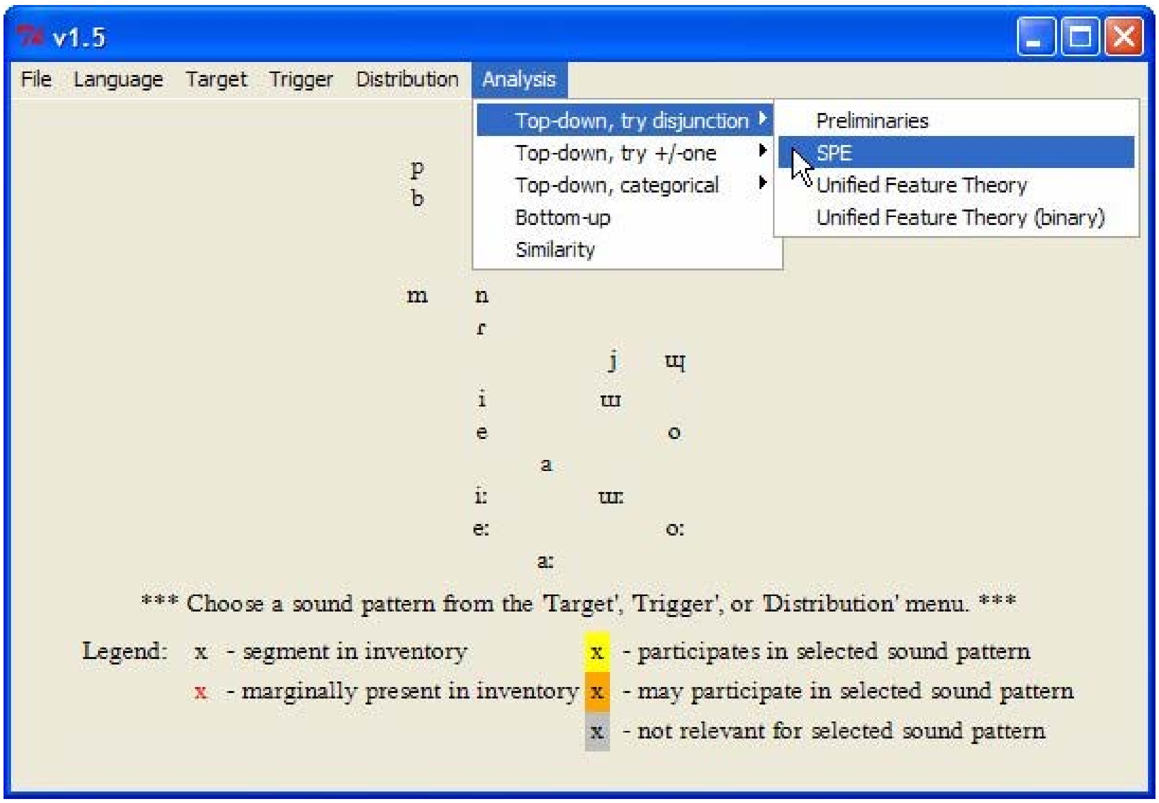


Figure 5.6. Choosing an analysis (database view)

Segments which were specified identically (or unspecified) for all segments in the inventory were excluded from the analysis. For each phonologically active class, shared feature values were identified, and compared with the feature specifications of segments not participating in the class. For example, the six segments in the class in Figure 5.4 have the same values for five features ([–vocalic, –voice, –round, –syllabic, –LONG])

(LONG is a feature added in order to account for length distinctions which are not intended to be accounted for by segmental features in theories such as SPE). Further, no segments in the complement share all of these values, so the class is natural according to SPE. Specifically, it is the natural class of voiceless segments, as shown in Figure 5.7.

	p	t	k	s	ʃ	h	b	d	g	z	m	n	ɾ	j	ɰ	i	iː	ɯ	ɯː	e	eː	o	oː	a	aː
consonantal	+	+	+	+	+	–	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
vocalic	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	+	+	+	+	+	+	+	+	+
sonorant	–	–	–	–	–	+	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
continuant	–	–	–	+	+	+	–	–	–	+	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
voice	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
nasal	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
coronal	–	+	–	+	+	–	–	+	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–
anterior	+	+	–	+	–	–	+	+	–	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
strident	–	–	–	+	+	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
lateral		–		–	–			–		–		–	–												
back	–	–	+	–	–	–	–	–	+	–	–	–	–	–	+	–	–	+	+	–	–	+	+	+	+
low	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
high	–	–	+	–	+	–	–	–	+	–	–	–	–	+	+	+	+	+	+	–	–	–	–	–	–
round	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–
distributed	+	–		–	+		+	–		–	+	–	–												
covered																–	–	–	–	–	–	–	–	–	–
syllabic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+
tense											–	–				+	+	+	+	+	+	+	+	–	–
del rel	–	–	–				–	–	–		–	–													
LONG	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	+	–	+	–	+

Figure 5.7. A natural class Japanese: [–voice]

The analysis of a similar class is shown in Figure 5.8. This is the class of segments which are subject to Rendaku "sequential voicing", i.e., they are voiced at the start of a non-initial morpheme which does not contain a voiced obstruent. These segments also share six feature values, but there is a segment in the complement (/p/) which also shares all of these feature values. As a result, there is no way to distinguish the phonologically active class from the other segments in the language in terms of a conjunction of SPE features, so it is unnatural in the SPE framework.

	t	k	s	ʃ	h	p	b	d	g	z	m	n	ɾ	j	ɰ	i	iː	ɯ	ɯː	e	eː	o	oː	a	aː
consonantal	+	+	+	+	–	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
vocalic	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	+	+	+	+	+	+	+	+	+
sonorant	–	–	–	–	+	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
continuant	–	–	+	+	+	–	–	–	–	+	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
voice	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
nasal	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
coronal	+	–	+	+	–	–	–	+	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–
anterior	+	–	+	–	–	+	+	+	–	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
strident	–	–	+	+	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
lateral	–		–	–				–		–		–	–												
back	–	+	–	–	–	–	–	–	+	–	–	–	–	–	+	–	–	+	+	–	–	+	+	+	+
low	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
high	–	+	–	+	–	–	–	–	+	–	–	–	–	+	+	+	+	+	+	–	–	–	–	–	–
round	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–
distributed	–		–	+		+	+	–		–	+	–	–												
covered																–	–	–	–	–	–	–	–	–	–
syllabic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+
tense											–	–				+	+	+	+	+	+	+	+	–	–
del rel	–	–				–	–	–	–		–	–													
LONG	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	+	–	+	–	+

Figure 5.8. An unnatural class in Japanese

In the event that a class was not describable as a conjunction of distinctive features, additional attempts were made to describe it using disjunction of feature bundles (union of natural classes) and subtraction of classes. The second tactic after feature conjunction was to describe the class as a disjunction of two feature bundles, effectively the union of the two classes. The class which was unnatural in Figure 5.8 is expressible as the disjunction of two classes in Figure 5.9: all the segments in Japanese which are either voiceless coronals or voiceless nonanterior segments.

	t	s	ʃ	k	h	p	b	d	g	z	m	n	ɾ	j	ɰ	i	iː	ɯ	ɯː	e	eː	o	oː	a	aː
consonantal	+	+	+	+	–	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
vocalic	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	+	+	+	+	+	+	+	+	+
sonorant	–	–	–	–	+	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
continuant	–	+	+	–	+	–	–	–	–	+	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
voice	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
nasal	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–
coronal	+	+	+	–	–	–	–	+	–	+	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–
anterior	+	+	–	–	–	+	+	+	–	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
strident	–	+	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
lateral	–	–	–					–		–		–	–												
back	–	–	–	+	–	–	–	–	+	–	–	–	–	–	+	–	–	+	+	–	–	+	+	+	+
low	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
high	–	–	+	+	–	–	–	–	+	–	–	–	–	+	+	+	+	+	+	–	–	–	–	–	–
round	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–
distributed	–	–	+			+	+	–		–	+	–	–												
covered																–	–	–	–	–	–	–	–	–	–
syllabic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+
tense											–	–				+	+	+	+	+	+	+	+	–	–
del rel	–			–		–	–	–	–		–	–													
LONG	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	+	–	+	–	+

Figure 5.9. Disjunction of natural classes: [–voice, +coronal] (lighter shading) ∨ [–voice, –anterior] (darker shading)

This class is also describable as one natural class subtracted from another. As seen in Figure 5.10, it is the class of all voiceless segments which are not anterior noncoronals. The class can be described formally as the class [–voice] minus the class [–coronal, +anterior]. This might also be described more straightforwardly as the class of nonlabial voiceless segments, but since there is no feature [labial] in SPE, the class of labials is described using the features [coronal] and [anterior]. Three of the four possible combinations of these two binary features already appear in segments in the class, and so these features cannot be used to rule out the fourth combination without explicitly subtracting segments specified as [–coronal, +anterior].

	t	s	ʃ	k	h	p	b	m	d	g	z	n	ɾ	j	ɰ	i	iː	ɯ	ɯː	e	eː	o	oː	a	aː
consonantal	+	+	+	+	–	+	+	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
vocalic	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	+	+	+	+	+	+	+	+	+
sonorant	–	–	–	–	+	–	–	+	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+
continuant	–	+	+	–	+	–	–	–	–	–	+	–	–	+	+	+	+	+	+	+	+	+	+	+	+
voice	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
nasal	–	–	–	–	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–
coronal	+	+	+	–	–	–	–	–	+	–	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
anterior	+	+	–	–	–	+	+	+	+	–	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
strident	–	+	+	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–
lateral	–	–	–						–		–	–	–												
back	–	–	–	+	–	–	–	–	–	+	–	–	–	–	+	–	–	+	+	–	–	+	+	+	+
low	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+
high	–	–	+	+	–	–	–	–	–	+	–	–	–	+	+	+	+	+	+	–	–	–	–	–	–
round	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	–	–
distributed	–	–	+			+	+	+	–		–	–	–												
covered																–	–	–	–	–	–	–	–	–	–
syllabic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+
tense								–				–				+	+	+	+	+	+	+	+	–	–
del rel	–			–		–	–	–	–	–		–													
LONG	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	+	–	+	–	+

Figure 5.10. Subtraction of natural classes: [–voice] (lighter shading) – [–coronal, +anterior] (darker shading)

Subtraction was attempted only if disjunction with two classes did not work. If neither approach worked, feature disjunction was attempted with an increasing number of classes. If the inventory of a language is fully contrastive (and this is not the case for every theory/language combination), then every segment is its own trivial natural class. Consequently, the worst case scenario is to account for a class with one natural class for each of its segments. There are about two hundred classes with only two members which cannot be accounted for as a conjunction of features in any of the three theories, but as long as the segments are contrastive, every theory can deal with them with disjunction, using one class for each segment. A case where three classes are needed to describe a three-segment class is found in Runyoro-Rutooro. /t̪ r j/ is the class of segments which turn into alveolar fricatives before certain suffixes starting with /j i/ (Figure 5.11).

	t̪	r	j	p	k	b	d	g	tʃ	dʒ	f	s	h	β	v	z	m	n	ɲ	l	w	i	u	e	o	a
consonantal	+	+	–	+	+	+	+	+	+	+	+	+	–	+	+	+	+	+	+	+	–	–	–	–	–	–
vocalic	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	+	+	+	+
sonorant	–	+	+	–	–	–	–	–	–	–	–	–	+	–	–	–	+	+	+	+	+	+	+	+	+	+
continuant	–	+	+	–	–	–	–	–	–	–	+	+	+	+	+	+	–	–	–	+	+	+	+	+	+	+
voice	–	+	+	–	–	+	+	+	–	+	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+	+
nasal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–
coronal	+	+	–	–	–	–	+	–	+	+	–	+	–	–	–	+	–	+	–	+	–	–	–	–	–	–
anterior	+	+	–	+	–	+	+	–	–	–	+	+	–	+	+	+	+	+	–	+	+	–	–	–	–	–
strident	–	–	–	–	–	–	–	–	+	+	+	+	–	–	+	+	–	–	–	–	–	–	–	–	–	–
lateral	–	–					–		–	–		–				–		–	–	+						
back	–	–	–	–	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–	+	+
low	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	+
high	–	–	+	–	+	–	–	+	+	+	–	–	–	–	–	–	–	+	–	–	+	+	+	–	–	–
round	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	–
distributed	+	–		+		+	–		+	+	–	–		+	–	–	+	–		–						
covered																						–	–	–	–	–
syllabic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+	+
tense																	–	–	–			+	+	+	+	–
del rel	–			–	–	–	–	–	+	+							–	–	–							
mov. glot. cl.	–			–	–	–	–	–																		
hi subgl. pres.	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Figure 5.11. Worst-case scenario: one class for each segment

This class can only be described in SPE as the union of three classes: [–voice, +coronal, +anterior] ∨ [+high subglottal pressure] ∨ [–consonantal, –vocalic, +voice, –back].

The result of automated analysis of five phonologically active classes in Japanese are shown in Figure 5.12. As in the analysis in this chapter and the next, classes which correspond only to distributional restrictions are omitted.

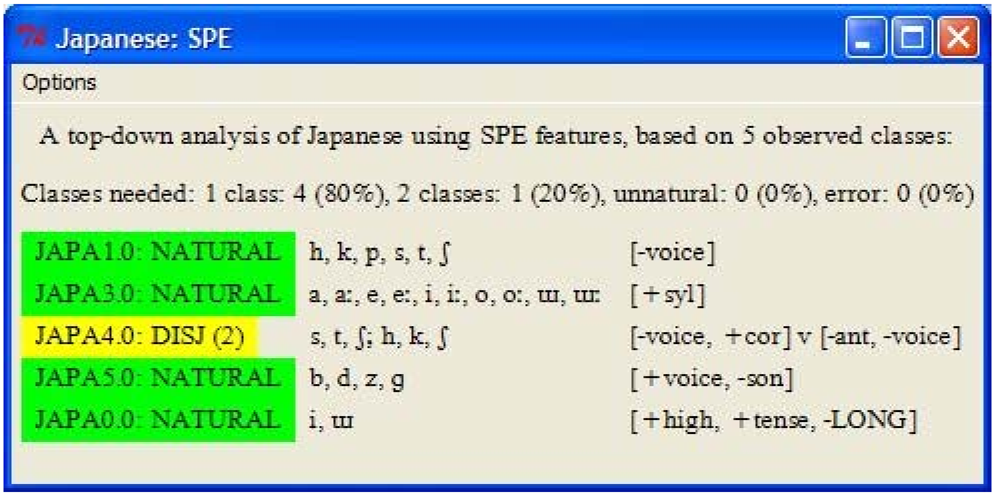


Figure 5.12. Results for Japanese (database view)

Having seen how the analyses are performed and viewed, we proceed to a look at the general results.

5.3. First look at the results

5.3.1. Overview

The survey involved a total of nearly 17,000 sound patterns. Many of these are distributional patterns only, and these classes are substantially more idiosyncratic than the classes which are targets or triggers for phonological alternations. The results reported in this dissertation are limited to classes of segments which participate in alternations as targets or triggers, and these classes are sufficient to address the questions asked here. If it turned out that the classes involved in alternations are easily accounted for in the feature theories, a case could still be made that the classes involved in distributional patterns are not accounted for so easily. Since many of the classes involved in alternations are not easily accounted for in the feature theories, the classes involved only in distributional patterns are superfluous for the current purposes. The differences between classes involved in distributional patterns and classes involved in alternations are an interesting area for further study.

Often several sound patterns in a particular language involve the same set of segments. In producing the figures reported in the next few chapters, these classes are each counted only once. Limiting the analysis to classes involved in alternations and counting each group of segments only once (even if it is involved in many different sound patterns) results in 6077 distinct classes which will be investigated in the next few chapters. Of these 6077, classes, more than one quarter cannot be described as a conjunction of features in any of the three feature theories, indicating that "unnatural" classes are not as marginal as they are often assumed to be. The success rates of the three theories are shown in Table 5.3.

Feature System	Characterizable (Natural)		Noncharacterizable (Unnatural)	
Preliminaries	3640	59.90%	2437	40.10%
SPE	4313	70.97%	1764	29.03%
Unified Feature Theory	3872	63.72%	2205	36.28%
ANY SYSTEM	4579	75.35%	1498	24.65%

Table 5.3. The ability of three feature systems to characterize 6077 phonologically active classes with a conjunction of distinctive features

The survey results are analyzed over the next three chapters. The remainder of this chapter presents some of the "unnatural" classes from both ends of the crazy spectrum. This includes bizarre groupings of segments which occur only once in the database and phonetically-definable classes which do recur in the database, but which nevertheless are not describable as conjunctions of distinctive features in any theory that has been proposed so far. The results are analyzed in detail in terms of Preliminaries, SPE, and Unified Feature Theory features in chapter 6. Some of the more widespread classes that these theories cannot account for are discussed in terms of other feature theories which are able to handle them. Chapter 7 examines crosslinguistically ambivalent segments, which provide strong evidence for Emergent Feature Theory over the theory of innate features.

5.3.2. Crazy classes

There are a wide range of classes which cannot be accounted for by traditional distinctive features. From a phonetic standpoint, they range from the crazy to the sensible, with those on the sensible end being more prone to being found in multiple languages. This section showcases some of the crazier classes as well as some of the more frequent "unnatural" classes in the database. Where possible, these examples include alternations. When examples of alternations are not available, the underlying forms posited by the grammar authors are given, and the reader is referred to these sources for more motivation of the underlying forms.

One crazy class is found in Kolami, where the suffix /-(u)l/ is a plural marker for a variety of nouns. The allomorphy is phonologically conditioned, with nouns ending in /ʈ ɖ n̪ r l i e a/ taking [-l] and nouns ending in /p t̪ k d̪ g s v z m ŋ j/ taking [-ul] (Emeneau 1961:46-50), as shown in (21). The two classes are shown in the context of Kolami's segment inventory in Figure 5.13. Other consonants and vowels in the language do not occur word-finally in this class of nouns.

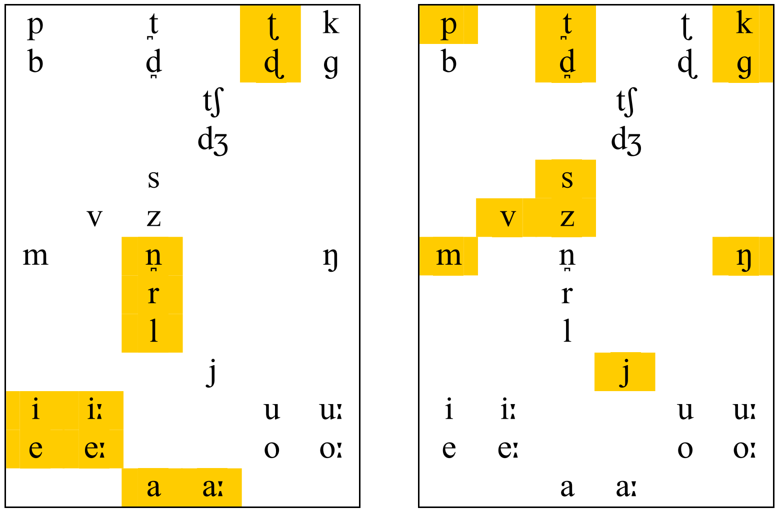
(21) Kolami plural allomorphy

a. [-l] after /ʈ ɖ n̪ r l i e a/

singular	plural	
d̪uʈ	d̪utl	‘hip’
eɖ	eɖl	‘bullock’
toːren̪	toːren̪l	‘younger brother’
sir	sid̪l	‘female buffalo’
kaje	kayel	‘fish’
biːam	biːl	‘rice’
kala	kalal	‘dream’

b. [-ul] after /p t̪ k d̪ g s v z m ŋ j/

singular	plural	
roːp	roːpul	‘plant’
ket̪	ket̪ul	‘winnowing fan’
maːk	maːkul	‘tree’
mood̪	mood̪ul	‘man of particular exogamous division’
d̪eg	d̪egul	‘heap, mass’
kis	kisul	‘fire’
aːv	aːvul	‘fathom’
gaːz	gaːzul	‘bangle’
d̪em	d̪emul	‘one draw on a pipe’
nenjeŋ	nenjeŋul	‘meat’
poj	pojul	‘hearth’



condition [-l] condition [-ul]

Figure 5.13. A phonologically active classes in Kolami

Regardless of which allomorph is treated as basic, the class of segments that needs to be referred to in order to derive the other allomorph is not specifiable with a conjunction of any traditional distinctive features. For example, the dental and alveolar nasal and liquids condition the [-l] allomorph, but cannot be excluded from the set of segments which condition [-ul] without also excluding the dental stops, which do condition [-ul].

Another very unnatural class occurs naturally in Evenki (Nedjalkov 1997:320, 175). In this case, suffix-initial /v s g/ change to nasals when they follow nasal consonants, but other consonants do not nasalize in this position. This class, shown in (22), is far from being specifiable with traditional distinctive features. For example, /g/ is distinguished from /d/ only by place of articulation, but ruling out /d/ on the basis of place would exclude other alveolars, such as /s/, which *is* included in the class.

(22) Evenki consonant nasalization

a. /v s g/ nasalize after nasals

/oron-vA/[2]	→	oron-mo	'the reindeer (acc. def.)'
/oron-vi/	→	oron-mi	'one's own reindeer'
/ŋanakin-si/	→	ŋanakin-ni	'your dog'
/oron-gatʃin/	→	oron-ŋatʃin	'like a/the reindeer'

cf.	/girki-vi/	→	girki-vi	'one's own friend'
	/lamu-gatʃin/	→	lamu-gatʃin	'like a/the sea'

b. Other consonants do not

/amkin-du/	→	amkin-du	'bed (dative.)'
/ekun-da/	→	ekun-da	'somebody/something/anything'

p		t		k	
b		d		g	
			tʃ		
			dʒ		
		s		x	h
	v		ʒ		
m		n	ɲ		
		r			
		l			

Figure 5.14. A phonologically active class in Evenki

In River West Tarangan (Nivens 1992:219), /m/ assimilates in place to following /t̪ g s j/ when they are brought together by reduplication, as shown in (23). Assimilation to /t̪/ is obligatory while assimilation to /g s j/ is optional. Assimilated and unassimilated forms are in variation in some cases (e.g. 'overcast', 'rub', female), while assimilated and unassimilated forms are obligatory in others (e.g. 'east' vs. 'ant'). Place assimilation does not occur when /m/ precedes other consonants, although /n/ and /ŋ/ do undergo place

[2] /A/ is an archiphoneme whose phonetic realization is determined by the preceding harmonic vowel.

assimilation in different, more restricted sets of environments. The class of segments which trigger place assimilation in /m/ is shown in the context of the consonant inventory in Figure 5.15. The class is unnatural whether or not /t̪/ is included. Separate processes affect the reduplicant, altering vowel quality and deleting certain vowels and glides. The intermediate stage in (23) occurs after these changes and before the place assimilation. The place assimilation appears in the difference between the intermediate stage and the surface form.

(23) River West Tarangan nasal place assimilation

a. /m/ may assimilate in place to /t̪ ɡ s j/

/RED+bitem/	→	bimtem	→	[bintém]	'DUP small'
/RED+ɸaɸa+jɛm+na/	→	ɸaɸamjɛmnə	→	[ɸaɸanjemnə]	'overcast 3s'
			~	[ɸaɸamjemnə]	
/RED+jɛr+gum/	→	jɛrgimgum	→	[jɛrgiŋgum]	'DUP NF rub'
			~	[jɛrgimgum]	
/RED+simar/	→	simsimər	→	[simsimər]	'DUP east'
/RED+sima/	→	simsimə	→	[sinsimə]	'ant (sp)'
/RED+kinir/	→	kankinɪr	→	[kaŋkinɪr]	'DUP female'
			~	[kankinɪr]	

b. but not to other consonants

/RED+jɛr+kɔm/	→	jɛrkimkam	→	[jɛrkimkam]	'DUP NF dislike'
/RED+dum+di/	→	dimdumdi	→	[dimdumdi]	'DUP six PL'
/RED+nam/	→	nimnam	→	[nimnam]	'berry (sp)'
/RED+lema+in/	→	limlemin	→	[limlémin]	'DUP five PL'
/RED+ruma+j/	→	rimrumɛ	→	[rimrumɛ]	'sheath 3s'

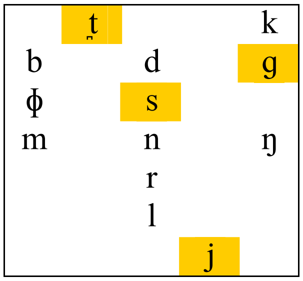


Figure 5.15. A phonologically active class in River West Tarangan

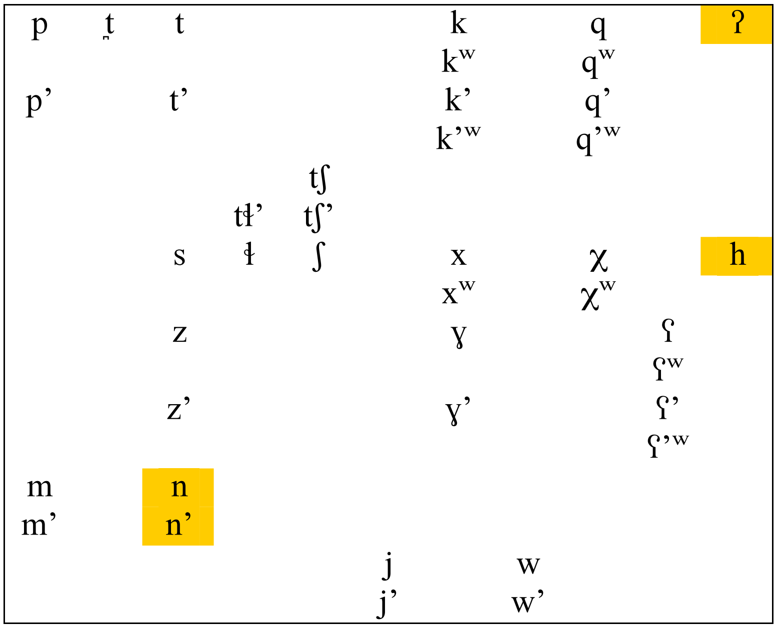
Finally, in Thompson (Thompson and Thompson 1992), /t/ undergoes deletion in very specific circumstances. To delete, /t/ must be preceded by /n n’ ʔ h/ and followed by /ʃ x^{w} n/, and the entire cluster must be tautosyllabic, as shown in (24). The classes are shown in the context of the consonant inventory in Figure 5.16. Neither class is describable as a conjunction of traditional features, because the segments in them share very few features which have been claimed to be innate, and no combination of these is shared to the exclusion of all other segments.

(24) Thompson /t/ deletion

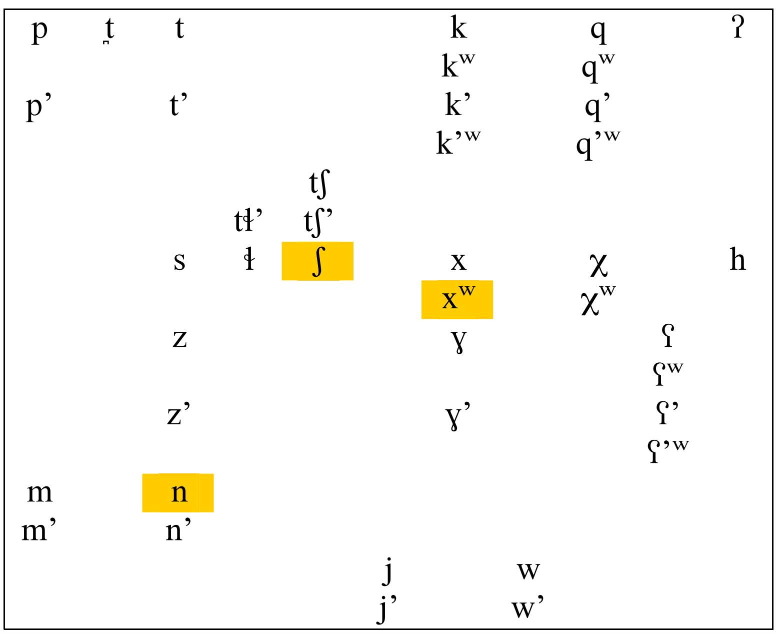
a. /t/ deletes between /n n’ ʔ h/ and /ʃ x^{w} n/ when the cluster is tautosyllabic
/ʔúq^{w}eʔ:-t-es/ → ʔúq^{w}eʔts → [ʔúq^{w}eʔ-s] ‘she drinks it’
/k’^{w}énmeh:-t-es/ → k’^{w}énmehts → [k’^{w}én-me-s] ‘she criticizes him’
/k^{w}én:-t-es/ → k^{w}énts → [k^{w}én-s] ‘he takes it’
/ʔúʔè:-n-t-en/ → ʔúʔentn → ʔúʔenn → [ʔúʔe-ne] ‘I sing him a lullaby’
/ʔúʔè:-n-t-ex^{w}/ → ʔúʔentx^{w} → [ʔúʔe-n-x^{w}] ‘you sing him a lullaby’
/ɬúk^{w}ʔ:-n-t-es/ → ɬúk^{w}n’ts → [ɬúk^{w}-n’-s] ‘he bails it out’

b. but not when the cluster is heterosyllabic
/tʃék:-n-t-sem-es/→ tʃéknt.se.m-s → [tʃék-e-tʃm-s] ‘she cools me’

c. and not between other consonants
/ʔúk^{w}eʔ:-t-p/ → [ʔúk^{w}eʔ-t-p] ‘you people drink it’
/ɬúk^{w}ʔ:-n-t-em/ → [ɬúk^{w}-n’-t-m] ‘we bail it out’



a. preceding context



b. following context

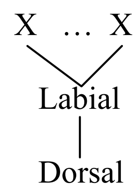
Figure 5.16. Phonologically active classes in Thompson

Each of these four cases involving unique phonologically active classes, along with hundreds of other unique classes in the database, must have an explanation in the history of the language, possibly a very complicated history. In addition to these unique unnatural classes, there are other, more common classes which can also be accounted for by drawing on the history of the languages in which they occur. Most of these classes, some of which are discussed in the next section, seem more natural in phonetic terms, even though many are challenging to traditional distinctive features. They simply occur as the result of changes which are more common and less complicated than those which produced the classes in this section.

5.3.3. Recurrent phonetically natural "unnatural" classes

Among the frequent types of unexpected classes is one which occurs in languages with labiovelar consonants. Labiovelar consonants are generally treated as though they possess properties of bilabial consonants as well as velar consonants. As a result, they are predicted to pattern with labials and with velars. In SPE, labiovelars are anterior velars, sharing [+back, +high] with velars and [+anterior] with bilabials. In various Feature Geometry approaches, labiovelars possess both the features [Labial] and [Dorsal]. In Major Articulator Theory (Selkirk 1988, 1991, 1993), the two features are in a dependency relation so that if [Labial] dominates [Dorsal], labiovelars pattern as dorsals, and if [Dorsal] dominates [Labial], they pattern as labials, as in Figure 5.17.

patterning with dorsals:



patterning with labials:

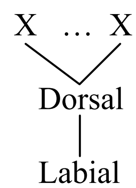


Figure 5.17. Labiovelars in Major Articulator Theory

None of these approaches predict that labials and velars could pattern together to the exclusion of labiovelars because the way to rule out labiovelars in a process involving place of articulation is to prohibit the labial features or the dorsal features. But labials and velars pattern together to the exclusion of labiovelars 19 times in 13 languages (in Bata (three times), Central Shona, Chakosi, Chori, Doyayo (twice), Dyirbal, Ejagham (four times), Gade, Gwari (Gbagyi), Jukun, Kporo, Lorma, and Urhobo). These examples of labiovelars suggest that languages capitalize on a distinction between consonants with complex places of articulation and singly-articulated consonants that is not captured by reference to place itself. Some of these cases do appear to be instances where labiovelars are limited in their distribution as well, and this fact alone may account for their failure to pattern with labials and velars. This does not appear to be the case in Gwari, however. In Gwari (Hyman and Magaji 1970), labial and velar consonants are optionally labialized before back rounded vowels, but labiovelars are not (25).

(25) Gwari labialization: /p b k g/, but not /k͡p g͡b/, are optionally labialized before back rounded vowels.

[gò]	~	[gʷò]	‘to receive’
		[gʷō]	‘to grind’
		[zukʷô]	‘hoe’
		[knūbʷà]	‘ear’
		[gnīkʷó]	‘market’
		[túkʷó]	‘head’
		[àpwò]	‘twin’
	cf.	[g͡bògnu]	‘squirrel’

p		t				**k**	k͡p
b		d				**g**	g͡b
ɓ							
			tʃ				
			dʒ				
	f	s	ʃ				
	v	z	ʒ				
m		n		ɲ			
						ŋʷ	
		l					
				j	ɥ		w

Figure 5.18. A phonologically active class in Gwari.

Another recurrent class not predicted by traditional distinctive features is the class of fricatives and sonorant consonants. These classes occur in fourteen languages (Amele, Abun, Aymara, Bukusu, Estonian, Faroese, Jacaltec, Libyan Arabic, Lower Grand Valley Dani, Nigerian English Pidgin, Onti Koraga, Russian, Samish dialect of Straits Salish, and Tuvaluan). Fricatives and sonorant consonants are phonetically similar in some ways, but they are not featurally similar. All that distinguishes fricatives from stops and affricates in most feature theories is the feature [continuant], and the sonorant consonants they pattern with in these cases include many traditional noncontinuants such as nasals and some liquids. Thus, innate features do not predict that fricatives and sonorant consonants will pattern together, but Emergent Feature Theory predicts that they will pattern together in some instances, because of their acoustic similarities, such as amplitude that is higher than oral stops but lower than vowels, and the absence of release burst or zeroes spanning the frequency spectrum (which are found in stops).

An example from Bukusu, in which nasals are deleted before fricatives and nasals, but not before other consonants (Austen 1974:53-57), is shown in (26). An alternative might be to treat this as the elsewhere context, because nasals assimilate in place to most other consonants (26b). However, /k/ does not trigger deletion (26c). Not only is this not the complement of the class of assimilation triggers, the class of assimilation triggers is not natural either, because of the absence of /k/, and the absence of fricatives combined with the presence of [+cont] glides (26c).

(26) Bukusu nasal deletion

a. Deletion with compensatory lengthening before fricatives and nasals

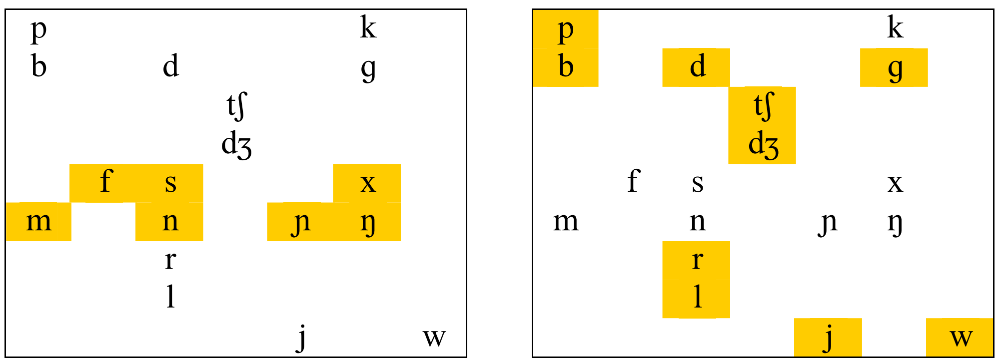
/i-n-fula/	→	[e:fula]	'rain'
/in-som-ij-a/	→	[e:somia]	'I teach'
/i-n-xele/	→	[e:xele]	'frog'
/in-nuun-a/	→	[e:nuuna]	'I suck'
/in-meel-a/	→	[e:meela]	'I am drunk.'
/i-n-ɲaɲa/	→	[e:ɲaɲe]	'tomato'
/i-n-ŋuaŋua/	→	[e:ŋwaŋwa]	'camel'

b. Place assimilation elsewhere

/in-wulil-a/	→	[embulila]	‘I hear’
/in-pim-a/	→	[empima]	‘I measure’
/in-bon-a/	→	[embona]	‘I see’
/in-ùʃex-a/	→	[eɲèʒexa]	‘I laugh’
/ùʃi-n-ɟu/	→	[ùʃiɲèʒu]	‘houses’
/ùʃi-n-jiṃb-o/	→	[ùʃiɲiṃbo]	‘songs’
/i-n-goxo/	→	[eɲgoxo]	‘hen’

c. (except before voiceless velars)

/in-kanakana/ → [enkanakana] ‘I think’



a. deletion triggers b. assimilation triggers

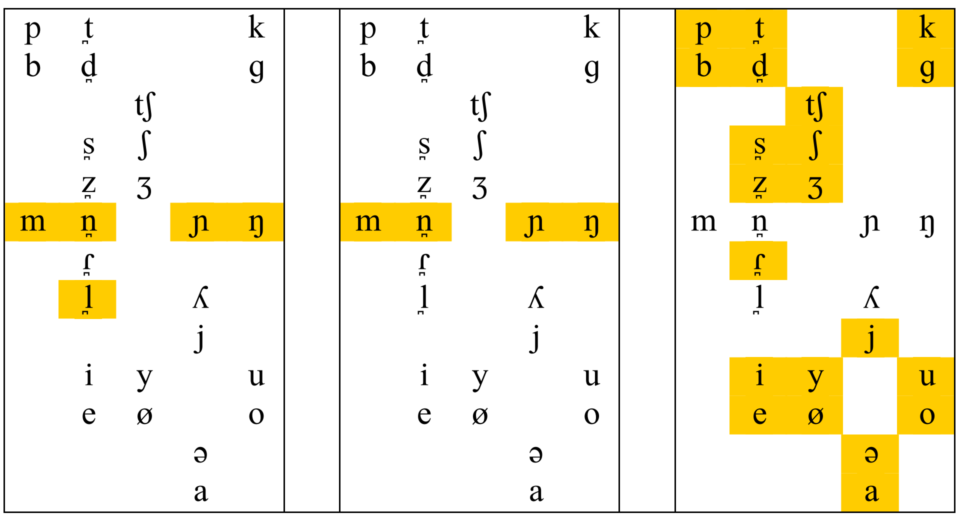
Figure 5.19. Phonologically active classes in Bukusu

Further groupings of different manners of articulation provide more evidence that languages may exploit classes made up of segments sharing phonetic properties, regardless of which property. Nasals and lateral liquids, which share formant structure as well as antiformants caused by side cavities, pattern together to the exclusion of all others in “unnatural” classes in Eastern Cheremis, Toba, and Warlpiri (twice), as well as in large numbers of classes which are natural in one or more theory due to other shared features. For example, in Eastern Cheremis (Sebeok 1961), /d̪/ is reduced to a lenis [đ̪] before /l/

and nasals /m n̪ ɲ ŋ/, as shown in (27a). It is produced as /d̪/ after nasals (27b), and reduced to [ð] everywhere else.

(27) Eastern Cheremis /d̪/ lenition

a.	/tud̪lan/	→	[tuɖ̪lan]	'to him'
	/mod̪maʃ/	→	[moɖ̪maʃ]	'game'
b.	/ʃənd̪as/	→	[ʃənd̪as]	'to set, put, plant'
c.	/tʃod̪ɾ̪a/	→	[tʃoðɾ̪a]	'forest'
	/lud̪o/	→	[luðo]	'duck'



a. /d̪/ → [ɖ̪] / __ X b. /d̪/ → [d̪] / X __ c. /d̪/ → [ð]/ __ X

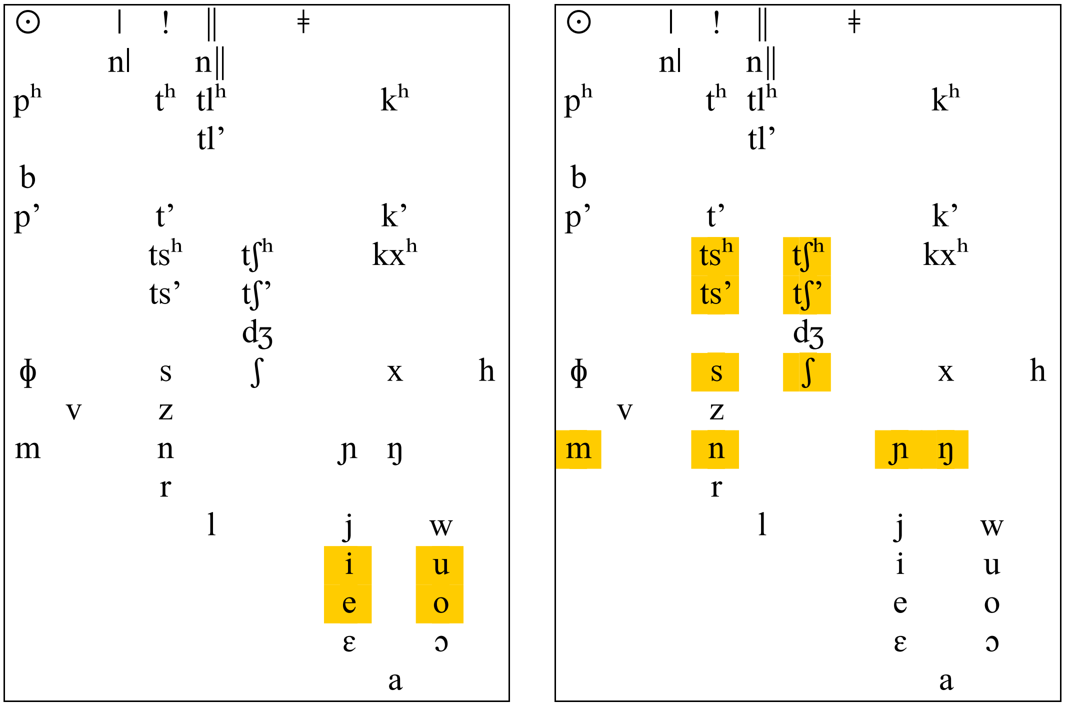
Figure 5.20. Phonologically active classes in Eastern Cheremis

/d̪/ may or may not occur before /ʎ/. While the class of nasals and laterals may be described as [+sonorant, –continuant] in some cases (in theories where laterals are [–continuant]), this approach does not allow nasals and laterals to pattern together to the exclusion of a flap or other noncontinuant sonorant, as in Eastern Cheremis. Other nasal/lateral classes (some natural and some unnatural) are illustrated in chapter 7.

Nasals and sibilants pattern together in four unnatural classes in Navajo, Tswana (twice), and Uneme. Cole (1962) reports that the raising of the lower mid vowels /ɛ ɔ/ in Tswana is conditioned by a combination of vowels and consonants. The raised allophones [ɛ̝ ɔ̝] occur when the following vowel is /i u e o/, and usually when followed by strident and nasal consonants (28b). One example in (28b) also shows a raised allophone occurring between /f/s, which are strident in some theories and nonstrident in others.

(28) Tswana vowel raising

a.	/sèlɛ́pɛ̀/	→	[sèlɛ́pɛ̀]	'axe'
	/tsɛ̀bɛ́/	→	[tsɛ̀bɛ́]	'ear'
	/gòrɛ́kà/	→	[gòrɛ́kà]	'to buy'
	/r̀rɛ́/	→	[r̀rɛ́]	'my father'
	/dìjɔ́/	→	[dìjɔ́]	'food'
	/gòbɔ́nà/	→	[gòbɔ́nà]	'to see'
	/kòbɔ̀/	→	[kòbɔ̀]	'blanket'
	/lèrúmɔ̀/	→	[lèrúmɔ̀]	'spear'
b.	/mòɛ̀ŋ̀/	→	[mòɛ̝̀ŋ̀]	'stranger'
	/gòbɛ̀sà/	→	[gòbɛ̝̀sà]	'to roast'
	/mɛ̀tsé/	→	[mɛ̝̀tsé]	'water'
	/m̀mɔ́nì/	→	[m̀mɔ̝́nì]	'seer'
	/kgɔ̀mó/	→	[kgɔ̝̀mó]	'cow'
	/mòlɔ̀mò/	→	[mòlɔ̝̀mò]	'mouth'
	/sèfɔ̀fù/	→	[sèfɔ̝̀fù]	'blind person'
	/mòrɛ́kì/	→	[mòrɛ̝́kì]	'buyer'



a. consistently trigger mid vowel raising   b. often trigger mid vowel raising

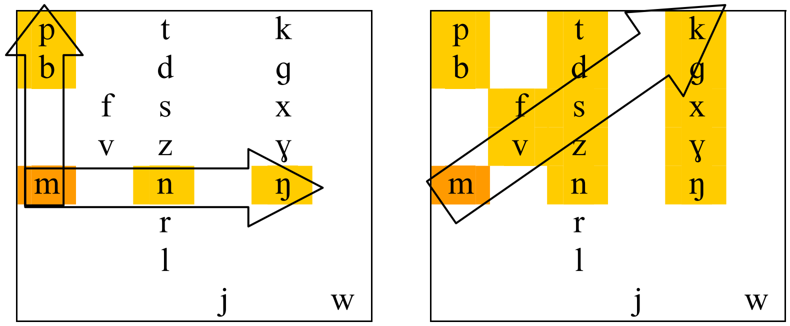
Figure 5.21. Phonologically active classes in Tswana

Flemming (2002) proposes auditory features to account for various phonological phenomena which involve segments with acoustic/auditory similarities that cannot be described using articulatory features, including cases where laterals and nasals pattern together (and see also Ohala 1993 for discussion of the sibilant-nasal connection in sound change). In Emergent Feature Theory, the phonetic similarity between nasals and laterals (Flemming’s motivation for positing a feature for them) is the reason why these classes are recurrent. In innate feature theory, nasals and laterals may pattern together only when they share features that are not shared by other segments, a claim which is falsified by cases such as Eastern Cheremis above, where nasals and laterals pattern together to the exclusion of a flap.

This section has featured phonetically natural classes which are recurrent crosslinguistically but have no features assigned to them in traditional innate feature theories. Because these classes are not describable as a conjunction of features, innate feature theories predict them to be no more common than the "crazy" classes of the previous section. Emergent Feature Theory correctly predicts that because of their phonetic similarity, they are more common.

5.3.4. Recurrent classes involving generalization in two directions

Several types of recurrent classes in the database are cases which appear to involve generalization in more than one direction, resulting in a concave distribution of segments. In the Swiss German example in chapter 4, a class which originally contained only /r/ was generalized in different directions in different dialects. In one case, the class was generalized in two different directions, to include segments which are similar to /r/ in manner (nasals) alongside segments which are similar to /r/ in place (coronals). Many classes in the database appear to involve generalization in two different directions. For example, it is reasonable to attribute a class involving labials and nasals, but not nonlabial nonnasals, to generalizations in two directions from a class which originally contained only /m/, as in Figure 5.22a. All of the segments are similar to /m/, but they are not necessarily more similar to other members of the class than to other segments which do not participate.



a. concave:
segments which match
/m/ in place or manner

b: convex:
segments which share
features with /m/

Figure 5.22. Convex and concave classes

The innate feature theories predict that generalization should only occur by means of feature conjunction, resulting only in convex classes (Figure 5.22b), and that the concave classes produced by generalization in two directions should arise only by chance, as the accidental union of two classes which happen to participate in identical sound patterns, and be no more frequent than non-overlapping classes participating in identical sound patterns, something which turns out to be comparatively rare.

One of the most common types of classes appearing to involve generalization in two directions is the class of back and high vowels, with 17 instances (in Agarabi, Amharic, Ciyao, Dagur, Eastern Cheremis, Efik, Greek, Itzaj Maya, Kinyamwezi (twice), Koiari, Mohawk, Mongolian, Pero, Sacapultec, So, and Tukang Besi). For example, in Kinyamwezi (Maganga and Schadeberg 1992:32), /i u ʊ/ are desyllabified before other vowels (29a-c). Other vowels (/ɪ e o a/) merge with following vowels into a single long vowel (29d-e).

(29) Kinyamwezi desyllabification

a.	/mi-íko/	→	[miikó]	‘taboos’
	/mi-´ɪga/	→	[mjɪ́ɪga]	‘speeds’
	/mi-énda/	→	[mjeenda]	‘clothes’
	/mi-áka/	→	[mjaáka]	‘years’
	/mi-ojo/	→	[mjoojo]	‘hearts’
	/mi-ʊ́je/	→	[mjoojé]	‘breaths’
b.	/mu-íβa/	→	[ŋwiiβá]	‘thief’
			[ŋwɪɪlʊ́]	‘light colored person
			[ŋweezí]	‘moon
			[ŋwaaná]	‘child’
			[ŋwooβa]	‘coward’
			[ŋwʊʊβí]	‘someone who takes shelter’
c.	/kʊ-íβa/	→	[kwiiβá]	‘to steal’
	/kʊ-íta/	→	[kwɪɪtá]	‘to do’
	/kʊ-eŋha/	→	[kweeŋha]	‘to bring’
	/kʊ-anʊkʊla/	→	[kwaanʊkʊla]	‘to receive’
	/kʊ-ókaja/	→	[kookája]	‘to fill’
	/kʊ-ʊ́mɪka/	→	[kʊʊmíka]	‘to dry’
b.	/a-lɪ-íβa/	→	[aliiβá]	‘he is stealing’
	/a-lɪ-íta/	→	[alɪɪtá]	‘he is doing’
	/a-lɪ-eŋha/	→	[aleeŋha]	‘he is bringing’
	/a-lɪ-anʊkʊla/	→	[alaanʊkʊla]	‘he is receiving’
	/a-lɪ-ókaja/	→	[alookája]	‘he is filling’
	/a-lɪ-ʊ́mɪka/	→	[alʊʊmíka]	‘he is drying’
c.	/a-ka-íβa/	→	[akiiβá]	‘she stole’
	/a-ka-íta/	→	[akɪɪtá]	‘she did’
	/a-ka-eŋha/	→	[akeeŋha]	‘she brought’
	/a-ka-anʊkʊla/	→	[akaanʊkʊla]	‘she received’
	/a-ka-ókaja/	→	[akookája]	‘she filled’
	/a-ka-ʊ́mɪka/	→	[akʊʊmíka]	‘she dried’

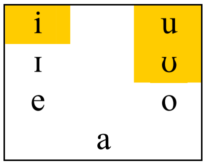


Figure 5.23. A phonologically active class in Kinyamwezi

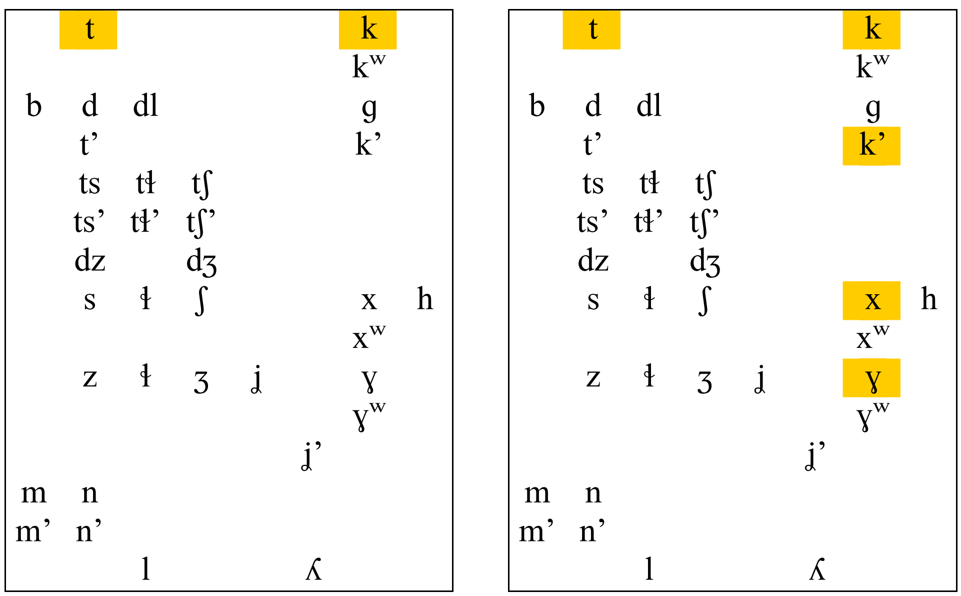
These cases may have started with /u/ (the high back vowel) and spread both to other high and other back vowels. Parallel to cases such as this one in Kinyamwezi, there are 8 classes of front and high vowels which may have started with /i/ (in Anajmaria Agn Armenian, Chamorro, Greek, Michigan German, Mwera, Gwandum dialect of Pero, and Sekani).

Among the consonants, there are 22 classes appearing to involve generalizations in both place and manner (Breton, Catalan, Coast Tsimshian, Comanche, Desano, Diola-Fogny, Gujarati, Inor dialect of West Gurage, Izi, Kolami, Manipuri, Michoacán Nahuatl, Muruwari, Navajo, Northern Tepehuan, Oklahoma Cherokee, Orma, Pengo, Tepuxtepec Mixe, Welsh, Western Shoshoni, Xakas), ten appearing to involve generalizations in place and voice (in Batibo Moghamo, Boraana Oromo, Faranah-Maninka, Hungarian, Irish, Kapampangan, Nangikurrunggurr, Nkore-Kiga, Orma, and Waata Oromo), and six appearing to involve generalizations in voice and manner (in Argobba, Bulgarian (twice), Greek, Kombai, Slovene, and Tiv).

For example, in Navajo (Reichard 1974:19), /t k ɣ x k’/ are labialized before /o/ (and /t k/ are aspirated), as shown in (30a). This is the class of grave voiceless stops and velar stops and fricatives. It may have begun with /k/ and spread to another voiceless stop (/t/) and other velars (/ɣ x k’/).

(30) Navajo aspiration and labialization

a.	/tó/	→	[tʰʷó]	‘water’
	/t’á-ʔákó-d-ígí/	→	[t’á-ʔákʰʷó-d-ígí]	‘that very one’
	/bi-ɣoʃ/	→	[boɣʷoʃ]	‘its thorn’
	/bi-xo-ɣɑn/	→	[boxʷo-ɣan]	‘where his house/home is’
	/dik’õ:dʒ/	→	[dok’ʷõ:dʒ]	‘it is sour, salty, acidulous’
b.	/-zõ:s/	→	[zõ:s]	‘tear fabric’
	/bé-so/	→	[bé-so]	‘money, dollar’
	/ʔálá-c-t’ó:dʒ/	→	[ʔálá-c-t’ó:dʒ]	‘bark of tree’
	/ʔá-dó:/	→	[ʔá-dó:]	‘from a remote point off’
	/ʔát’é-go/	→	[ʔát’ê-go]	‘that way, just as that is’



a. aspirated before /o/ b. labialized before /o/

Figure 5.24. Phonologically active classes in Navajo

As with any of these classes which appear to involve generalization in two directions, it could be claimed that there are two classes (plain voiceless stops and voiceless velars) which coincidentally do the same thing. Investigation into the history of these sound patterns is necessary before reaching the conclusion that they did indeed arise from overgeneralization in two directions from a "kernel" that now appears as the overlap between the two generalizations.

5.3.5. Recurrent phonetically unnatural classes

A few recurrent classes are not predicted by any innate feature theories and also do not have obvious shared phonetic properties. Labial, velar, and glottal consonants pattern together in seven languages (Cabécar, Chontal Maya, Dhivehi, Inor (dialect of West Gurage), Midland Mixe, North Highland Mixe, and Sie), and sonorant consonants and voiceless obstruents pattern together to the exclusion of voiced obstruents in twelve cases in eight languages (Catalan (twice), Faroese, Khmuʔ (twice), Kiowa, Lithuanian, Papago (O'odham), Pero (twice), and Vietnamese (twice)). In Pero (Frajzinger 1989:23, 33), morpheme-final stops undergo total assimilation to a following nasal or voiceless stop (31a), while a following voiced stop triggers not assimilation but epenthesis (31b). This grouping is not predicted, since sonorants and voiceless obstruents share no features or phonetic properties that they do not also share with voiced obstruents.

(31) Pero stop assimilation

a.	/káp/ + /kò/	→	[kákkò]	'he told'
	/pét/ + /nà/	→	[pénnà]	'he went out'
	/tʃúp/ + /kò/	→	[tʃókkò]	'he has shown'
	/tʃìrép/ + /mù/	→	[tʃírémmù]	'our women'
b.	/káp/ + /dʒí/	→	[kávídʒì]	'eat (habitual)'
	/tʃúg/ + /dʒí/	→	[tʃúgídʒí]	'talk (habitual)'

p	**t**			**k**	
b	d			g	
ɓ	ɗ				
		tʃ			
		dʒ			
m	**n**			**ŋ**	
	r				
	l				
			j		w

Figure 5.25. A phonologically active class in Pero.

Finally, corner vowels (usually /a i u/) pattern together to the exclusion of mid vowels (tense, lax, or both) and in some cases, other high and low vowels, in 25 languages (Assiniboine, Ciyao, Ejagham, Ekigusii, Ikalanga, Kilivila, Kimatuumbi, Kiowa, Kuvi, Mundari, Nkore-Kiga, Pa’anci, Runyoro-Rutooro, Sayula Popoluca, Shambala, Swazi, Telugu, Tsishaath Nootka (Nuuchahnulth), Tswana, Wiyot, Xhosa, Yapese, and Zezuru Shona).

What these three vowels share in most of these inventories is that they are the most peripheral vowels in the vowel space. A natural phonological pattern for these peripheral segments to participate in, to the exclusion of vowel closer to the center of the vowel space, is neutralization. In Kiowa (Watkins 1984), /i ĩ u ũ a ã/ are lowered, lowered, and raised, respectively, when they occur before nasals (32a), but not elsewhere (32b). Mid vowels /e ẽ o õ ɔ ɔ̃/ are unaffected (32c).

(32) Kiowa vowel lowering and raising

a. Corner vowels are raised or lowered when a nasal follows,

/min/	[mĩn]	‘about to’
/bimk^{h}ɔj/	[bĩmk^{h}ɔj]	‘bag’
/gun/	[gõn]	‘dance/pf’
/jan/	[jɛ̃n]	‘2sg/pat:pl/obj’

b. but not before other consonants.

/kil/	[kid̥l]	‘dwell, be camped’
/gul/	[gud̥l]	‘write/imp’
/sal/	[sad̥l]	‘be hot’

c. Mid vowels are unaffected.

/ton/	[tõn]	‘be fat’
/dɔm/	[dɔ̃m]	‘earth, ground’

i		u	ĩ		ũ
e		o	ẽ		õ
		ɔ			ɔ̃
	a			ã	

Figure 5.26. A phonologically active class in Kiowa

A different pattern involving corner vowels occurs in Pa’anci (Skinner 1979). /k/ is voiced before unaccented /i u a/ (33a), and voiceless elsewhere (33b).

(33) Pa’anci /k/ voicing.

a.	/kitʃi/	[gɪtʃí]	‘with’
	/taku/	[dágu]	‘what’
	/wamnáka/	[o̯amnága]	‘I see.’
b.	/ke+ha/	[keha]	‘turtle shell’
	/koʃkápi/	[koʃkápi]	‘boys’

i		u
e		o
	a	

Figure 5.27. A phonologically active class in Pa’anci

The effort to categorize “unnatural” classes is compromized somewhat by the fact that they are harder to describe consistently than classes which are accounted for using traditional distinctive features. Often one or more shared phonetic properties is identifiable, but the less common classes lack common terms to describe them. Further, in the same way that many classes can be described in several different ways using distinctive features, many classes can also be described in several different ways using phonetic descriptions. This makes categorizing them difficult. Nevertheless, the existence of recurrent phonologically active classes involving a wide variety of shared phonetic properties suggests that innate feature theories merely highlight some of the most common phonetic properties which can form the basis for phonological patterns. Innate feature theories claim that there are phonetic properties (those which are not associated with any innate feature) which cannot form the basis for phonological patterns, but it is not clear what those properties are, given that there are many unpredicted properties which actually are relevant for many phonological patterns. In short, innate feature theories appear to be unnecessarily restrictive. Emergent Feature Theory, on the other hand, predicts that any phonetic property can form the basis for a phonological pattern, and that phonological patterns based on the most salient phonetic properties will be most prevalent. This prediction is investigated in the next chapter. Further, the fact that many classes which are unnatural in featural terms have phonetic properties in common, much like their “natural” counterparts, suggests that they should indeed be accounted for by the same mechanism, as they are in Emergent Feature Theory.

CHAPTER 6

SURVEY RESULTS IN TERMS OF DISTINCTIVE FEATURE THEORIES

This chapter reports an analysis of the 6077 phonologically active classes in the database in terms of three well-known feature theories. Additional feature theories are brought in as appropriate when they are able to account for recurrent classes that the other theories cannot account for. As theories of innate features, these theories have been proposed ostensibly in order to describe all phonological phenomena in all (spoken) languages. As seen in chapter 5, there are quite a few classes they cannot account for, and a variety of possible explanations will be considered. At the end of a chapter, a model based on phonetic similarity is sketched, and it is seen that this is promising as a model for predicting phonologically active classes.

6.1. Preliminaries, SPE, and Unified Feature Theory

The ability of innate feature theories to account for the observed phonologically active classes is measured in different ways in this chapter. The first, discussed in this section, is a simple success/failure rate. Given a set of segments within a given inventory with a feature matrix specified by a particular feature theory, it is either the case that the segments can be described to the exclusion of all others using a conjunction of features, or that they cannot. Therefore, each of the feature theories can be assigned a success rate based on the portion of phonologically active classes it can characterize. While Unified Feature Theory has substantially more features than the other two theories (see Table 5.2, above), the fact that many of them are unary limits the possible natural classes it predicts. The success rate of the approaches combined can also be computed, according to whether or not *any* of the three approaches can characterize a particular class.

SPE features are able to account for 70.97% of the phonologically active classes, the most of the three theories. More than one fourth of the classes cannot be described with a conjunction of SPE features. Unified Feature Theory features are able to account for 63.72% of the phonologically active classes, and Preliminaries (hereafter JFH) features are able to account for 59.90% of the observed classes. The similarity between UFT's and Preliminaries' success rates is a bit surprising considering that UFT effectively has more than three times as many features (in part because natural classes can be defined by place features in three different ways (V-place, C-place, or either). However, Unified Feature Theory was designed with considerations other than natural class coverage, such as simplicity in formulating phonological rules. The fact that more than a third of the classes these rules need to refer to are inexpressible as conjunctions of features is nonetheless troubling.

Feature System	Characterizable (Natural)		Noncharacterizable (Unnatural)	
Preliminaries	3640	59.90%	2437	40.10%
SPE	4313	70.97%	1764	29.03%
Unified Feature Theory	3872	63.72%	2205	36.28%
ANY SYSTEM	4579	75.35%	1498	24.65%

Table 6.1. The ability of three feature systems to characterize 6077 phonologically active classes with a conjunction of distinctive features

Figure 6.1 shows the overlap between the coverage of the three feature systems. There is substantial overlap between the three systems, and Preliminaries' coverage is almost entirely within the coverage of SPE, which is not surprising given that SPE is a more or less direct descendant of Preliminaries. SPE has substantial overlap with each of the other two systems individually. Each of the different regions of partial coverage in Figure 6.1 is dominated by particular types of classes that are problematic for each theory.

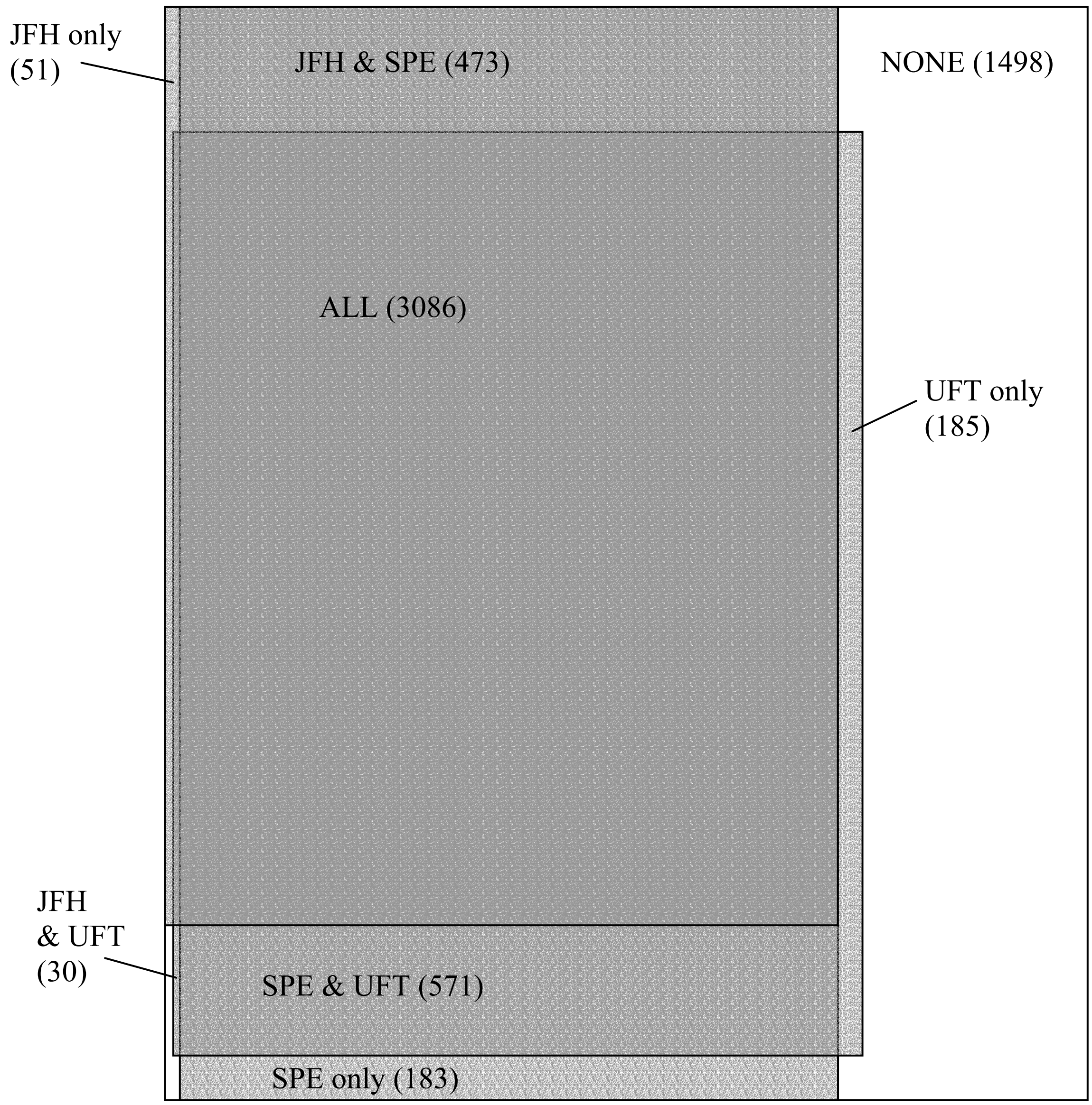


Figure 6.1. Coverage overlap of primary feature systems (number of classes in parentheses)

Of the 30 classes describable in JFH and UFT but not SPE, 22 involve the class of dental/alveolar and palatal consonants, inexpressible in SPE where palatals are [–coronal]. Of the 571 classes accounted for by SPE and UFT but not JFH, 192 involve the class of consonants (vs. vowels), which require the disjunction [consonantal] ∨ [nonvocalic] in JFH, 79 involve the class of sonorants, inexpressible in JFH, and 45 involve vowels as opposed to rhotic approximants, which are vocalic in JFH. Of the 474 classes describable in JFH and SPE but not UFT, the majority require the – value of a place feature, which is not available in UFT, such as nonfront vowels (84), nonback/nonround vowels (67), labial and coronal ("anterior") consonants but not velars (59), labial and velar ("grave") but not coronal (44), nonlabialized consonants (36), and unrounded vowels (36).

Of the 185 classes describable only in UFT, 26 are dental/alveolar/postalveolar/retroflex and velar ("lingual") consonants, as opposed to labial, and 15 are dental/alveolar/postalveolar/retroflex and palatal consonants. Parallel to the first case are front and back (but not central) vowels (12 cases), statable only in UFT, although the class of central vowels (16 cases) is not statable in UFT.[1] Of the 183 classes describable only in SPE, 13 involve various labial, dental/alveolar/postalveolar/retroflex, and palatal consonants as opposed to velars, and seven involve velar and glottal consonants. Of the 51 classes describable only in JFH, 25 involve labial and velar consonants as opposed to dental/alveolar/postalveolar/retroflex and palatal consonants, and seven involve nonretroflex consonants.

Table 6.2 shows the success of various alternative approaches to representing the classes in the feature theories. When classes were not representable with a conjunction of features, a disjunction of multiple feature bundles was attempted. Disjunction of features amounts to unions of natural classes. For example, the grave class is not representable as a conjunction of features in UFT, but it is representable as the disjunction [Labial] ∨

[1] Central vowels are not statable in UFT because they lack place features and place features are privative. While the classes of round, front, and back vowels can be stated as the vowels possessing [Labial], [Coronal], and [Dorsal] features, respectively, central vowels share no features that are not shared by all other vowels.

[Dorsal]. If a disjunction of two specifications was not successful, a subtraction of one class from another was tried. If neither approach involving two classes was successful, the disjunction of more specifications was attempted. In the event that each segment in an inventory has a unique feature specification, *any* class is specifiable as a disjunction of feature bundles. In the worst case scenario, this amounts to one class per segment. As seen in Table 6.2, as many as nine classes were necessary in order to represent a class with disjunction.

Best analysis	*Preliminaries*		*SPE*		Unified Feature Theory	
Natural (feature conjunction)	3640	59.9%	4313	71.0%	3872	63.7%
Disjunction (2 classes)	1443	23.8%	1248	20.5%	1266	20.8%
Subtraction (2 classes)	59	0.97%	71	1.17%	94	1.55%
Disjunction (3 classes)	233	3.83%	201	3.31%	205	3.37%
Disjunction (4 classes)	64	1.05%	56	0.92%	67	1.10%
Disjunction (5 classes)	17	0.28%	21	0.35%	17	0.28%
Disjunction (6 classes)	0	0.00%	4	0.07%	5	0.08%
Disjunction (7 classes)	1	0.02%	0	0.00%	0	0.00%
Disjunction (8 classes)	0	0.00%	0	0.00%	1	0.02%
Disjunction (9 classes)	0	0.00%	1	0.02%	0	0.00%
Unnatural (even w/disjunction)	620	10.2%	162	2.67%	550	9.05%

Table 6.2. The ability of three feature systems to characterize 6077 phonologically active classes with a conjunction, subtraction, or disjunction of distinctive features

The classes which are unnatural even with disjunction are cases where segments do not have unique feature specifications and therefore cannot be distinguished from each other with a theory (e.g. prenasalized stops vs. nasals in *Preliminaries*) or in cases where there is no way to identify a particular segment to the exclusion of others (e.g. central vowels vs. other vowels in UFT).

For comparison, the three feature theories were tested with randomly-generated classes. Ideally, the theories would reject a large number of these classes. If they can describe randomly-generated classes easily, then their ability to distinguish natural from unnatural classes is undermined. For each of the 6077 classes in the database, a class of equal size was created by randomly selecting segments from the inventory of the language in which the class occurs. Table 6.3 shows an example from Japanese, where all three theories reject one of five observed phonologically active classes, but reject all five classes created by randomly selecting segments from the segment inventory of Japanese.

Phonologically active classes	JFH	SPE	UFT	Randomly-generated classes	JFH	SPE	UFT
/i ɯ/	👍	👍	👍	/b ʃ/	👎	👎	👎
/h k p s t ʃ/	👍	👍	👍	/aː d eː k z ɰ/	👎	👎	👎
/a aː e eː i iː o oː ɯ ɯː/	👍	👍	👍	/b e iː j m o t ɰ ɾ ʃ/	👎	👎	👎
/h k s t ʃ/	👎	👎	👎	/aː eː i oː p/	👎	👎	👎
/b d z g/	👍	👍	👍	/d m z ɾ/	👎	👎	👎

Table 6.3. Phonologically active classes and randomly-generated classes in Japanese

As seen in Table 6.4, very few of the randomly-generated classes are natural in any of the theories, but a fairly large number of classes can be described using disjunction. All three theories succeed in being able to describe far more phonologically active classes than randomly-generated classes with a conjunction of features. However, more than half of the randomly-generated classes can be described with the union of no more than three classes in each of the three theories (64% in SPE). This suggests that the ability of the theories to describe a substantial number of "unnatural" phonologically active classes with feature disjunction does not attest to their ability to deal with naturally occurring classes. Rather, this simply reflects the fact that half of all possible classes can be represented with the union of three or fewer classes, and the naturally occurring classes which are unnatural in these theories are no exception.

Best analysis	*Preliminaries*		*SPE*		Unified Feature Theory	
Natural (feature conjunction)	342	5.63%	467	7.68%	270	4.44%
Disjunction (2 classes)	1718	28.3%	1994	32.8%	1745	28.7%
Subtraction (2 classes)	9	0.15%	17	0.28%	11	0.18%
Disjunction (3 classes)	948	15.6%	1160	19.1%	939	15.5%
Disjunction (4 classes)	624	10.3%	774	12.7%	630	10.4%
Disjunction (5 classes)	349	5.74%	456	7.50%	352	5.79%
Disjunction (6 classes)	247	4.06%	292	4.81%	246	4.05%
Disjunction (7 classes)	107	1.76%	126	2.07%	121	1.99%
Disjunction (8 classes)	29	0.48%	29	0.48%	48	0.79%
Disjunction (9 classes)	8	0.13%	3	0.05%	16	0.26%
Disjunction (10+) or error	241	3.97%	290	4.77%	400	6.58%
Unnatural (even w/disjunction)	1455	23.9%	469	7.72%	1299	21.4%

Table 6.4. The ability of three feature systems to characterize 6077 randomly-generated classes with a conjunction, subtraction, or disjunction of distinctive features

Tables 6.5-7 show the most common natural classes within each of the three feature theories. The most common classes in each theory are familiar classes which are easily defined in phonetic terms. Features in all capitals are those which were added in order to handle distinctions which are not intended by the theory to be covered by features.

Rank	Number	Class Description	Example	Features
#1	306	[non-consonantal, vocalic]	/i u e o a/	2
#2	164	[nasal]	/m n ŋ/	1
#3	88	[diffuse, tense]	/i u/	2
#4	85	[unvoiced]	/p t k s ʃ h/	1
#5	65	[acute, tense]	/i e/	2
#6	61	[flat]	/u ʊ o ɔ/	1
	61	[compact, grave, non-vocalic]	/k g/	3
#8	59	[grave, voc]	/u ɨ o a/	2
#9	48	[non-diffuse, vocalic]	/e o ɛ ɔ a/	2
#10	47	[interrupted, unvoiced]	/p t k tʃ/	2
#11	46	[continuant, vocalic]	/i u a l/ (*/ɾ/)	2
#12	41	[acute, non-compact, non-consonantal]	/i ɪ e ɛ/	3
	41	[LONG]	/iː uː eː oː aː/	1
#14	39	[interrupted, non-vocalic, oral, voiced]	/b d dʒ g/ (*/l r ɾ/)	3
#15	37	[vocalic]	/i u e o a l r/	1
	37	[non-diffuse, tense]	/e o/	2
	37	[non-compact, tense]	/i u e o/	2
#18	36	[consonantal, vocalic]	/l r/	2
#19	34	[consonantal]	/b d t k s n l/ (*/j/)	1
#20	32	[tense]	/i u e o/	1
	32	[non-consonantal, plain (vs. flat), vocalic]	/i ɨ e æ a/ (*/u o/)	3
#22	30	[consonantal, unvoiced]	/p t k s/ (*/h/)	2
	30	[SHORT, non-consonantal, vocalic]	/i u a/ (*/l r iː uː aː/)	3
#24	29	[grave, interrupted, non-compact]	/p b/ (*/t k g ɸ/)	3
#25	27	[nasal, vocalic]	/ĩ ũ ẽ õ ã/	2
#26	26	[lax]	/ɪ ʊ ɛ ɔ a/ (*/i u e/)	1
#27	25	[voiced]	/b d g z n l i u a/	1
	25	[plain (vs. flat), tense]	/e i/	2
	25	[non-consonantal, non-vocalic, voiced]	/j w/ (*/h ʍ/)	3
	25	[interrupted, non-vocalic, oral]	/p t k b d g/ (*/ɾ/)	3
	25	[grave, strident]	/f v/, /q G χ ħ/	2
#32	23	[non-vocalic]	/p t ʔ b g s h z n j/	1
#33	22	[consonantal, interrupted, unvoiced]	/p t k/	3
#34	22	[compact, strident]	/tʃ dʒ ʃ ʒ/	2
	21	[continuant, non-diffuse, non-vocalic]	/j w/	3
#36	21	[acute, compact]	/ʈ c ɖ ɟ ɳ ɲ ɭ ʎ j/	2
#37	20	[non-consonantal, unvoiced]	/j w i u ɪ ʊ e o ɛ ɔ/	2
#38	20	[grave, unvoiced]	/p k f x/	2
#39	19	[grave, non-compact, non-vocalic]	/p b f w/	3

Table 6.5. The most common natural classes (Preliminaries)

Rank	Number	Class Description	Example	Features
#1	433	[+syl]	/i u e o a m̩ n̩/	1
#2	180	[–syl]	/p t k s h m n l r j w/	1
#3	162	[+nasal]	/m n ŋ/	1
#4	86	[+high, +tense]	/i u/	2
#5	80	[+tense, –back]	/i e/	2
#6	77	[+round]	/u ʊ o ɔ/	1
#7	73	[–voice]	/p t k s ʃ h/	1
#8	64	[+syl, –back]	/i ɪ e ɛ/	2
#9	62	[+back, –son]	/k g x ŋ/	2
#10	57	[+tense]	/i u e o/	1
	57	[+back, +voc]	/ɨ u ʊ ə o ɔ a/	2
#12	53	[–son]	/p t k b d g tʃ dʒ s z/	1
#13	46	[+voice, –cons, –voc]	/j w/	3
#14	44	[+syl, –high]	/e o ɛ ɔ a/	2
#15	43	[+voice, –son]	/b d g dʒ z/	2
#16	40	[+LONG]	/iː uː eː oː aː/	1
#17	37	[+syl, –round]	/i ɨ e/	2
	37	[+syl, –LONG]	/i u a/ (*/iː uː aː)	2
#19	36	[–cont, –voice]	/p t k ʔ tʃ/	2
	36	[+tense, –high]	/e o/	2
#21	35	[–movement of glottal closure]	/p t k b d g tʃ */p’ ɓ…/	1
	35	[–cont, –son]	/p t k b d g tʃ dʒ/	2
#23	33	[+cor, +voc]	/l r/	2
#24	32	[+voc, –tense]	/ɪ ʊ ɛ ɔ a/ (*/i u e/)	2
	32	[+cor, –movement of glottal closure]	/t d tʃ dʒ/ (*/t’ ɗ/)	2
#26	30	[+voice, –syl]	/b d g z m n l r j w/	2
	30	[+high, +voc]	/i ɨ ɪ ɯ u ʊ/	2
#28	29	[+voice, –movement of glottal closure]	/b d g/ (*/ɓ ɗ ɠ/)	2
	29	[+cons]	/t k b d s n l r/ (*/h j/)	1
	29	[+ant, –tense]	/m n/	2
#31	28	[+delayed release]	/ts dz tʃ dʒ/	1
#32	27	[+nasal, +voc]	/ĩ ũ ẽ õ ã/	2
#33	25	[+voice]	/b d g z n l i u a/	1
#34	24	[+ant, –cor]	/p b f v m w/	2
#35	23	[+back, +cons]	/k g ŋ/	2
#36	21	[+high, –back, –syl]	/tʃ dʒ ɲ ʎ j/	3
#37	20	[–cons, –syl]	/j w/	2
	20	[+syl, –nasal]	/i u a/ (*/ĩ ũ ã/)	2
	20	[+son, –voice]	/ʔ h ʍ/	2
	20	[+cor]	/t d c ɟ s z ç ʝ n l r j/	1

Table 6.6. The most common natural classes (SPE)

Rank	Number	Class Description	Example	Features
#1	401	[+SYLLABIC]	/i u e o a m̩ n̩/	1
#2	185	[–SYLLABIC]	/p t k s h m n l r j w/	1
#3	163	[+nasal]	/m n ŋ/	1
#4	124	[+SYLLABIC, Coronal]	/i e/	2
#5	91	[+SYLLABIC, Labial]	/u o/	2
#6	86	[C-place Lingual, Dorsal]	/k g x ŋ/	2
#7	78	[–voice]	/p t k s ʃ h/	1
#8	70	[+vocoid, –SYLLABIC]	/j w/	2
#9	61	[+SYLLABIC, –open2]	/i u e o/	2
#10	55	[–continuant, –sonorant]	/p t k b d g tʃ dʒ/	2
#11	48	[–sonorant]	/p t k b d g tʃ dʒ s z/	1
	48	[+SYLLABIC, –open3]	/i u ɪ ʊ e o/	2
#13	46	[+SYLLABIC, Lingual]	/i u e o/	2
#14	44	[+SYLLABIC, –LONG]	/i u a/ (*/iː uː aː)	2
#15	43	[+voice, –sonorant]	/b d g dʒ z/	2
#16	42	[+vocoid]	/j w i u ɪ ʊ e o ɛ ɔ/	1
#17	41	[+LONG]	/iː uː eː oː aː/	1
#18	40	[+open2, V-place]	/e o/	2
#19	36	[+voice, –SYLLABIC]	/b d g z m n l r j w/	2
#20	35	[–continuant, –voice]	/p t k ʔ tʃ/	2
#21	33	[C-place Labial]	/p b f v m w/	1
	33	[+open2]	/ɛ ɔ a/	1
#23	32	[+approx, –vocoid]	/l r ɾ/	2
#24	29	[–vocoid]	/t k d g s z n l r/	1
	29	[–sonorant, Dorsal]	/k g x/	2
	29	[+SYLLABIC, +nasal]	/m̩ n̩/ or /ĩ ũ ã/	2
#27	28	[+strident, –continuant]	/ts tʃ dz dʒ/	2
#28	26	[+approx, –SYLLABIC]	/l r ɾ j w/	2
#29	25	[–continuant, –sonorant, Coronal]	/t d tʃ dʒ/	3
	25	[+voice, –continuant, –sonorant]	/b d g dʒ/	3
#31	24	[+voice]	/b d g z n l i u a/	1
	23	[+open3]	/æ a/	1
#33	21	[–continuant, –sonorant, Labial]	/p b/	3
#34	20	[–SYLLABIC, Labial]	/p b f v m w/	2
	20	[–SYLLABIC, –anterior]	/ʈ ɖ c ɟ tʃ dʒ ʂ ʐ ç ʝ/s	2
	20	[+SYLLABIC, –nasal]	/i u a/ (*/ĩ ũ ã m̩ n̩)	2

Table 6.7. The most common natural classes (UFT)

Sagey (1986) predicts that the frequency of natural classes should be negatively correlated with the number of features used to describe them. Other versions of the innate feature theory do not make these predictions. Natural classes found in the database involve between one and five features, although no UFT class involves more than four. As seen in Tables 6.5-7, many of the most common natural classes in each theory require two or more features. Figures 6.2-4 show the 25 most common classes for each number of features, within each theory.

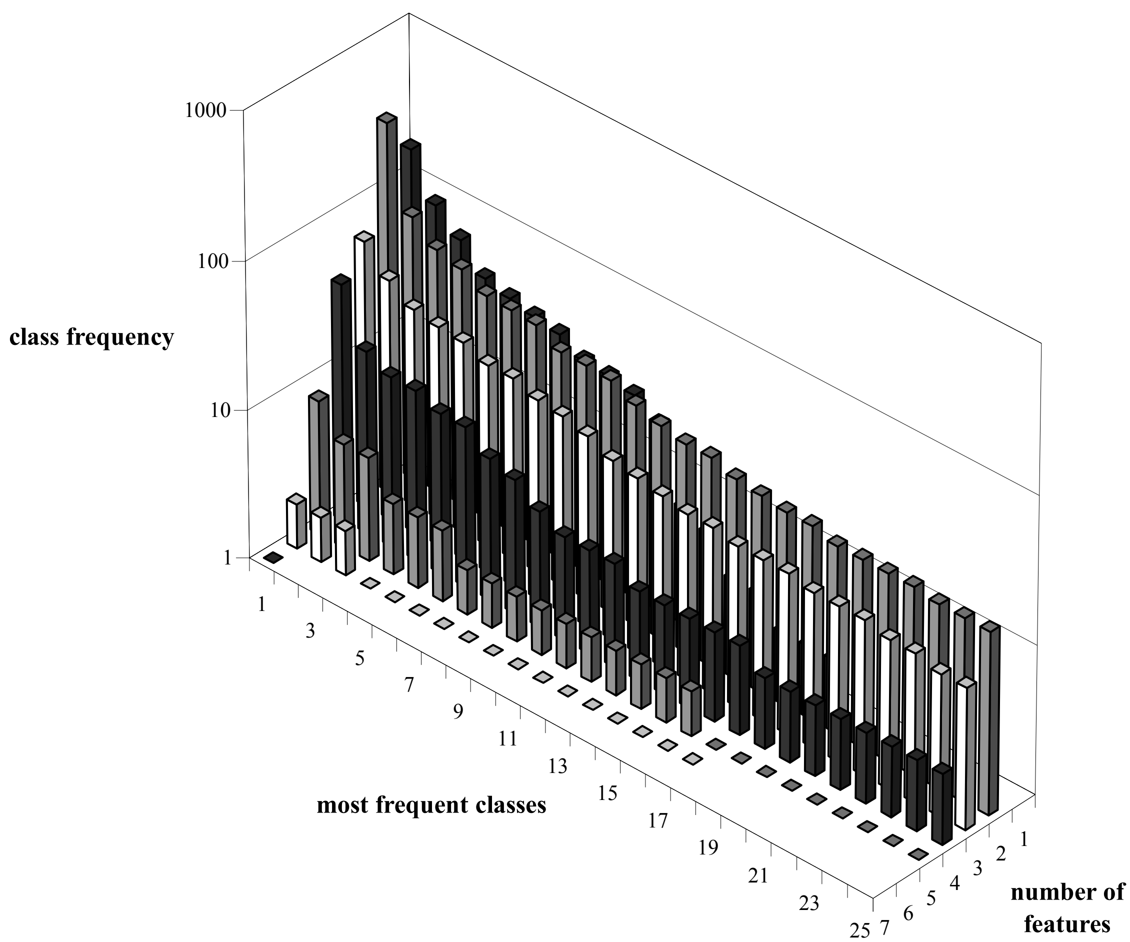


Figure 6.2. The most common natural classes by number of features (JFH)

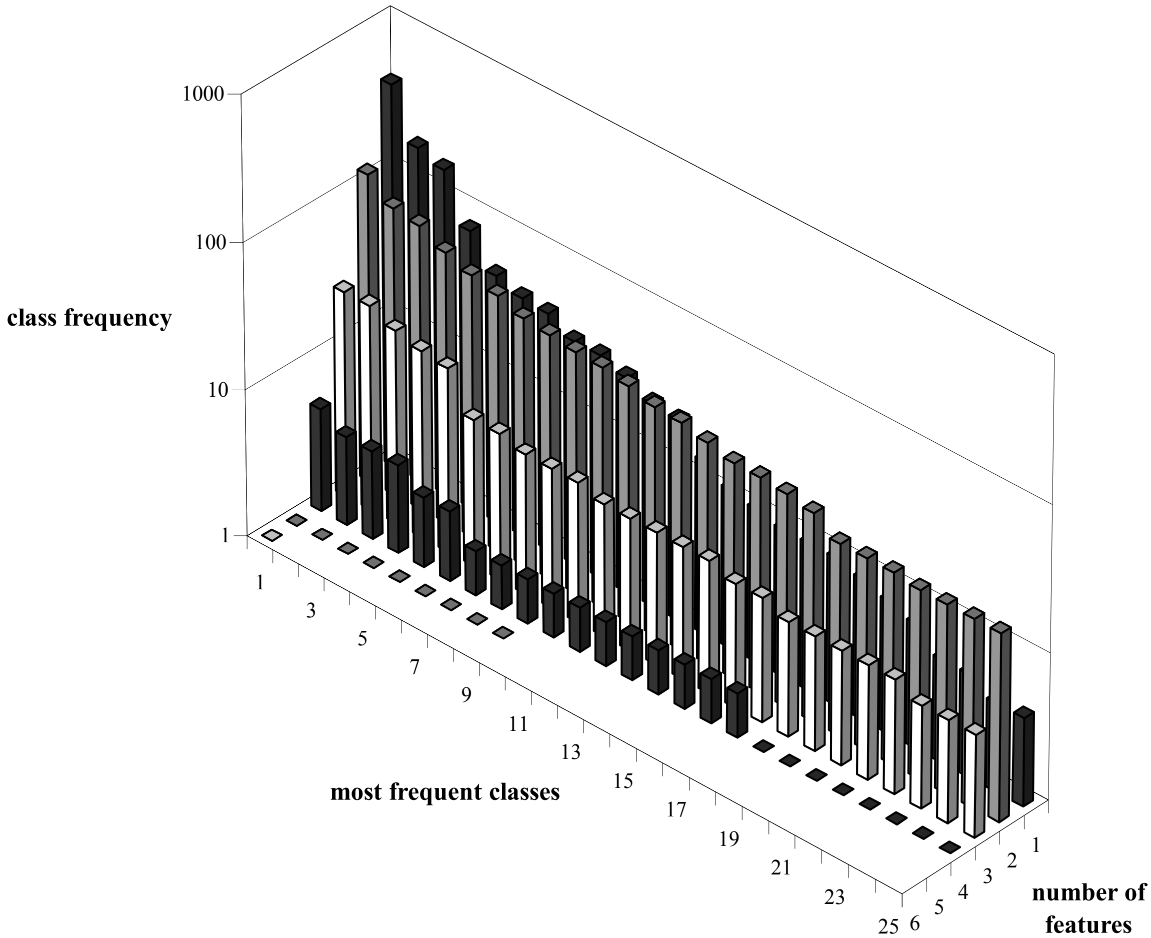


Figure 6.3. The most common natural classes by number of features (SPE)

Classes with few features are favored by the algorithm which minimizes the number of features used to specify a class. On the other hand, classes with more features are favored by the fact that there are simply more of them, and thus they comprise a larger percentage of the possible classes, including the frequent ones. In all three cases, two-feature classes seem to get the best of both worlds. Even so, of the 195 possible two-feature classes in Preliminaries, only 145 occur at least once in the database, and only 271 of the 575 possible SPE two-feature classes occur one or more times. 267 of the 1392 possible UFT two-feature classes are attested at least once. If features were truly the building blocks of phonological patterns, we would expect to see more of these classes appearing. Their absence indicates that other factors (such as those which Emergent Feature Theory attributes natural class behavior to) are at play.

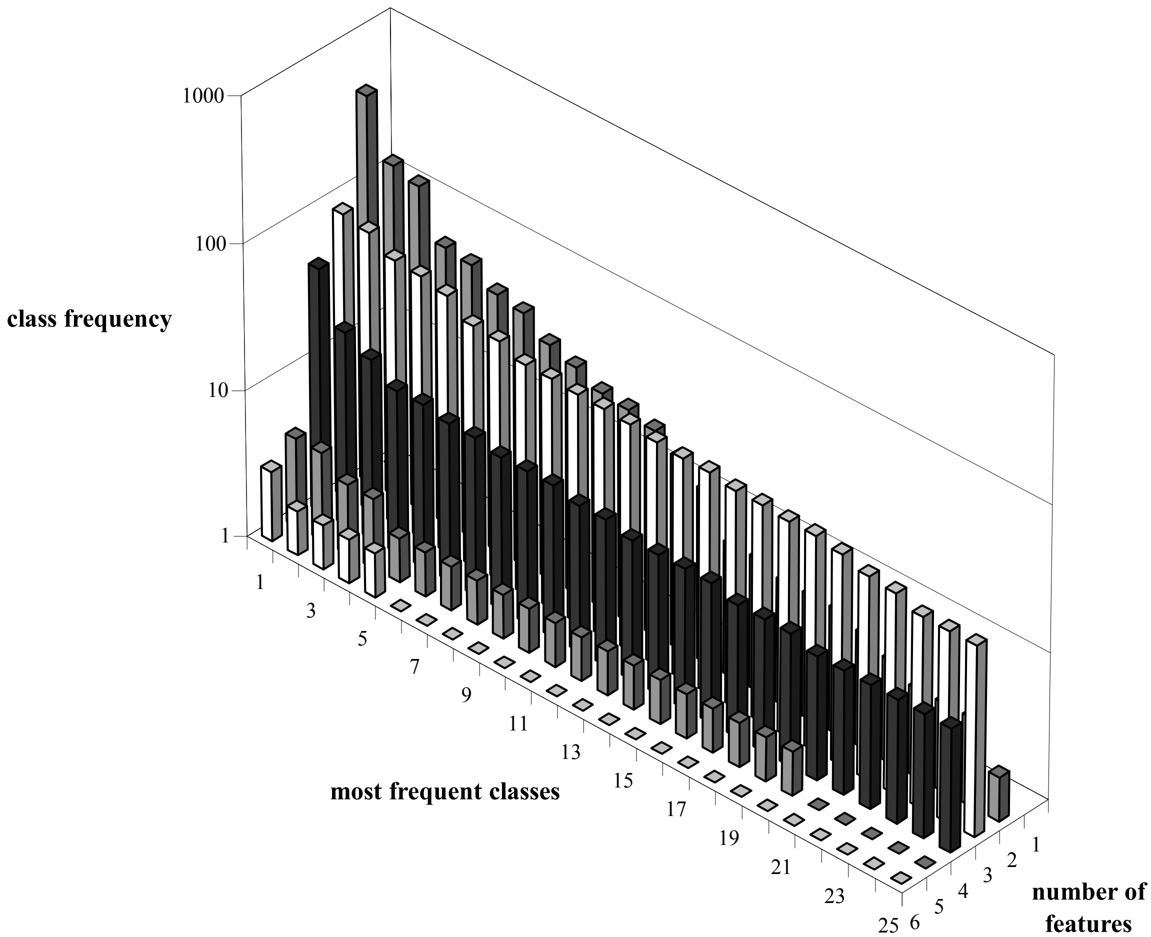


Figure 6.4. The most common natural classes by number of features (UFT)

Figures 6.5-7 show the distribution of frequent and infrequent classes according to the three theories. Natural classes are shown as light bars and unnatural classes are whose as dark bars. The unnatural classes are stated as disjunctions or subtractions, and since all of the unnatural classes are (by definition) ones that the theories are not intended to represent, the frequency of many unnatural classes is probably underrepresented here, with various disjunctions and subtractions actually referring to the same type of unnatural class. While innate feature theories predict that natural classes definable in their features will be more frequent than any idiosyncratic unnatural classes which may occur, there is no evidence of this in the data. In Preliminaries and Unified Feature Theory, unnatural classes rank among the most common recurrent classes. Even in SPE, there is no objective way to partition classes into natural and idiosyncratic categories. Many apparently unnatural classes recur in multiple languages, and ranking classes according to frequency results in a distribution which slopes gently from the common classes which are easily described in phonetic terms and easily characterized in traditional phonetically-defined features, all the way down to the rare classes which occur only once in the survey. Not only is there no visible boundary between the natural and the unnatural, the two are interleaved, with some of the most common unnatural classes being more frequent than most natural classes, and with the vast majority of the natural classes which are predicted by combining distinctive features completely unattested.

In Preliminaries (Figure 6.5), seven unnatural classes rank among the most common classes, even in a theory that is not prepared to deal with them. These are:

- [cons, oral] ∨ [non-voc] (i.e., consonants, occurring 40 times),
- [cons] ∨ [non-voc] (i.e., consonants, occurring 31 times),
- [cons, mellow] ∨ [non-voc] (i.e., nonstrident consonants, occurring 17 times),
- [non-cons, plain(f), voc] ∨ [tense] (i.e., vowels, occurring ten times),
- [cons] ∨ [non-voc, oral] (i.e., consonants, occurring nine times), and
- [cons, voc] ∨ [nasal] (i.e., nasals and liquids, occurring nine times).

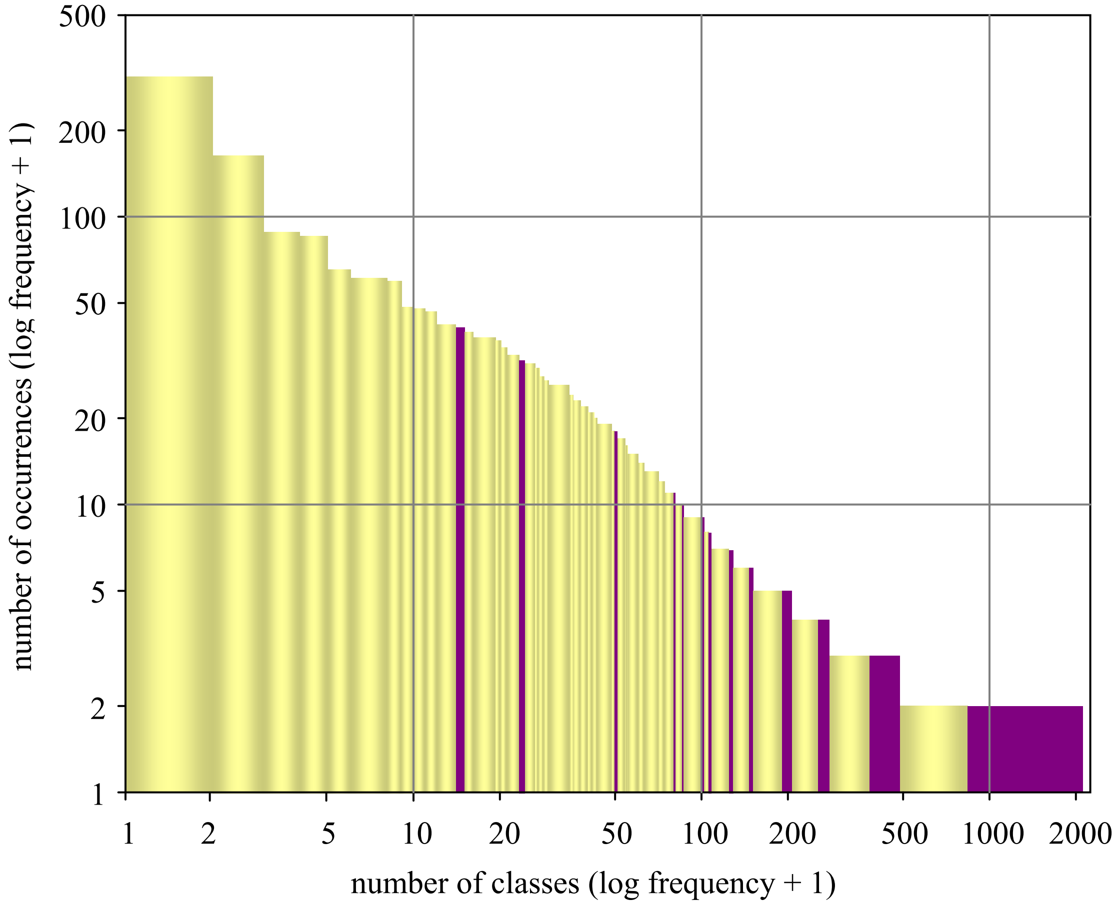


Figure 6.5. The distribution of frequent and infrequent natural and unnatural classes (Preliminaries)

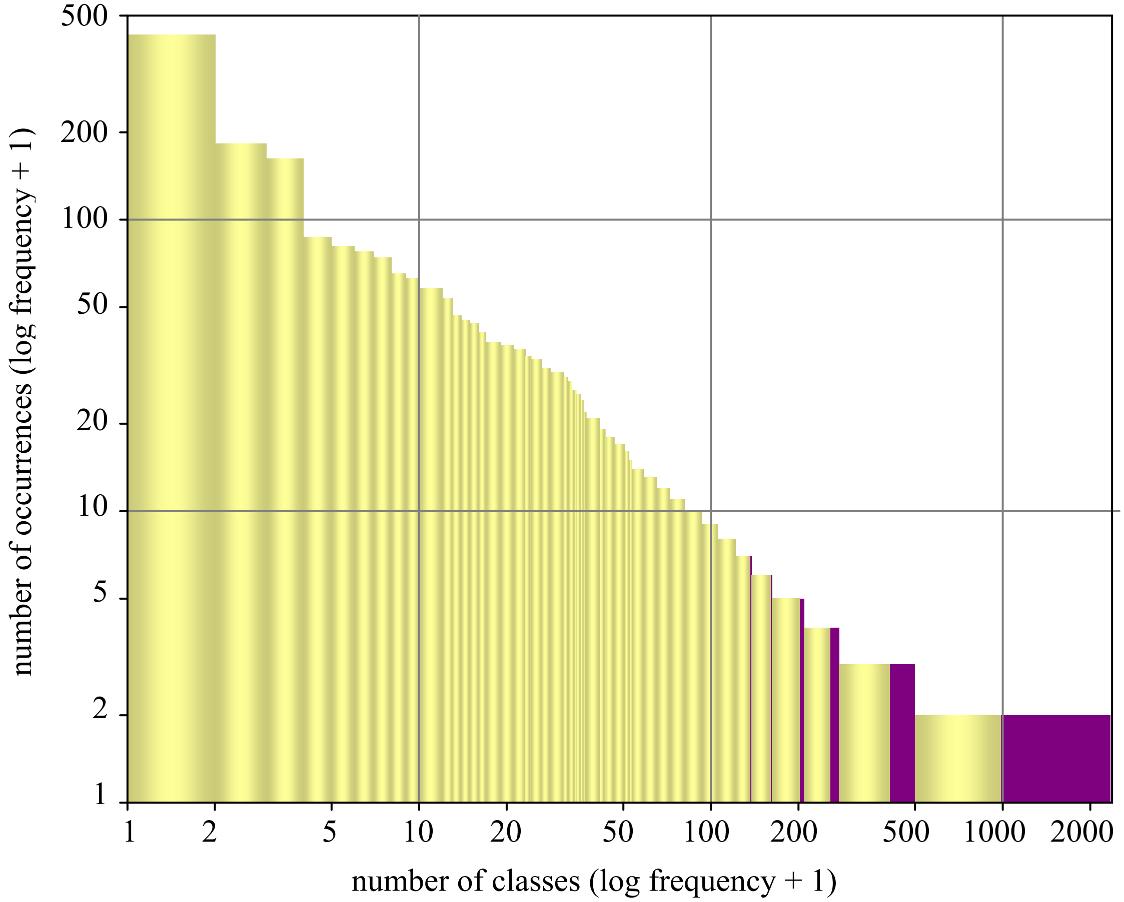


Figure 6.6. The distribution of frequent and infrequent natural and unnatural classes (SPE)

In SPE (Figure 6.6), the most common unnatural class is [+high, +tense] ∨ [+voc, –tense] (/i u a/ or /i u ɛ ɔ a/), occurring six times. This chart looks much better than the other two. In fact, the 113 most common classes are statable as a conjunction of SPE features. The situation is actually worse than it appears, for a couple of reasons. For example, the unnatural classes are more recurrent than they appear when they are counted in terms of the very theory that has difficulty representing them. As mentioned above, there are recurrent classes JFH and UFT can handle but SPE cannot, such as the 22 classes involving dental/alveolar and palatal consonants. Common classes such as this one are fragmented and register instead as several less common classes. One of the reasons for this is that there are often several different ways to represent classes, particularly classes which require feature disjunction, and so classes which are common do not appear to be common, because each possible feature analysis is counted separately. A more theory-neutral method of counting recurrent classes would reduce this problem.

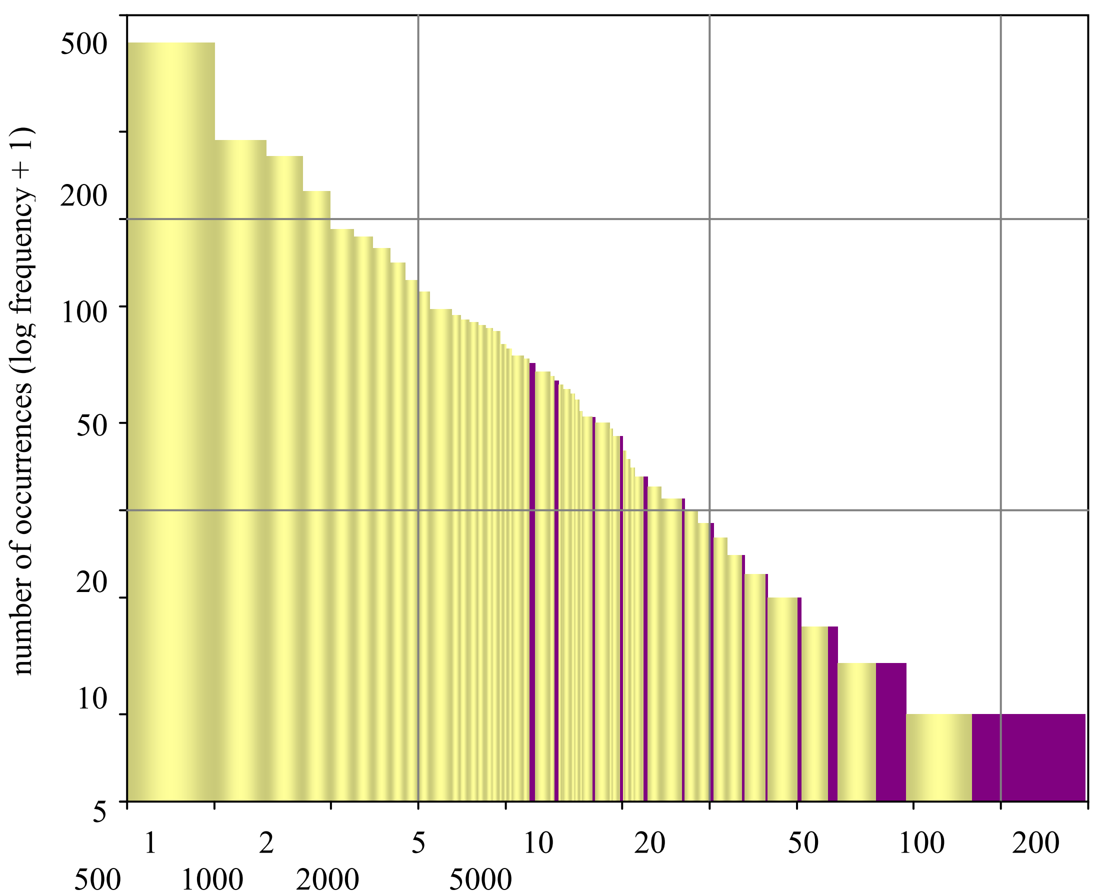


Figure 6.7. The distribution of frequent and infrequent natural and unnatural classes (UFT)

In UFT (Figure 6.7), seven unnatural classes are shown in the top part of the chart, ranking among the most common classes. These are:

- [+SYLLABIC, Labial] ∨ [+open1]
- (i.e., round back vowels & /a/, occurring 31 times)
- [+SYLLABIC, Coronal] ∨ [+open1]
- (i.e., unrounded front vowels & /a/, occurring 27 times)
- [+open1] ∨ [+open2, Labial]
- (i.e., round nonhigh back vowels & /a/, occurring 20 times)
- [+open1] ∨ [+open2, Coronal]
- (i.e., unrounded nonhigh front vowels & /a/, occurring 17 times)
- [–son, Dorsal] ∨ [–son, Labial]
- (i.e., grave obstruents, occurring 12 times)
- [+SYLLABIC, –open2] ∨ [+open1]
- (i.e., high and low vowels, occurring 12 times)
- [+distributed, –open6] ∨ [–open6, Labial]
- (nonlow front vowels and nonlow round vowels, occurring 10 times)
- [+SYLLABIC, Dorsal] ∨ [+open1]
- (back vowels & /a/, occurring 10 times)

Just as there is a wide range of frequencies among the classes occurring in the database, there is a wide range of frequencies of the features used to define them. Tables 6.8-10 show the frequency of occurrence of each feature in the natural classes descriptions in each of the three feature theories. It is clear from the tables that all features are not equal. Some are more common than others. The features which are most common in natural class specifications are those which occur in the most inventories. For example [sharp] in *Preliminaries* is rare in large part because few languages have contrastive palatalization. Emergent Feature Theory predicts that the number of occurrences of a particular feature is directly associated with how clear the phonetic correlates are (and how likely the features are to be involved in a phonetically-based generalization) This prediction is examined later in this section.

Rank	Number	Feature	Rank	Number	Feature
#1	855	vocalic	#16	269	plain (vs. flat)
#2	644	non-consonantal	#17	259	voiced
#3	623	non-vocalic	#18	239	continuant
#4	540	interrupted	#19	209	flat
#5	524	acute	#20	205	mellow
#6	499	grave	#21	168	lax
#7	462	oral	#22	159	strident
#8	456	tense	#23	129	SHORT
#9	442	unvoiced	#24	65	LONG
#10	407	non-compact	#25	54	unchecked
#11	390	consonantal	#26	38	plain (vs. sharp)
#12	298	compact	#27	24	checked
#13	288	diffuse	#28	11	sharp
#14	286	non-diffuse	#29	6	NON-EXTRA
#15	272	nasal	#30	2	EXTRA

Table 6.8. The most common features occurring in natural classes (Preliminaries)

Rank	Number	Feature	Rank	Number	Feature
#1	731	+syllabic		153	–low
#2	456	–sonorant	#27	140	–vocalic
#3	447	–syllabic	#28	131	–LONG
#4	419	+tense	#29	118	+distributed
#5	402	+high	#30	111	–anterior
#6	395	–back	#31	97	–strident
#7	379	–voice	#32	94	–glottal closure
#8	375	+coronal	#33	80	+strident
#9	373	+voice	#34	79	–hi subglottal pressure
#10	333	+vocalic	#35	64	+LONG
#11	307	+back	#36	52	–distributed
#12	282	–high	#37	37	+delayed release
#13	251	+anterior	#38	36	–delayed release
#14	245	+nasal	#39	22	–lateral
#15	215	+sonorant	#40	20	+low
#16	211	–continuant	#41	17	+glottal closure
#17	204	–mov. glottal closure	#42	9	+lateral
#18	195	–coronal	#43	8	+mov. glottal closure
#19	185	+continuant		8	+hi subglottal pressure
#20	180	+consonantal	#45	6	–EXTRA
#21	175	–round	#46	2	+EXTRA
#22	173	+round	#47	1	–del rel 2nd closure
#23	166	–consonantal	#48	0	+covered
#24	164	–nasal			–covered
#25	153	–tense		0	+del rel 2nd closure

Table 6.9. The most common features occurring in natural classes (SPE)

Each of the three theories has features which are used to define a large number of natural classes as well as features which are used very little. The theories are right to posit the commonly-used features, which do indeed allow the specification of many of the classes which occur. The seldom-used features do not seem to share the same status as the commonly used ones, in terms of being part of the set of innate features. In general, these theories do not have anything to say about why some features are more useful than others (nor were they intended to), and below some possible factors are explored. None of the theories comes close to accounting for all of the phonologically active classes or even all of the recurrent ones, indicating that more ways of defining classes are needed. The wide variety of recurrent "unnatural" classes indicates that simply adding more seldom-used features is not a very good solution.

Rank	Number	Feature	Rank	Number	Feature
#1	1058	+SYLLABIC	#36	53	–lateral
#2	536	–SYLLABIC	#37	49	vocalic
#3	486	–sonorant	#38	42	C-place Labial
#4	417	–continuant	#39	33	+constricted glottis
#5	390	Coronal	#40	31	–open4
#6	285	–voice	#41	29	–ATR
#7	274	Labial	#42	25	+ATR
#8	256	+nasal	#43	21	Pharyngeal
#9	250	+voice		21	+open4
#10	185	Dorsal	#45	17	C-place Pharyngeal
#11	170	–strident		17	+spread glottis
	170	+sonorant	#47	14	–open1
#13	158	–open2		14	+lateral
#14	152	–distributed	#49	13	+open1
#15	151	–nasal	#50	7	–open6
#16	144	C-place Lingual	#51	5	–open5
#17	132	+continuant	#52	4	–EXTRA
#18	126	–vocoid	#53	3	+C-place distributed
#19	124	Lingual	#54	2	+open6
#20	122	+vocoid		2	+EXTRA
#21	121	–anterior	#56	1	V-place Lingual
	121	+strident		1	V-place Labial
#23	118	–LONG		1	C-place Coronal
#24	115	C–place		1	–C-place distributed
#25	114	–open3		1	+open5
#26	106	–constricted glottis	#61	0	V-place Dorsal
#27	102	+approx		0	–C-place anterior
#28	100	+open2		0	+V-place distributed
#29	98	–approximant		0	C-place Dorsal
#30	80	V–place		0	V-place Pharyngeal
#31	76	+anterior		0	V-place Coronal
#32	74	+open3		0	+C-place anterior
#33	64	–spread glottis		0	–V-place distributed
#34	62	+LONG		0	+V-place anterior
#35	60	+distributed			

Table 6.10 The most common features occurring in natural classes (UFT)

6.1.1. Place of articulation

The feature theories predict different possible subgroupings of place of articulation among consonants. Table 6.11 shows the subgroupings of different places of articulation found in the database. This includes all of the classes which involve segments from two or more places of articulation to the exclusion of at least one other, provided that the distinction cannot be made in some other dimension such as manner. For example, /m n/ does not count as an example of labials and coronals patterning together if these are the only nasals in the language.

The three most common classes are the three possible combinations of two places from among labial, coronal, and velar. Each of the three feature theories predicts at least one of these classes, but none predicts all three. SPE and Preliminaries predict the class of coronals and labials, but only if all the coronals are anterior coronals. Most of the labial/coronal classes do only involve anteriors, but 48 classes involve posterior coronal consonants as well.

On the other hand, UFT predicts no classes involving labials and coronals but not velars, because its place features have no negative values and the lowest node that dominates [Labial] and [Coronal] also dominates [Dorsal]. With a Lingual node, UFT explicitly predicts the class of coronals and velars, which SPE does not predict under most circumstances. But UFT does not predict the grave class, which Preliminaries predicts explicitly. Each theory is a different set of snapshots showing some common classes while neglecting others. None of them shows the entire picture of classes which can arise from sound change and generalization.

Rank	Number	Class Description
#1	175	LABIAL & CORONAL (127 ARE ANTERIOR)
#2	132	CORONAL & VELAR (LINGUAL)
#3	101	LABIAL & VELAR (GRAVE)
#4	18	VELAR & GLOTTAL
#5	13	CORONAL, VELAR, AND LARYNGEAL
#6	10	LABIAL, VELAR, AND LARYNGEAL
#7	8	CORONAL & GLOTTAL
#8	7	LABIAL, CORONAL, AND LARYNGEAL
#9	6	LABIAL & LARYNGEAL
#10	5	VELAR & UVULAR 5
#11	4	LABIAL, CORONAL, AND UVULAR
	4	CORONAL & PHARYNGEAL
	4	VELAR & PHARYNGEAL
	4	VELAR & LARYNGEAL
	4	UVULAR & PHARYNGEAL
	4	UVULAR & LARYNGEAL
	4	PHARYNGEAL & LARYNGEAL
#18	3	CORONAL, VELAR, UVULAR, AND LARYNGEAL
	3	CORONAL, VELAR, AND PHARYNGEAL
#20	2	LABIAL, VELAR, AND UVULAR
	2	LABIAL & UVULAR
	2	CORONAL, VELAR, AND LARYNGEAL
	2	VELAR, UVULAR, AND LARYNGEAL
	2	UVULAR, PHARYNGEAL, AND LARYNGEAL
#25	1	LABIAL, CORONAL, AND PHARYNGEAL
	1	LABIAL & PHARYNGEAL
	1	CORONAL, UVULAR, PHARYNGEAL, AND LARYNGEAL
	1	CORONAL, PHARYNGEAL, AND LARYNGEAL
	1	VELAR, UVULAR, PHARYNGEAL, AND LARYNGEAL
	1	VELAR, PHARYNGEAL, AND LARYNGEAL
	1	LABIAL, VELAR, UVULAR, AND LARYNGEAL
	1	LABIAL, VELAR, PHARYNGEAL, AND LARYNGEAL
	1	LABIAL, UVULAR, AND PHARYNGEAL
	1	LABIAL, UVULAR, PHARYNGEAL, AND LARYNGEAL

Table 6.11. Place groupings

SPE makes the claim that phonological patterns can be described using only articulatory features, so the presence of classes that can only be defined acoustically are problematic. SPE predicts the grave class indirectly, in articulatory terms, with the negative value of the feature [coronal]. In addition to many unnatural grave classes (unnatural in ways unrelated to place), there are 25 phonologically active classes of labial and velar segments in languages with palatals and/or uvulars which are handled easily by Preliminaries and UFT, but not by SPE, whose articulatory features are only capable of defining grave classes in languages whose inventories of places of articulation are limited enough that grave happens to equal [–coronal].

The fact that all three pairs of [labial], [coronal], and [velar] are robustly attested indicates that each theory is right about the subgroupings of places they do predict, but wrong about the classes that it excludes. There are many examples of all kinds of subgrouping involving these three places and many less common classes. The findings suggest that any class is possible, but that certain ones involving common places of articulation which share clear articulatory or perceptual properties are most common. The fact that so many different groupings are observed is part of the reason why there are different feature theories. Examining a lot of data at the same time demonstrates that they are correct in positing many of the generalizations that they do, but that none of them is universal.

6.1.2. Phonetic correlates

Emergent Feature Theory predicts that the features with the clearest phonetic correlates will be the most useful for describing natural classes, because these phonetic correlates, rather than the features themselves, are the basis for the generalizations which gave rise to many of the classes. In the next three tables, the phonetic groundedness of the features is compared to the frequency of the features. How frequent a feature can be within natural classes is dependent upon how frequent the feature is in inventories. To control for this, the frequencies of the features are adjusted for the relative availability of the features.

Availability is based on the number of segments in an inventory which bear each value of a feature. If no segments in the inventory are specified for a particular feature value, then the feature is not available for describing natural classes, no matter how phonetically robust it is. Similarly, if only a small portion of the segments are defined for one of the values, the feature is relatively unavailable. A feature is maximally available for natural class formation/description when half of the segments are specified for one value of the feature and half are specified for the other. The numerical representation of availability is defined as the percentage of segments in the language which bear the least common value of the feature. Thus, availability can never be more than 50%. For example, if two out of 25 segments in an inventory are [+spread glottis], then the availability of [spread glottis] is 8%. If 30 out of 50 segments in an inventory are [+sonorant] and 20 are [–sonorant], then the availability of [sonorant] in that language is 40%. The crosslinguistic availability of a feature, as shown in the following tables, is the average of the availability values for all the languages in the survey. The adjusted frequency of occurrence of a feature is the sum of the occurrence of each value (if the feature has more than one value) divided by the availability, i.e., the projected number of occurrences of the feature in a database of the same size in which all features have an availability of 50%. Alternatively, availability could be estimated on the basis of the random classes in Table 6.4.

With the features on equal footing in terms of availability, the frequency of occurrence of all the features can be compared. In the Tables 6.12-14, the adjusted frequencies of the features are compared with their phonetic groundedness, according to a variety of sources. Determining the phonetic groundedness of all the features in the three feature theories is a big task, and so in this case groundedness was estimated on the basis of three criteria and then compared with some of the available experimental evidence on the subject. The adjusted frequency of the features does appear to be roughly correlated with their phonetic groundedness.

The three criteria for groundedness are salience, boundary definition, and uniqueness. All three criteria were rated subjectively on a scale from one to three, with three being the highest. Salience is the perceptual or articulatory distinctiveness of the phonetic correlates of the feature. Boundary definition is how clear the boundary is between one value of the feature and the other. For example, [nasal] and [strident] are both associated with fairly salient contrasts, but differ in their boundary definition. While it is fairly clear which segments are nasal and which are oral, it is less clear where the boundary between strident and mellow should be, given the ambiguity of labiodental and (in Preliminaries) uvular consonants, and the high frequency noise associated with some nonstrident stop release bursts. Uniqueness indicates to what extent the feature is expected to make distinctions no other feature can make. For example, while [nasal] can make many distinctions that no other feature can make, [consonantal] and [vocalic] involve a lot of redundancy, only differing for liquids and glides. This is obviously an oversimplification. Other factors such as interactions between features (see Archangeli and Pulleyblank 1994) and word position, syllable position, and segmental context clearly play roles that are not considered here.

Feature	Estimated groundedness				Adj. Freq.	Avail.	Frequency	
	sal.	bnd.	uniq.	TOT			+	–
tense/lax	2	2	3	7	4836.0	6.5%	456	168
nasal/oral	3	3	3	9	3792.3	9.7%	272	462
flat/plain	2	1	1	4	3704.5	6.5%	209	269
vocalic	2	3	1	6	2545.4	29.0%	855	623
consonantal	2	2	1	5	1457.0	35.5%	390	644
grave/acute	2	3	2	7	1321.4	38.7%	499	524
voiced/unvoiced	3	3	3	9	987.8	35.5%	259	442
interrupted/continuant	2	2	1	5	805.0	48.4%	540	239
compact/noncompact	1	1	2	4	780.5	45.2%	298	407
strident/mellow	3	1	2	6	705.3	25.8%	159	205
diffuse/nondiffuse	1	2	2	5	637.7	45.2%	288	288
checked/unchecked	2	2	3	7	403.0	9.8%	24	54
sharp/plain	1	1	3	5	379.8	6.5%	11	38
LONG	n/a	n/a	n/a	n/a	n/a	0%	65	129
EXTRA	n/a	n/a	n/a	n/a	n/a	0%	2	6

Table 6.12. Correlation between phonetic groundedness and adjusted frequency of features in natural classes (JFH)

Feature	Estimated groundedness				Adj. Freq.	Avail.	Frequency	
	sal.	bnd.	uniq.	TOT			+	–
round	3	3	3	9	2697.0	6.5%	173	175
distributed	1	2	2	5	2635.0	3.2%	118	52
syllabic	3	3	1	7	2608.4	22.6%	731	447
nasal	3	3	3	9	2113.2	9.7%	245	164
tense	2	2	2	6	1773.2	16.1%	419	153
back	2	2	2	6	1209.0	29.0%	307	395
movement of gl. clos.	1	2	2	5	1095.3	9.7%	8	204
voice	3	3	2	8	1059.6	35.5%	373	379
low	2	1	3	6	893.8	9.7%	20	153
vocalic	1	2	1	4	814.6	29.0%	333	140
high	2	1	3	6	757.3	45.2%	402	282
sonorant	3	2	1	6	693.4	48.4%	215	456
coronal	2	2	2	6	679.6	41.9%	375	195
consonantal	1	2	1	4	487.5	35.5%	180	166
lateral	3	3	3	9	480.5	3.2%	9	22
anterior	1	1	2	4	467.6	38.7%	251	111
glottal (3ary) closure	1	2	2	5	430.1	12.9%	17	94
continuant	1	1	1	3	409.2	48.4%	185	211
strident	3	1	1	5	342.9	25.8%	80	97
delayed prim. release	2	3	2	7	196.3	9.7%	37	1
del. rel. of 2nd closure	n/a	n/a	n/a	n/a	n/a	0%	0	0
hi subglottal pressure	n/a	n/a	n/a	n/a	n/a	0%	8	79
covered	n/a	n/a	n/a	n/a	n/a	0%	0	0
LONG	n/a	n/a	n/a	n/a	n/a	0%	64	131
EXTRA	n/a	n/a	n/a	n/a	n/a	0%	2	6

Table 6.13. Correlation between phonetic groundedness and adjusted frequency of features in natural classes (SPE)

Feature	Estimated groundedness				Adj. Freq.	Avail.	Frequency	
	sal.	bnd.	uniq.	TOT			+	–
SYLLABIC	3	2	1	6	3529.6	22.6%	1058	536
nasal	3	3	3	9	2102.8	9.7%	256	151
open2	2	2	3	7	1999.5	6.5%	100	158
spread	3	2	3	8	1255.5	3.2%	17	64
lateral	3	3	3	9	1038.5	3.2%	14	53
C-place	1	2	2	5	891.2	6.5%	115	
voice	3	2	2	7	753.9	35.5%	250	285
open3	2	2	3	7	728.5	12.9%	74	114
labial	3	3	3	9	707.8	19.4%	274	
sonorant	3	2	1	6	677.9	48.4%	170	486
continuant	1	1	2	4	576.6	48.4%	132	426
strident	3	1	2	6	563.8	25.8%	121	170
constricted	1	2	3	6	538.6	12.9%	33	106
dorsal	2	2	3	6	477.9	19.4%	185	
C-place lingual	2	3	1	6	446.4	16.1%	144	
coronal	2	2	3	6	431.8	45.2%	390	
vocoid	3	2	1	6	427.1	29.0%	122	126
ATR	1	2	2	5	418.5	6.5%	25	29
open1	2	2	3	7	418.5	3.2%	13	14
V-place	1	1	1	3	413.3	9.7%	80	
anterior	1	1	2	4	381.7	25.8%	76	121
approximant	3	2	1	6	281.8	35.5%	102	98
lingual	2	2	3	7	240.3	25.8%	124	
C-place labial	3	3	1	7	217.0	9.7%	42	
vocalic	2	2	1	5	84.4	29.0%	49	
V-place labial	3	3	1	7	5.2	9.7%	1	
C-place coronal	2	2	1	5	1.9	25.8%	1	
C-place dorsal	n/a	n/a	n/a	n/a	n/a	9.7%	0	
V-place dorsal	n/a	n/a	n/a	n/a	n/a	9.7%	0	
C-place anterior	n/a	n/a	n/a	n/a	n/a	19.4%	0	0
V-place coronal	n/a	n/a	n/a	n/a	n/a	9.7%	0	
C-place pharyngeal	n/a	n/a	n/a	n/a	n/a	0%	17	
open4	n/a	n/a	n/a	n/a	n/a	0%	21	31
open5	n/a	n/a	n/a	n/a	n/a	0%	1	5
open6	n/a	n/a	n/a	n/a	n/a	0%	2	7
V-place lingual	n/a	n/a	n/a	n/a	n/a	0%	1	
V-place pharyngeal	n/a	n/a	n/a	n/a	n/a	0%	0	
pharyngeal	n/a	n/a	n/a	n/a	n/a	0%	21	
C-place distributed	n/a	n/a	n/a	n/a	n/a	0%	34	12
distributed	n/a	n/a	n/a	n/a	n/a	0%	60	152
V-place anterior	n/a	n/a	n/a	n/a	n/a	0%	0	0
V-place distributed	n/a	n/a	n/a	n/a	n/a	0%	0	0
LONG	n/a	n/a	n/a	n/a	n/a	0%	62	118
EXTRA	n/a	n/a	n/a	n/a	n/a	0%	2	4

Table 6.14. Correlation between phonetic groundedness and adjusted frequency of features in natural classes (UFT)

It is not possible to evaluate the utilization of the phonetic properties directly, as they are all mediated by the features and the feature systems in which they appear. There are many factors contributing to the adjusted frequency of the features, and they are not a direct reflection of the phonetic properties of the classes they represent. Nevertheless, the estimated groundedness of the features appears to correlate somewhat with the adjusted frequency, especially for SPE, which incidentally has the highest success rate of the three feature systems. Even if the groundedness does not translate into accuracy, the SPE feature counts are based on a larger portion of the phonologically active classes (since they can account for more of them).

A number of perception studies have examined the usefulness of phonetic features for discrimination of segments under various listening conditions. Table 6.15 shows the relative rankings of features in terms of sequential information analyses from confusion matrices from various studies. Shown here are results from Miller and Nicely (1955), Singh and Black (1966), Graham and House (1971), and Wang and Bilger (1973). See Wang and Bilger for discussion of these results. These results also show a correlation with the adjusted frequencies of the distinctive features.

Emergent Feature Theory claims that the phonetic properties of speech sounds, rather than distinctive features, are primarily responsible for their groupings into phonologically active classes. The fact that there is a correlation between the frequency of phonetically grounded features and experimental measurements of their perceptual distinctiveness, even with all of the complications presented by the feature theory itself, is promising.

Feature	Sequential information rank				Adj. Freq.	Avail.	Frequency	
	M&N	S&B	G&H	W&B			+	–
round	—	—	6	—	2697.0	6.5%	173	175
nasal	1	1	8	1	2113.2	9.7%	245	164
back	—	4	—	5	1209.0	29.0%	307	395
voice	2	5	4	2	1059.6	35.5%	373	379
low	—	7	9	4	893.8	9.7%	20	153
vocalic	—	2	—	—	814.6	29.0%	333	140
high	—	—	—	6	757.3	45.2%	402	282
consonantal	—	—	7	—	487.5	35.5%	180	166
anterior	—	—	5	6	467.6	38.7%	251	111
continuant	4	—	—	4	409.2	48.4%	185	211
strident	3	—	1	7	342.9	25.8%	80	97
[place]	5	8	10	8	n/a	n/a	n/a	n/a
[frication]	—	—	3	—	n/a	n/a	n/a	n/a
[duration]	—	—	2	—	n/a	n/a	n/a	n/a

Table 6.15. Sequential information analysis results (rankings) for various features compared with SPE survey results (Miller and Nicely 1955, Singh and Black 1966, Graham and House 1971, Wang and Bilger 1973)

6.1.3. Defining unnatural classes

It was expected that innate feature theories will be forced to use feature disjunction in order to account for many of the classes in the database as the unions of smaller classes which they are capable of describing. As seen above in Figures 6.5-7, this is true. Feature theories predict that this will happen on occasion, as there is nothing which prevents multiple classes from being affected by the same process. The result would be the union of two natural classes appearing to behave as a single phonologically active class.

Emergent Feature Theory predicts that the most common of the classes which require disjunction or subtraction will be those which are phonetically natural but inexpressible in the theory with a conjunction of features. The innate feature theories predict that the most common complex classes will be composed of classes which are very common natural classes on their own.

		Components			
Rank	Number	Rank among natural classes	Number of natural classes	Class	Description
#1	40	#116	6	[consonantal, oral]	consonants
		#32	23	∨ [non-vocalic]	
#2	31	#19	34	[consonantal]	consonants
		#32	23	∨ [non-vocalic]	
#3	17	#335	1	[consonantal, mellow]	nonstrident consonants
		#32	23	∨ [non-vocalic]	
#4	10	#20	32	[non-consonantal, plain	vowels
		#20	32	(vs. flat), vocalic] ∨ [tense]	
#5	9	#19	34	[consonantal]	consonants
		#96	7	∨ [non-vocalic, oral]	
	9	#18	36	[consonantal, vocalic]	nasals and liquids
		#2	164	∨ [nasal]	
#7	8	n/a	0	[consonantal, plain (vs. flat)]	nonlabialized
		#32	23	∨ [non-vocalic]	consonants, etc.
	8	#228	2	[consonantal, non-compact]	labial, dental, and
		#32	23	∨ [non-vocalic]	alveolar consonants
#9	7	#3	88	[diffuse, tense] ∨ [lax]	high tense vowels and
		#26	26		lax vowels
	7	#19	34	[consonantal] ∨ [unvoiced]	consonants
		#4	85		(including /h ʔ/)
	7	#109	6	[acute, nasal]	liquids and coronal
		#18	36	∨ [consonantal, vocalic]	nasals

Table 6.16. The most common complex classes (Preliminaries)

The results support the emergent feature approach. While many unnatural classes are describable as the union of two natural classes, the most common of the classes which can be analyzed in this way are composed of phonetically-similar segments, but analyzable only as the union of classes which are very rare on their own.

A prime example is the two most common unnatural classes in JFH. Both of these classes represent the class of consonants (as opposed to vowels). While this is a phonetically natural class, the natural classes which are patched together to represent them are even less common than the class being constructed by this ad hoc means.

Tables 6.16-18 list the number of occurrences of the most common classes requiring disjunction or subtraction, along with their rank among common unnatural classes. The number of occurrences of the natural classes which they are based on are also listed, along with their ranks among the most common natural classes. It is clear that the most common unnatural classes do not result from combinations of the most common natural classes.

Clearly this is an indication that JFH leaves a hole in its coverage. It is unable to characterize the set of consonants (including glides and liquids), even though this is a common class. The fact that this class can be constructed from smaller rarer classes that JFH can describe is a coincidence. Many of the unnatural classes listed for UFT in Table 6.18 are classes involving front or back vowels and a single low vowel.

Rank	Number	Components: Rank among natural classes	Components: Number of natural classes	Class	Description
#1	6	#4 #24	86 32	[+high, +tense] ∨ [+vocalic, –tense]	/i u a/ or /i u ɛ ɔ a/
#2	5	#40 #80	20 9	[+coronal] ∨ [–anterior, –back, –syllabic]	dental/alveolar and palatal consonants
	5	#245 #245	2 2	[+coronal, –tense] ∨ [+high, +nasal]	dental/alveolar and palatal nasals
#4	4	#156 #10	4 57	[+low, +vocalic] ∨ [+tense]	low vowels and tense vowels
	4	#156 #3	4 162	[+lateral] ∨ [+nasal]	laterals and nasals
	4	#58 #24	12 32	[+high, +vocalic, –round] ∨ [+vocalic, –tense]	unrounded high vowels and lax vowels
	4	#4 #6	86 77	[+high, +tense] ∨ [+round]	round vowels and high tense vowels
	4	n/a #24	0 32	[+back, –low, –round] – [+vocalic, –tense]	velar consonants, unrounded nonlow back and tense vowels
	4	#196 n/a	3 0	[+back, +voice, –sonorant] ∨ [+coronal, +voice, +movement of glot clos]	voiced velar obstruents and coronal implosive
	4	n/a #10	0 57	[+back, +voice, –low, –round] ∨ [+tense]	voiced velar consonants, unrounded nonlow back and tense vowels
	4	#379 #134	1 5	[+anterior, –coronal, –voice] ∨ [+back, –voice]	voiceless labials and velars

Table 6.17. The most common complex classes (SPE)

Rank	Number	Components: Rank among natural classes	Components: Number of natural classes	Class	
#1	31	#5 #55	91 11	[+SYLLABIC, Labial] ∨ [+open1]	round back vowels and /a/
#2	27	#4 #55	124 11	[+SYLLABIC, Coronal] ∨ [+open1]	unrounded front vowels and /a/
#3	20	#55 #180	11 3	[+open1] ∨ [+open2, Labial]	round nonhigh back vowels and /a/
#4	17	#55 #103	11 6	[+open1] ∨ [+open2, Coronal]	unrounded nonhigh front vowels and /a/
#5	12	#24 #51	29 12	[–son, Dorsal] ∨ [–son, Labial]	grave obstruents
#6	12	#9 #55	61 11	[+SYLLABIC, –open2] ∨ [+open1]	high and low vowels
	10	n/a #180	0 3	[+distributed, –open6] ∨ [–open6, Labial]	front and round nonlow vowels
#8	10	#47 #55	14 11	[+SYLLABIC, Dorsal] ∨ [+open1]	back vowels and /a/
#9	8	#322 #322	1 1	[+nasal, Coronal] ∨ [+nasal, Labial]	coronal and labial nasals
	8	n/a #322	0 1	[+nasal, –distributed] ∨ [+nasal, Labial]	alveolar and labial nasals
	8	#42 #55	18 11	[+SYLLABIC, –open2, Coronal] ∨ [+open1]	front and low vowels

Table 6.18. The most common complex classes (UFT)

Similarly, the innate feature theories predict that the classes occurring most frequently in the feature description of unnatural classes should also be the most common natural classes, if these classes arise as a result of the cooccurrence of different natural classes that happen to be involved in similar phonological patterns. The results are far from that. Tables 6.19-21 show the most common components of complex unnatural classes. The classes are simply the ones necessary in order to piece together the actually occurring classes that these feature theories cannot represent as conjunctions of features.

Rank	Number	Rank among natural classes	Number of natural classes	Class
#1	150	#32	23	[non-vocalic]
#2	123	#18	36	[consonantal, vocalic]
#3	98	#2	164	[nasal]
#4	89	#19	34	[consonantal]
#5	77	#125	5	[interrupted, vocalic]
#6	63	#143	4	[consonantal, continuant, vocalic]
#7	51	#59	13	[acute, diffuse, tense]
#8	50	#109	6	[consonantal, oral]
#9	49	#37	20	[non-consonantal, unvoiced]
	49	#109	6	[acute, nasal]

Table 6.19. The ten most common components of complex classes (Preliminaries)

Rank	Number	Rank among natural classes	Number of natural classes	Class
#1	51	#245	2	[+coronal, –tense]
#2	41	#156	4	[+lateral]
#3	34	#245	2	[+vocalic, –lateral]
#4	33	#1	433	[+syllabic]
	33	#3	162	[+nasal]
	33	#4	86	[+high, +tense]
	33	#134	5	[+back, –voice]
#8	29	#156	4	[+low, +vocalic]
	29	n/a	0	[+coronal, –movement of glottal closure]
#10	27	#71	10	[+high, +round]

Table 6.20. The ten most common components of complex classes (SPE)

Rank	Number	Rank among natural classes	Number of natural classes	Class
#1	203	#55	11	[+open1]
#2	63	#322	1	[+nasal, Labial]
#3	60	#5	91	[+SYLLABIC, Labial]
#4	54	#1	401	[+SYLLABIC]
#5	52	#6	86	[Dorsal, C-place Lingual]
#6	50	#51	12	[–sonorant, Labial]
	50	#4	124	[+SYLLABIC, Coronal]
#8	43	#8	70	[+vocoid, –SYLLABIC]
#9	41	#62	10	[+lateral]
#10	39	#322	1	[+spread glottis]

Table 6.21. The ten most common components of complex classes (UFT)

While most theories of innate features do predict that unions of natural classes can participate in phonological patterns by chance, they do not predict the types of disjunctions shown here to be necessary to characterize many of the phonologically active classes in the database. Further, it wasseen above in Table 6.4 that the theories are quite effective at describing even randomly-generated classes using the disjunction of two or more feature bundles. These findings weaken one of the remaining caveats available to innate feature theory.

6.2. Other feature theories

While the analysis in this chapter has focused on three feature theories, it is helpful to consider other features and that have been proposed, in order to account for some of the classes these three theories do not account for.

One feature not included in any of the above theories is [guttural] (McCarthy 1991), which applies to uvulars, pharyngeals, and laryngeals. This feature accounts for classes which were accounted for in SPE using [–high]. Since [–high] was no longer in use to refer to consonants in this way at the time, [guttural] was a useful addition to Feature Geometry. McCarthy (and Chomsky and Halle) are correct to propose that sound patterns may make use of a distinction between sounds produced at the uvula or farther back, and sounds produced in front of the uvula. But there are also classes which utilize a similar but slightly different distinction, in which velar fricatives pattern with gutturals. These classes (e.g. in Libyan Arabic) are natural in a theory in which [pharyngeal] refers to laryngeal consonants as well as velar fricatives, which has been proposed by Paradis and LaCharité (2001). However, similar classes which also include velar stops (e.g. in North Israel Bedouin Arabic) require still another definition of the relevant feature.

Avery and Idsardi (2001) propose an account of laryngeal features in which the features form constituents below the laryngeal node. [spread] and [constricted] form the constituent Glottal Width, [stiff] and [slack] form the constituent Glottal Tension, and [raised] and [lowered] form the constituent Larynx Height. Avery and Idsardi use these subgroupings to account for phenomena in Japanese and Korean. This and other Feature Geometry proposals are intended to serve purposes other than to refine the set of predicted natural classes, but such a refinement is nevertheless a consequence. If this arrangement of laryngeal features is assumed, then in addition to the predictions about laryngeal contrast within inventories, a wider range of possible classes defined by laryngeal configuration are expected, possibly including an account for classes in which implosives, but not ejectives, pattern together with both voiced and voiceless stops, or vice versa (e.g. in Adilabad Gondi, Dahalo, Boraana Oromo, Orma, and Waata Oromo)

Additionally, on the topic of laryngeal contrasts, the feature [sonorant voice] has been proposed as a feature that voiced sonorants possess in lieu of the traditional feature [voice] (Rice and Avery 1989, Rice 1992). This feature allows for straightforward analyses of voicing-sensitive phonological patterns which ignore voiced sonorants. The proposal for this feature recognizes phonetic differences between sonorant voicing and obstruent voicing, namely that the former involve spontaneous voicing and the latter do not, and therefore predict (correctly) that phonological patterns may exploit this distinction. However, this feature does not predict any new natural classes, since [sonorant voice] corresponds directly to the conjunction [sonorant, voice] in defining classes.

As mentioned above, supplementing a set of articulatory features with auditory features (Flemming 2002) allows for the representation of some phonologically active classes which are unnatural if only articulatory features are available, such as the full range of classes including just laterals and nasals, and the classes containing sibilants and nasals.

Finally, as shown by Flemming (1998) and Yip (2004a, 2004b), constraint interaction in Optimality Theory predicts a potentially unlimited array of phonologically active classes. It was seen above that Optimality Theory represents class subtraction directly, with antagonistic constraints referring to overlapping classes of segments. If factorial typology is taken seriously, then classes which are defined by fewer interacting constraints are expected to be more common, and this in turn depends on the feature set which is used to formulate the constraints. It is expected that the classes describable by subtraction of classes would involve the subtraction of common classes. The only highly-ranked subtraction class in the three theories is [+back, –low, –round] – [+vocalic, –tense] in SPE. This class is defined in terms of the class of tense vowels, which is quite common, and the class of nonlow nonround back vowels, which does not occur as a class in the database, casting doubt on the idea that this subtraction class results from the interaction of constraints referring to more common classes. In order to evaluate the predictions of Optimality Theory approaches to natural classes, it will be necessary to see how many of the classes formed by the union of natural classes can be described as the subtraction of one class from another, and if the component classes are indeed common.

All of the approaches discussed in this subsection have the effect of adding to the range of possible classes predicted by innate distinctive features. Some of them also withdraw predicted classes from other areas, either by abandoning certain features, which is easily remedied by reintroducing them, or by redefining features, which is less easily remedied. None of these approaches is able to characterize as many phonologically active classes as one would expect if it truly involved a feature set that is specified in Universal Grammar, and is the alphabet from which phonological patterns are constructed.

6.3. Summary

Every proposal for a new feature or a new feature definition recognizes the connection between a particular set of phonetic properties and the existence of phonological patterns which exploit it. This aspect of innate feature theory is in complete agreement with Emergent Feature Theory: various recognizable phonetic properties are associated with phonological patterns. But none of these feature proposals has accompanied evidence for the existence of certain predicted phenomena with evidence *against* the existence of other non-predicted phenomena, and none of the approaches examined is able to account for more than three fourths of the phonologically active classes in this survey. In short, while there is a consensus that there is a connection between phonetic similarity (signified by distinctive features) and phonological activity, there is disagreement over which phonetic properties are appropriate for defining phonologically active classes, and there is no theory of what phonetic properties are *prohibited* from defining phonologically active classes. Feature theories disagree on what is not predicted, and for each theory, there is a wide range of naturally occurring phonologically active classes that they do not predict.

The many instantiations of innate feature theory have provided strong evidence that certain, usually robust, phonetic properties are involved in phonologically active classes. The decades spent on this enterprise have provided quite a bit of insight into what phonetic properties are most likely to define classes. Indeed, phonological theory is greatly indebted to innate distinctive feature theory for this information. But there is also a wide range of less common classes with less robust phonetic correlates, and no evidence that any classes are ruled out. It must be concluded that the positive proposal of innate distinctive feature theory is correct, and the negative proposal is incorrect. To progress further in the pursuit of explanation for phonologically active classes, it is necessary to abandon the hypothesis that features are innate, and to focus on the phonetic properties which actually underlie the phonological groupings and on how abstract features are learned.

6.4. Towards a phonetic similarity model

All of the feature theories discussed above make use of phonetically-defined features. If the features they propose are not actually innate, then the classes they correctly predict must be attributed to the phonetic dimensions the features are grounded in. In Emergent Feature Theory, phonologically active classes are accounted for in part as the result of generalizations to groups of phonetically similar segments. This predicts that a model of phonetic similarity should be able to predict likely phonologically active classes at least as well as any phonetically-based feature theory.

In order to capture all of the factors which are expected to contribute to phonologically active class formation, an adequate model of phonetic similarity would need to draw upon perceptual and articulatory information, and would need to include information on a wide range of segments. Constructing a model which would be sufficient to address all of the questions a phonetic similarity model is intended to answer is beyond the scope of this dissertation, but it is possible to construct a pilot model to at least demonstrate the promise of this pursuit.

The pilot model draws on the confusion matrices from Wang and Bilger's (1973) perception study. This study was selected because it involves a greater number of segments than other studies such as Miller and Nicely (1955), who test only 16 consonants. Wang and Bilger's study examines confusions among 25 English consonants

(/p t k b d g tʃ dʒ f θ s ʃ h v ð z ʒ m n ŋ l ɹ j ʍ w/) in CV and VC syllables. Wang and Bilger's four confusion matrices (different overlapping subsets of consonants were tested separately) were combined into one large 25 × 25 matrix. This confusion matrix was converted into a distance matrix, and a multidimensional scaling analysis was performed in SPSS, to give a 5-dimensional model (Table 6.22).

consonant	1	2	3	4	5
p	2.1971	-0.2245	-0.2685	0.2126	0.5442
t	1.6899	0.9856	0.2222	-0.019	-0.313
k	-0.4668	-0.9313	1.6769	-1.1242	-1.5968
b	0.135	0.1403	-1.585	-0.1685	0.9983
d	-0.6007	0.9871	-0.5486	-1.2595	-0.7856
g	-0.2727	-0.7603	0.019	-1.3472	-0.2326
tʃ	1.4799	0.5594	0.417	1.4956	-1.16
dʒ	-0.4668	-0.9313	1.6769	-1.1242	-1.5968
f	1.2601	0.1347	-1.321	0.5386	0.5863
θ	0.5124	0.3567	-1.6357	0.4913	-0.4406
s	0.8298	-0.7117	-1.3018	1.5072	-0.3333
ʃ	0.5451	-0.0148	0.5705	1.8838	-1.0385
h	1.9862	-0.0132	-0.0509	0.6395	1.3597
v	-1.3551	-0.1245	-0.9896	0.018	0.9307
ð	-1.3185	0.2025	-1.4942	-0.2456	-0.1715
z	-1.7014	-0.4442	-0.5025	0.4631	-0.0811
ʒ	-1.557	-0.8806	0.3357	-0.1338	-0.7621
m	-0.4174	2.1854	0.4043	-0.1509	0.7004
n	-1.2158	1.9007	0.437	0.4317	0.5388
ŋ	-0.7017	1.908	1.3051	-0.2257	0.6335
l	-0.7273	-0.2966	0.135	-2.3354	0.4682
r	-1.6106	-0.8786	1.413	-1.5881	0.1598
j	-0.4668	-0.9313	1.6769	-1.1242	-1.5968
ʍ	0.205	-1.7658	1.0611	0.7069	1.2041
w	-0.8369	-1.4551	1.6261	0.2103	0.8945

Table 6.22. Five phonetic dimensions based on a MDS analysis of Wang and Bilger's (1973) confusion matrices

A second model was constructed based on a 4-dimensional multidimensional scaling analysis and an artificial fifth dimension representing place of articulation, a dimension which is underrepresented by the perception data (Table 6.23).

consonant	1	2	3	4	place
p	2.0672	-0.3226	-0.1127	0.3974	2
t	1.6384	0.561	0.2322	-0.03	0.25
k	1.6462	0.1001	-0.788	0.2464	-1
b	0.1099	-1.1066	0.4613	1.1769	2
d	-0.8865	0.6735	0.3082	0.5008	0.25
g	-0.5574	0.4428	-0.8944	0.5666	-1
tʃ	1.8815	-0.3452	0.3365	-1.3485	-0.25
dʒ	-0.0487	-0.0824	-0.8453	-1.4504	-0.25
f	1.1991	-1.1841	0.3203	0.6757	1.5
θ	0.5653	-1.3404	-0.1661	0.2496	0.75
s	1.1397	-1.6482	-0.4573	-0.6091	0.25
ʃ	0.9697	-0.4734	0.0552	-1.8084	-0.25
h	1.9136	-0.328	0.1809	1.1234	-2
v	-1.2442	-0.9172	0.2457	0.7115	1.5
ð	-1.2065	-1.1332	0.0708	0.5476	0.75
z	-1.3718	-0.7649	-0.273	-0.4026	0.25
ʒ	-1.5278	-0.2681	-0.6768	-0.9585	-0.25
m	-0.3581	0.3035	2.1646	0.1436	2
n	-1.0701	-0.2371	1.8616	-0.469	0.25
ŋ	-0.693	1.273	1.8297	-0.214	-1
l	-1.2228	1.5877	0.6704	0.8532	0.25
r	-1.8048	1.7443	-0.6744	-0.0041	0.25
j	-0.6232	1.9828	-0.7387	-1.442	-0.25
ʍ	0.3348	0.602	-1.5976	1.0295	2
w	-0.8504	0.8807	-1.5131	0.5146	2

Table 6.23. Four phonetic dimensions based on a MDS analysis of Wang and Bilger's (1973) confusion matrices and one artificial dimension based on place of articulation

The pairwise single-linkage hierarchical clustering algorithm in the C Clustering Library (de Hoon 2002) was used to locate clusters of segments which are similar with respect to up to five dimensions. A sample dendrogram shows the clusters found in the consonant inventory of Jamaican Creole, based on all five dimensions in the model in Table 6.22. Both of these models can then be compared with the innate feature models in terms of their ability to predict the phonologically active classes that occur.

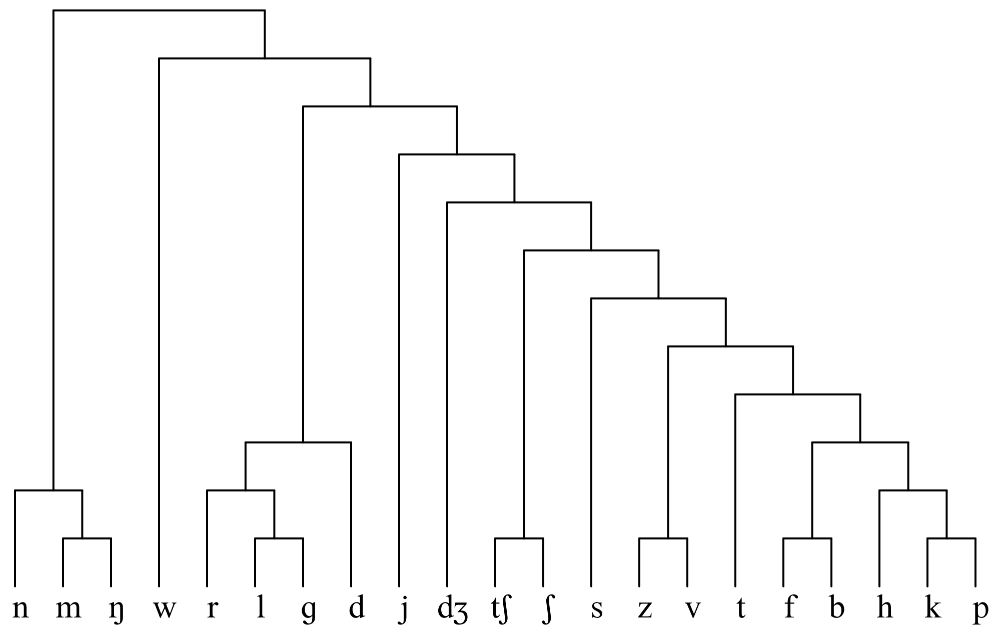


Figure 6.8. A dendrogram based on overall similarity of Jamaican Creole consonants.

The phonetic similarity and innate feature models each assign a score to any set of segments within an inventory, reflecting the likelihood of that set of segments participating being a phonology active class. The innate feature models assign scores according to how many classes are required to represent the set of segments. Classes describable as a conjunction of features receive a score of zero, and one point is added for every additional feature-defined natural class needed to describe the observed class. Because it was the most successful of the innate feature models, SPE is used for comparison to the phonetic similarity models. A lot of different scoring schemes are possible, but these were chosen in order to be in the spirit of the way unnatural classes are handled in each approach, i.e., by combining natural classes in innate feature theory, and by extending a generalization in Emergent Feature Theory.

The phonetic similarity models assign scores according to how well the segments cluster with respect to the model. A set of segments which is a cluster according to the hierarchical clustering algorithm gets a score of zero. Classes which are not clusters are examined starting with the largest cluster which is a subset of the set of segments in question. The score assigned to the class is the sum of the distances from each segment not in the cluster to the nearest segment which is in the cluster.

The data against which the models are tested was limited to the 16 varieties of 15 languages in the database whose consonant inventories employ a subset of the 25 consonants from the Want and Bilger study: Agta (Casiguran Dumagat), Berbice Dutch, Daga, Desano, Jamaican Creole, Kickapoo, Lingala, Meriam, Mishmi, Montagnais, Ndyuka, Nyanja, Sawai, Sentani (including Central dialect), and Xakas. Classes were limited to those which involve no vowels, a total of 59 classes.

The purpose of each of these models is not simply to give good ratings to likely classes, but to distinguish likely classes from unlikely ones. Randomly created classes were used as a control. For each class in each language, a class of the same size was generated randomly. The control for each language was created from ten iterations of this process. The same control was used for all three approaches. Because the purpose is to distinguish likely classes from unlikely ones, each model ideally should give high scores to the randomly-selected classes and low scores to the actual classes. The average scores provided for each language by each model were scaled, and all of these are listed in Table 6.24.

	5 dimensions		4 dim. + place		SPE	
	real	random	real	random	real	random
Berbice Dutch	1.237	2.285	0.630	1.876	0.178	1.451
Agta (Casiguran Dumagat)	0.287	1.792	0.333	1.319	0.000	1.082
Daga	0.000	1.015	0.000	0.633	0.000	0.674
Desano	0.665	1.900	0.414	1.643	0.636	1.082
Jamaican Creole	0.000	0.719	0.000	0.863	0.000	1.400
Kickapoo	0.730	1.459	0.105	1.659	0.000	0.891
Lingala	0.314	1.686	1.222	1.380	0.000	0.923
Meriam	0.000	1.407	0.000	1.164	0.000	0.636
Mishmi	1.040	2.062	1.126	1.564	0.420	1.374
Montagnais	0.000	0.867	0.000	0.985	1.273	0.891
Ndyuka	0.892	2.389	0.703	1.903	0.127	1.451
Nyanja	0.000	1.391	0.000	1.126	0.000	1.693
Sawai	0.813	2.671	2.643	2.108	0.000	1.909
Sentani	0.000	0.083	0.398	1.631	0.000	0.547
Sentani (Central)	0.000	1.385	0.000	1.266	0.000	0.509
Xakas	0.692	2.220	1.106	2.201	0.477	1.686

Table 6.24. Scaled average scores according to three models

The ability of all three approaches to distinguish real from random classes is significant, based on univariate analyses of variance (ANOVA) [5 dimensions: $F(1,15) = 32.663$, $p < 0.001$; 4 dimensions + place: $F(1,15) = 18.990$, $p < 0.001$; SPE: $F(1,15) = 89.006$, $p < 0.001$]. A single ANOVA with model and real vs. random as factors did not show a significant interaction between these two factors [$F(1,2) = .538$, $p = 0.586$], but means and 95% confidence intervals are shown in Figure 6.9.

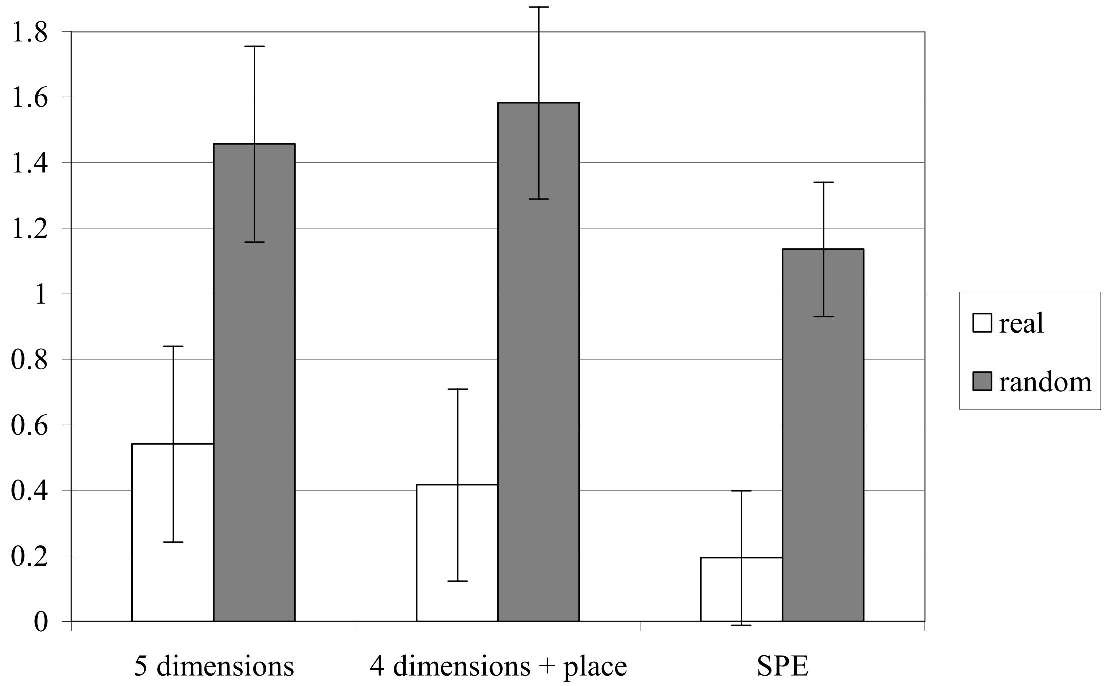


Figure 6.9. Means and 95% confidence intervals for three models.

The ANOVAs and Figure 6.9 show that SPE and the two phonetic similarity models are basically equal in their ability to distinguish real from random classes, but not by very much. The fact that a phonetic similarity model based only on confusion matrices from a single perception study can come so close to an innate feature model is cause for optimism about the prospect of making a less rudimentary model using more comprehensive perceptual and articulatory data.

The ability of this pilot phonetic similarity to be on an equal footing with an innate features model shows the success of innate feature models is not due to the features, but the phonetic facts they are grounded in. Further, it is completely reasonable to attribute the occurrence of phonologically active classes to generalization based on phonetic similarity. A more advanced model would be expected to make better predictions about likely generalizations. The collection of phonetic parameters used to predict classes is not intended to be part of linguistic competence, but simply a picture of the phonetic factors that are relevant for generalization, which is one of the sources of phonologically active classes in Emergent Feature Theory. This model is not directly applicable to sound change, which is another source of phonologically active classes. Phonetic effects such as coarticulation are not predicted on the basis of phonetic similarity, so predicting classes created by sound change requires a different model.

6.5. Conclusions

This chapter has presented the results of the survey of phonologically active classes in general terms, and has examined them in terms of various theories of distinctive features. The predictions made by feature theories have been shown to be correct in the sense that many of the classes they predict truly are common. Nevertheless, many classes which occur and recur in the database are not predicted by these theories at all, and innate feature theories require something like Emergent Feature Theory to account of the actual frequency of occurrence of predicted natural classes anyway. A rudimentary model based on phonetic similarity is able to predict likely classes just as well as SPE, suggesting that the phonetic facts features are grounded in, not the features themselves, are responsible for the theories' success.

CHAPTER 7

FURTHER: EVIDENCE FOR EMERGENT FEATURES: AMBIVALENT SEGMENTS

Ambivalent segments provide an interesting type of evidence for the emergence of distinctive features. It has long been known that some speech sounds have more predictable phonological patterning than others. While some sounds have remained relatively firm in their formal representation over the years, the phonological ambivalence of certain segments has led to disagreements in how they should be represented, and the precise nature of their phonological specification has been somewhat murky. The feature [continuant] is involved in a number of these cases of representational murkiness. Since its introduction (on its own and as the opposite of [interrupted]), there has generally been consensus that fricatives and vowels are most definitely [+continuant], and that oral stops are certainly [–continuant]. But flaps, trills, and lateral liquids have been observed patterning as continuants with fricatives and also patterning as noncontinuants with stops. The feature specification of these liquids has been appropriately controversial.

The analysis of the behavior of these segments will capitalize on the observation that classes with ambivalent segments and 'unnatural' classes tend to involve phonetically similar segments, much like more conventional natural classes. Thus, a unified account of natural and unnatural classes is possible. As will be seen, all of these types of classes can largely be attributed to phonetically-based generalization, with the 'natural' classes simply being attributed to the most common generalizations, those involving phonetic properties which correspond to traditional distinctive features. Ambivalent segments, such as lateral liquids, are those which lie in the middle of some phonetic dimension, so that they can be involved in generalizations originating closer to either end.

Focusing on just the voiced alveolar lateral liquid /l/, diverse phonological patterning and phonological analyses may be observed. For example, Jakobson, Fant, and Halle (1954) group laterals with [continuant] sounds (as opposed to [interrupted]), and similarly Chomsky and Halle (1968) group /l/ with [+continuant] sounds. But 15 years later, Halle and Clements (1983), among others, group laterals with [–continuant] sounds. Kaisse's (ms) informal survey of eleven phonology texts from 1968 to present finds that six of them (55%) treat /l/ as [+continuant], three (36%) treat it as [–continuant], and two (18%) treat it as variable from language to language. Two of the most recent texts disagree on the [continuant] specification of /l/. It will be seen in the following pages that the actual crosslinguistic patterning of /l/ matches these percentages fairly closely.

The difficulty of categorizing /l/ and other liquids on the basis of a phonetic definition of [continuant] is noted by Chomsky and Halle (1968:318, emphasis C&H):

> The characterization of the liquid [l] in terms of the continuant-noncontinuant scale is even more complicated [than the characterization of other liquids]. If the defining characteristic of the stop is taken…as total blockage of air flow, then [l] must be viewed as a continuant and must be distinguished from [r] by the feature of "laterality." If, on the other hand, the defining characteristic of stops is taken to

> be the blockage of air flow past the primary stricture, then [l] must be included among the stops. The phonological behavior of [l] in some languages supports somewhat the latter interpretation.

In treating /l/ as a continuant, Halle and Clements (1983) accordingly adopt a definition that refers specifically to the mid-sagittal region of the vocal tract, which is obstructed in the production of laterals. Kaisse (2000) summarizes the lateral/[continuant] issue as follows: The status of laterals hinges on whether [continuant] is defined in terms of occlusion in the oral tract ('vowel tract', in SPE (p. 318)) or occlusion in the mid-sagittal region of the oral tract. But conversely, the proper definition can only be determined by examining the phonological patterning of laterals. Kaisse examines 17 languages in which [continuant] is relevant for characterizing a process involving /l/, and concludes that sonorant laterals are [–continuant], because they pattern that way in the great majority of these languages, and suggests that the apparent counterexamples should be reanalyzed.

Kenstowicz and Kisseberth (1979:21) summarize the broader state of affairs: phonological patterning motivates the partitioning of speech sounds according to the features [consonantal] and [sonorant], but both are very difficult to define phonetically:

> There are no truly satisfactory articulatory or acoustic definitions for the bases of these two different partitions [consonant and sonorant]. Nevertheless, they are crucial for the description of the phonological structure of practically every language.

Taking this as a starting point for an investigation into the behavior and representation of lateral liquids and other seemingly ambivalent segments, there are essentially two observations: on the one hand it is clear based on phonological patterning that spoken languages exploit an opposition between segments with phonetic properties characterized as ‘continuant’ and ‘interrupted’; on the other hand, it is not clear where the boundary lies, and /l/ is caught in the middle. In the course of this chapter, it will also be seen that nasals exhibit ambivalent behaviour similar to what has been observed for lateral liquids.

The debate over whether /l/ or any other segment is [+continuant] or [–continuant] presupposes that it must be one or the other. This presupposition follows from the claim that distinctive features are universal, innate, and explanatory (Chomsky 1968, Chomsky and Halle 1968, Clements 1985, etc.), stated very clearly by Clements and Hume (1995:245):

> [S]ince features are universal, feature theory explains the fact that all languages draw on a similar, small set of speech properties in constructing their phonological systems… Feature theory… has provided strong confirmation for the view that languages do not vary without limit, but reflect a single general pattern which is rooted in the physical and cognitive capacities of the human species.

Taken seriously, this claim means that the behaviour of /l/ is attributed to whether or not it possesses the specification [+continuant]. The indecision of the past half-century may be attributed to a lack of data points or to the incorrect analysis of certain counterexamples. A weak version of the universalist claim is that segments realized phonetically as [l] may result from two distinct feature bundles, namely one that contains [+continuant] and one that contains [–continuant]. Thus, the phonological patterning would need to be known before the feature specifications could be determined, and so the phonetic properties and phonological patterning are not actually predicted by a universal set of distinctive features. This leaves unanswered the question of why this happens with

/l/ but not with /d/ or /z/, if the ambivalence is permitted by formal rather than phonetic factors.

To understand the relationship between the feature [continuant] and segments such as lateral liquids and nasals, we can ask two questions:

- Are /l/ and other segments truly crosslinguistically ambivalent in their phonological patterning?
- If so, is there a way to predict the flexibility of a given partition and the behaviour of segments along the boundary?

Emergent Feature Theory attributes crosslinguistic regularity of patterning to salient phonetic properties. It follows that segments and classes defined by the clearest properties will be most consistent in their phonological patterning. This in turn predicts that segments which are phonetically more ambiguous with respect to a given parameter (e.g. lateral liquids with respect to [continuant]) will be phonologically more ambivalent.

7.1. Prototypically non-prototypical segments: lateral liquids

A dental, alveolar, retroflex, or palatal lateral liquid appears in 928 of the 6077 phonologically active classes. These 928 classes are categorized according to their apparent specification for the feature [continuant]. Three different feature theories are used in order to maximize the possibility that the classes will be statable as the conjunction of features, and also to maximize the number of alternative analyses not requiring [continuant].

In Preliminaries and SPE lateral liquids are [interrupted] and [–continuant], respectively, while UFT treats them as [+continuant]. To negate any idiosyncratic differences between these feature theories that are unrelated to [continuant], the feature analyses were duplicated with each feature theory's [continuant] specification for lateral liquids reversed. This added a few classes which were unspecifiable otherwise. The features used each of these feature systems are listed above in Table 5.2.

All possible feature characterizations of these classes were computed. The criteria for [continuant] specification are shown in Figure 7.1. A class is classified as necessarily [+continuant] or [–continuant] if it is characterizable using the feature [continuant] in one or more of the eight feature systems in, *and* it is not characterizable within any of these feature systems *without* using the same value of the feature [continuant].

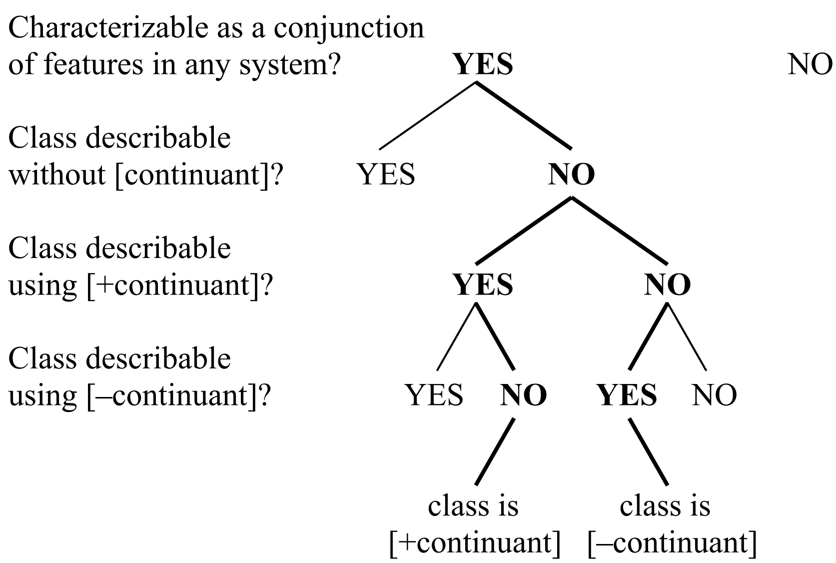


Figure 7.1. Criteria for assigning [continuant] specification to a phonologically active class

Many of the classes in the database are characterizable in many different ways, and these criteria exclude a number of cases which a phonologist would likely analyze using the feature [continuant] but which have alternative analyses which do not involve [continuant]. These classes are excluded because they do not provide crucial evidence about the continuancy status of lateral liquids.

66 classes require the feature [continuant], and of these, 36 are necessarily [+continuant] and 30 are necessarily [–continuant] (Figure 7.2). A full 29 classes are characterizable without the feature [continuant] only by virtue of SPE's [heightened subglottal pressure], which distinguishes /l/ from /r/. These are primarily cases where lateral liquids pattern with nasals and/or unaspirated oral stops, which are [–heightened subglottal pressure], to the exclusion of /r/, which is [+heightened subglottal pressure]. In the absence of this feature, these classes would join the ranks of the [–continuant]. There are also several classes which would need to be [+continuant] if not for Unified Feature Theory's [+/–vocoid] and/or [+/–approximant] features. If one feature theory were to be selected as the correct one, the number of alternatives would decrease, resulting in an increase in the number of classes requiring [+continuant] or [–continuant] and also an increase in the number of 'unnatural' classes with no features specification.

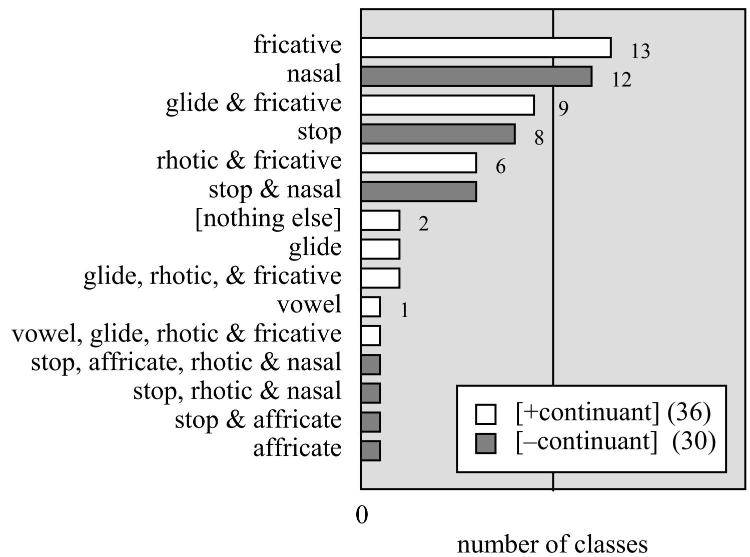


Figure 7.2. The other members of [+continuant] and [–continuant] classes containing lateral liquids

In the [+continuant] and [–continuant] classes that they participate in, lateral liquids occur most commonly with fricatives and nasals. Among the [+continuant] classes, lateral liquids occur in 13 classes with at least one fricative in 12 languages (Arapesh, Agulis Armenian, Central Outer Koyukon, Ecuador Quichua, Ehueun, Epie, Lumasaaba, Manipuri, Yecuatla variety of Misantla Totonac (twice), Navajo, Shambala, and Ukue), with at least one glide and one fricative in nine classes in eight languages (Ehueun, Epie, Lumasaaba, Mising, an innovative variety of Bearlake Slave, Temne (twice), Tswana, and Umbundu), and with at least one rhotic and one fricative in six classes in five languages (Doyayo, Finnish (twice), Greek, Onti Koraga, and Runyoro-Rutooro). Multiple lateral liquids occur with no other segments in two classes which are only characterizable in theories where they are [+continuant] (in Arabana and Dunquin Irish). Lateral liquids occur with at least one glide in two classes (in Okpe and Wiyot), with at least one rhotic, one glide, and one fricative in two classes (in Doyayo and

Estonian), with vowels in one case (in Yucatan Maya), and with vowels, glides, fricatives, and a rhotic in one case (in Catalan).

On the [–continuant] side, lateral liquids occur with at least one nasal in 12 classes in 10 languages (Alyawarra, Basque, Dieri (twice), Gooniyandi, Koromfé, Libyan Arabic, Yucatan Maya, Spanish, Toba, and Yir-Yoront (twice)), with at least one oral stop in eight classes in seven languages (Catalan, Dholuo, the Kolkuma dialect of Ijo, Koromfé (twice), Turkish, Tsakhur, and Tswana), and with at least one nasal and oral stop in six classes (in Anywa, Arabana, Catalan, Nangikurrunggurr, Wangkangurru, and Yir-Yoront). There is one example each of lateral liquids occurring in classes with an affricate (in Guatuso), with affricates and oral stops (in Mishmi), and with oral stops, a nasal, and a flap in Agn Armenian.

The most general observation to be taken from these results is that lateral liquids do indeed pattern with continuants as well as noncontinuants, and with surprising even-handedness, patterning 55% of the time with continuants and 45% of the time with noncontinuants. These results will now be examined in more detail and put into context. The patterning of other segments will be examined, along with the patterning of lateral liquids in classes which are not characterizable in any of the feature systems. Before accounting for the ambivalence of lateral liquids, the extent to which this ambivalent behavior is unique to them will be investigated.

7.2. Segments which are more prototypically prototypical

The results presented in the previous subsection have shown that lateral liquids are ambivalent with respect to the feature [continuant]. In order to learn whether lateral liquids are unique in this respect, a similar analysis was conducted with three other groups of voiced consonants at the same places of articulation as the lateral liquids examined above, namely voiced oral stops, voiced fricatives, and nasals, all produced at places of articulation from dental to palatal (i.e., /d̪ d ɖ ɟ/, /z̪ z ʒ ʑ ʐ ʝ/, /n̪ n ɳ ɲ/ and closely related segments). While all of the feature theories being considered treat oral and nasal stops as noncontinuants and fricatives as continuants, variants with [continuant] specifications for each of the relevant classes of segments inverted were tried as well, in order to detect cases where a class containing one of these segments would be natural only in case the segment had a [continuant] specification which is opposite its traditional specification, i.e., to find evidence that they too may be ambivalent.

The voiced oral stops occur in 43 classes which are necessarily [–continuant], and in only one class which is natural only if it is treated as a continuant. This class is in Koya Gondi, where /ɖ/ patterns with /s̪ r j/. The voiced fricatives occur in 41 classes which are necessarily [+continuant], but also in six classes which are natural only of the fricative is treated as a noncontinuant segment. In Ndyuka, /z/ appears to be straightforwardly patterning with stops instead of fricatives; word-initial nasals become syllabic before stops /b d g p t k/ and /z/, but not before /v f s h/ or any other consonants. In the other cases, the ambivalence appears to be best attributed to another segment. These are all classes of voiced obstruents which are subject to devoicing and/or trigger the voicing of voiceless obstruents, involving /z/ and/or /ʒ/, along with any voiced affricates or stops occurring in the language (in Bulgarian, Cres Čakavian, Hungarian, Pengo, and Slovene). In all five cases, the segments involved comprise all voiced obstruents but /β/ (in Pengo) or /v/ (in the others). As traditionally analyzed, these cases are less about the ambivalence of /z/ and /ʒ/ with respect to [continuant] and more about the ambivalence of /v/ and /β/ with respect to [sonorant], an analysis which is more consistent with other phonological patterns in some of the languages. Further, if the phonetic basis of phonological features is to be maintained, a noncoronal voiced fricative (which may be prone to being approximated) is more phonetically plausible as a sonorant than a strident fricative is as a stop. Section 7.4 contains further evidence of nonstrident voiced fricatives patterning with sonorants.

The nasals occur in 21 classes which are necessarily [–continuant] and 17 which are only natural if the nasal is treated as a continuant, as seen in Table 7.1. This situation is complicated somewhat by the presence of lateral liquids in many of these classes. Because the theories in question differ in their treatment of lateral liquids, nasals patterning with lateral liquids can provide evidence both for and against the continuancy of nasals. Whether nasals and lateral liquids appear to pattern together as continuants or as noncontinuants depends on the other segments in the inventories. Nasal+lateral classes are natural only as noncontinuants in eight cases (in Alyawarra, Basque, Gooniyandi, Koromfé, Yucatan Maya, Spanish, Toba, and Yir-Yoront), and natural either way in five cases in four languages (Dieri (twice), Libyan Arabic, Warlpiri, and Yir-Yoront).

	[+continuant]		[–continuant]	
/z̪ z ʐ ʒ ʑ ʝ/ etc.	41	87.2%	6	12.8%
/l̪ l ɭ ʎ/ etc.	36	52.9%	32	47.1%
/n̪ n ɳ ɲ/ etc.	17	44.7%	21	55.3%
/d̪ d ɖ ɟ/ etc.	1	2.3%	43	97.7%

Table 7.1. The patterning of four groups of consonants with respect to [continuant]

The number of apparently continuant classes of nasals and lateral liquids increases quite a bit if nasals at other places of articulation are considered (see below). If lateral liquids are not allowed to provide crucial evidence for or against the continuancy of nasals, then there are only nine examples of [–continuant], including five cases where the nasals pattern with consonants such as lateral liquids and stops and affricates (in Arabana, Capanahua, Nangikurrunggurr, Wangkangurru, and Yir-Yoront), and twelve examples of [+continuant], including four cases where the nasals pattern with liquids and fricatives (in Finnish, Kalispel, Kuku dialect of Bari, and Onti Koraga). If lateral liquids are specified with the opposite [continuant] value of the nasals, then the number of examples are reduced even further, as seen in Table 7.2, with four examples of the nasals patterning with stops and/or affricates (in Catalan, Comanche, Higi, and Tiv), and eight examples of the nasals patterning with continuants such as fricatives (in Abun, Boraana Oromo, Korean, Macuxi, Russian, Uneme, and West Greenlandic), or a fricative and a vowel (in Northern Tepehuan).

segments in class with /n̪ n ɳ ɲ/ etc.	[+continuant]		[–continuant]	
laterals & other segments	4		5	
other segments only	8		4	
TOTAL	12	57.1%	9	42.9%
lateral liquids (and other nasals) only	5		12	
TOTAL w/lateral liquids	17	44.7%	21	55.3%

Table 7.2. The patterning of dental, alveolar, retroflex, and palatal nasals

In this section it has been seen that oral stops and fricatives, which are expected to be prototypical [–continuant] and [+continuant] consonants, do indeed pattern as expected in nearly all cases. Thus, the ambivalent behaviour of lateral liquids is indeed special. However, it is not limited just to lateral liquids. Rather, /v/ patterns with sonorants, and nasals pattern with [+continuant] consonants in numerous cases, something which is explored in more detail in the next subsection. While ambivalence for any of these segments, including oral stops and fricatives, is formally equivalent, there is an emerging phonetic account: In all three cases of ambivalence seen so far, the segments involved are phonetically ambiguous with respect to the feature involved. Fricatives and oral stops are more prototypical, and they are also much more consistent crosslinguistically in their phonological patterning.

7.3. The ambivalence of nasals

The investigation of nasals in the previous section was intended to provide comparison for the lateral liquids which occur at the same places of articulation. However, this approach is misleading with respect to questions about the continuancy of nasals, because if nasals can behave as continuants, this of course should not be limited to coronals. Since nasals do seem to pattern with continuants on at least some occasions, this subsection examines nasals at all places of articulation, to explore the possibility that all the nasals in a particular language might pattern as [+continuant].

A similar approach to stops and fricatives, allowing all of the stops to be continuant or all of the fricatives to be noncontinuant, would be problematic. Not only would an important means of partitioning obstruents (and the only means of distinguishing nonstrident fricatives from unaspirated stops) be lost, but the phonetic basis of the feature [continuant] would be severely subverted, since oral stops and fricatives are canonical noncontinuants and continuants, respectively. It would also be contrary to the phonological evidence from the stops and fricatives seen above.

The evidence from the patterning of nasals is less definitive than the evidence from oral stops and fricatives, and justifying the inclusion of nasals with continuants would require only a minor rewording of the definition of [continuant] (changing 'vowel tract' to 'vocal tract' or 'oral and nasal tracts'). So while it is impractical to consider all oral stops to be continuants or all fricatives to be noncontinuants, it is practical to consider that labial, velar, and uvular nasals, along with the nasals in (48) and (49), may be continuants. Jakobson, Fant, and Halle (1954) do not specify nasals for the feature [continuant], and in their analysis of English, Chomsky and Halle (1968) make very little use of the fact that nasals are defined as [–continuant].

The results of the analysis of nasals in general are shown in (50). Allowing other nasals to flip-flop along with the coronal nasals considered above does not increase any of the figures for nasals patterning as [–continuant], because the other nasals are already specified as noncontinuant in all the theories. Figures for nasals patterning as continuants increase by two examples of nasals patterning with fricatives and lateral liquids (in Amele and Faroese), five examples with fricatives and some combination liquids, glides, and vowels (in Jacaltec, Mokilese, Samish, Tuvaluan, and Wangkangurru), three examples with only fricatives (in Bukusu, Lower Grand Valley Dani, and Navajo), and ten with only lateral liquids. The classes with only nasals and lateral liquids include two which are only natural if they are continuant (in Arabana and Wangkangurru), plus the eight which were counted above as noncontinuant (because the other nasals in the classes were necessarily noncontinuant).

segments in class with /n̪ n ɳ ɲ/ etc.	[+continuant]		[–continuant]	
lateral liquids & other segments	11		5	
other segments only	11		4	
TOTAL	22	71.0%	9	29.0%
lateral liquids (and other nasals) only	15		12	
TOTAL w/lateral liquids	37	63.8%	21	36.2%

Table 7.3. Evidence for and against the continuancy of nasals in general

From a theory-design standpoint, it does indeed seem prudent to include nasals with noncontinuants. Doing so provides a means of partitioning the sonorants (which, with the exception of glottal stop, are otherwise all [+continuant] in SPE) without referring to nasality, which is necessary to account for nasals patterning with some but not all nonnasal sonorants. The non-continuancy of nasals appears to be relevant for one rule in SPE, namely rule #56 in chapter IV, shown in Figure 7.3. This rule inserts [u] to break up word-final stop+[l] clusters in derivable words exemplified by such paradigms as *table–tabular–tabulate*, *constable–constabulary*, *angle–angular–triangulate*, etc. (Chomsky and Halle 1968:196).

$$\varnothing \rightarrow u \;/\; \begin{bmatrix} -\text{cont} \\ -\text{voc} \\ +\text{cons} \end{bmatrix} \text{—} l + VC\,[-\text{seg}]$$

Figure 7.3. Rule #56

Word-final nasal+[l] clusters are subject to this rule, and although no such examples are given, Chomsky and Halle suggest that the presence of [u] in words such as *formula* may be attributable to the same rule. If nasals were intended to trigger this rule, there would have been no way to make a natural class out of oral stops and nasals in the SPE system without nasals being [–continuant]. Pairs such as *tremble–tremulous* indicate that Chomsky and Halle are correct to posit this natural class, but in retrospect this single example does not warrant overlooking all the evidence from other languages and concluding that nasals are universally [–continuant]. Evidence indicates that not only are nasals not exclusively noncontinuant, but they are actually *more likely* to pattern with continuants to the exclusion of noncontinuants than vice versa. The grouping of nnnnnasals with continnnnnuants is intuitive to many, and this intuition is indeed backed up by phonological evidence.

7.4. Generalization

Phonological processes generalize in ways that do not necessarily correspond to distinctive features, resulting in classes where lateral liquids may pattern with noncontinuants as well as continuants. Evidence of this is seen in groups of related languages with similar inherited phonological patterns. Data on the following pages illustrate three processes which affect slightly different segments in related languages: pre-stopping in Pama-Nyungan, consonant nasalization in Edoid, and postnasal hardening in Bantu. The point of this section is not to argue definitively for a particular set of diachronic changes but to argue for a hypothetical explanation that does not require hypothetical innate features and that is capable of accounting for observations that innate features are unable to address.

The first case involves a process affecting a group of laterals and/or nasals which appears to have been generalized differently in different languages. In many Pama-Nyungan languages spoken in and south of the Lake Eyre Basin, nasals and/or liquids are pre-stopped (e.g., /l/ → [dl]) either syllable-finally or after a stressed syllable (Austin 1981, Breen 2001, Dench 1995, Dixon 2002, Hercus 1994). An example from Diyari, where apico-dental and lamino-alveolar nasals and laterals are optionally prestopped when following the main stress and preceding a vowel, is shown in (34). Nasals do not undergo prestopping in nasal-initial words (because laterals do not occur word-initially, it is unknown whether laterals would behave similarly).

(34) Pre-stopping in Diyari (Austin 1981:18-19).

a.	/jula/ → [júdlʌ] ~ [júlʌ]	'you too'
	/n̪ulu/ → [n̪údlu] ~ [n̪úlu]	'he'
	/kal̪u/ → [kʌ́d̪l̪u] ~ [kʌ́l̪u]	'liver'
	/mul̪a/ → [múd̪l̪ʌ] ~ [múl̪ʌ]	'nose'
b.	/kani/ → [kʌ́dni] ~ [kʌ́ni]	'frillnecked lizard'
	/wana/ → [wʌ́dnʌ] ~ [wʌ́nʌ]	'yamstick'
	/jin̪a/ → [jíd̪n̪ʌ] ~ [jín̪ʌ]	'mother's mother'
c.	/ŋana/ → [ŋʌ́nʌ]	'to be'
	/n̪an̪a/ → [n̪ʌ́n̪ʌ]	'her'

The identity of the class of sounds targeted by this process appears to have been interpreted differently in each language, as shown in Figure 7.4. /l/ and other lateral liquids pattern with nasals in five of the languages (Figure 7.4a-d), while pre-stopping is limited just to nasals or laterals in one language each (Figure 7.4e-f). The class of pre-stopping consonants is further limited by place in four different ways (Figure 7.4a-d), only two of which are readily expressible as a conjunction of traditional features (Wangkangurru and Diyari), assuming that laterals are [–continuant], flap is [+continuant], and labials are [+anterior]. Kuyani, Adnyamathanha, and Arabana require feature disjunction. The segments active in Kuyani and Adnyamathanha are described as the union of the classes defined by [+son, –cont, +lab] and [+son, –cont, +cor] (unless [–velar] is proposed). The segments active in Arabana are [+son, –cont, +ant] ∨ [+son, –cont, –ant, –distr], assuming [+ant] includes labials.

a. Kuyani & Adnyamathanha

p	t̪	t	ʈ	c	k
m	**n̪**	**n**	**ɳ**	**ɲ**	ŋ
	l̪	**l**	**ɭ**	**ʎ**	
		ɾ	ɽ		
w				j	

[+son, –cont, +lab] ∨ [+son, –cont, +cor]

b. Arabana

p	t̪	t	ʈ	c	k
m	**n̪**	**n**	ɳ	**ɲ**	ŋ
	l̪	**l**	ɭ	**ʎ**	
		r			
w			ɻ	j	

[+son, –cont, +ant] ∨ [+son, –cont, –ant, –distr] ([+ant] includes labials)

c. Wangkangurru

p	t̪	t	ʈ	c	k
m	**n̪**	**n**	ɳ	ɲ	ŋ
	l̪	**l**	ɭ	ʎ	
		ɾ			
		r			
w			ɻ	j	

[+son, –cont, +ant] (only if [+ant] refers to labials; otherwise requires disjunction)

d. Diyari (Dieri)

p	t̪	t	ʈ	c	k
		d	ɖ		
m	**n̪**	**n**	ɳ	ɲ	ŋ
	l̪	**l**	ɭ	ʎ	
		ɾ			
w			ɻ	j	

[+son, –cont, +cor +ant]

e. Lower Southern Aranda

p	t̪	t	ʈ	c	k
m	**n̪**	**n**	**ɳ**	**ɲ**	**ŋ**
	l̪	l	ɭ	ʎ	
		ɾ			
w			ɻ	j	h

[+nas]

f. Martuthunira

p	t̪	t	ʈ	c	k
m	n̪	n	ɳ	ɲ	ŋ
	l̪	**l**	**ɭ**	**ʎ**	
		r			
w			ɻ	j	

[+lat]

Figure 7.4. Pre-stopping consonants in some Pama-Nyungan languages, generally requiring [–continuant] laterals

While these processes in related languages are obviously related to one another, there is no way to unify the classes in terms of a single set of the distinctive features that have been proposed so far. It is clear that various segments were added or removed from the class of pre-stopped sonorants in the different languages. New generalizations were formed about what consonants are involved, but these generalizations are not consistent with a universal feature set. While a reconstruction is beyond the scope of this work, a look at the genetic relationships between these seven languages (*Ethnologue*, Grimes, Grimes, and Pittman 2000) reveals that the languages which limit pre-stopping to a proper subset of the labial and coronal places of articulation are all in the Karnic branch of the Pama-Nyungan Family (Figure 7.5). The exclusion of laterals in Lower Southern Aranda and of nasals in Martuthunira appears to be innovative (i.e. undergeneralizations), while the inclusion of the velar nasal in Lower Southern Aranda appears to be innovative (an overgeneralization).

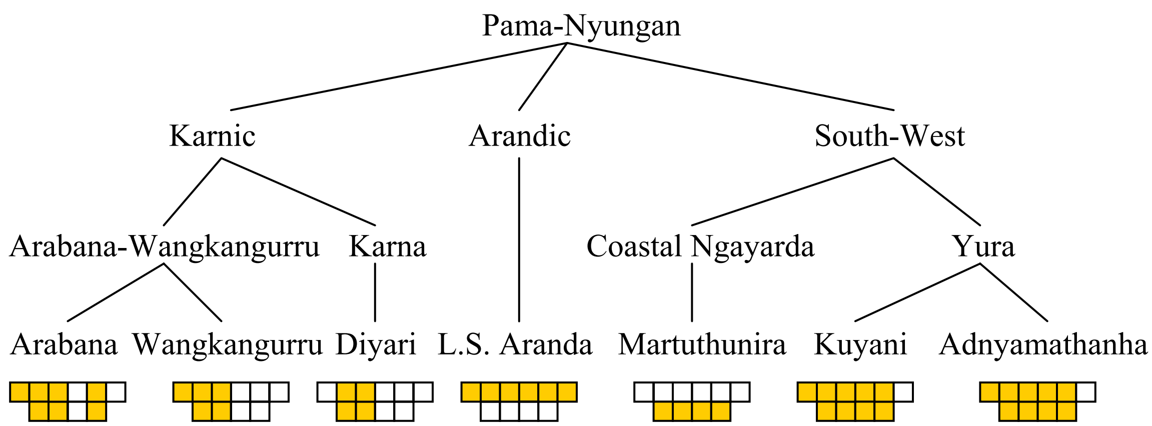


Figure 7.5. The genetic relationships among seven Pama-Nyungan languages

A similar type of example comes from Edoid languages (Elugbe 1989), where certain consonants are generally nasalized when they precede nasal vowels, only here, lateral approximants pattern with continuants. Consonant nasalization in Edo is illustrated in (35).

(35) Edo consonant nasalization (Elugbe 1989:77, 133-81)

a. /lɔ̃/ → [nɔ̃] ‘ask’
/ɹ̝ɛ̃/ → [ɾ̃ɛ̃] ‘know’ (/ɹɛ̃/ → [ɹ̃ɛ̃] for most younger speakers)
/ʋɛ̃/ → [ʋ̃ɛ̃] ‘have’
/jã/ → [ɲɛ̃] ‘tear apart
/wɔ̃/ → [ŋwɔ̃] ‘drink’

b. /lo/ → [lo] ‘use’
/a-ɹ̝o/ → [a-ɹ̝o] ‘eye’ (/a-ɹo/ → [a-ɹo] for younger speakers)
/ʋɛ/ → [ʋɛ] ‘be wide’
/o-ji/ → [o-ji] ‘thief’
/wa/ → [wa] ‘you (pl.)’

Several Edoid languages with this sound pattern are shown in Figure 7.6. While the process is similar in all of the languages, the set of consonants involved varies from language to language. These classes include lateral liquid, tap, and glides in Okpe, Urhobo, and Uvbie (Figure 7.6a-c), lateral liquid, glides, and voiced bilabial fricative in Ehueun (Figure 7.6d), lateral liquid and voiced bilabial fricative in Ukue (Figure 7.6e), nonnasal sonorants and voiced bilabial stop in Eruwa[1] (Figure 7.6f), lateral liquid, glides, and velar fricative in Epie (Figure 7.6g), lateral liquid, glides, and glottal fricative in Aoma, and lateral liquid, tap, glide, and oral stops (which acquire nasal release before nasal vowels) in Edo (Figure 7.6h).

[1] Elugbe (1989:61) reports that [b] and [m] appear to be in complementary distribution in Eruwa, with [b] never occurring before nasal vowels, and he hypothesizes that [m] is the allophone of /b/ which occurs there.

a. Okpe						
p		t	c	k	k͡p	
b		d	ɟ	g	g͡b	
ɸ	f	s	ç			h
	v	z	ʑ	ɣ	ɣʷ	
m						
		r				
		ɾ				
		l				
	ʋ		**j**		**w**	

[–syl, +son, –nasal, –low, –hi subgl. press.]

b. Urhobo						
p		t	c	k	k͡p	
b		d	ɟ	g	g͡b	
ɸ	f	s	ç			h
	v	z	ʑ	ɣ		
m		n	ɲ			
		r̥				
		ɾˡ				
		l				
	ʋ		**j**		**w**	

[+voice, –syl, +son, –nasal]

c. Uvbie						
p		t	c	k	k͡p	
b		d	ɟ	g	g͡b	
	f	s	ʃ			h
	v	z	dʒ			
m			ɲ			
		r				
		ɾ				
		l				
	ʋ		**j**		**w**	

[–syl, +son, –nasal, –low, –hi subgl. press.]

d. Ehueun						
		t		k	k͡p	
b		d		g	g͡b	
ɸ	f	s				h
β	v	z				
		r̥				
		r				
		l				
			j		**w**	

[+voice, +cont, –syl, –strid, –hi subgl. pres.]

e. Ukue						
		t̪	t		k	k͡p
b		d̪	d		g	g͡b
	f					h
β	v					
			r̥			
			r			
			l			
				j		w

[+cons, +cont, –strid, –hi subgl. press.]

f. Eruwa					
p		t		k	k͡p
b		d		g	g͡b
	f	s		x	
	v	z		ɣ	
(m)					
		l			
	ʋ	**ɹ**	**j**		**w**

[–syl, –nasal, +son] ∨ [+voi, –cor, +ant]

g. Epie					
p		t		k	k͡p
b		d		g	g͡b
ɓ		ɗ			
	f	s			
	v	z		**ɣ**	
m					
		(r)			
		l			
			j		**w**

[+cont, –syl, –strid, (–hi subgl. press.)]

h. Aoma						
p		t		k	k͡p	
b		d		g	g͡b	
	f	s		x		**h**
	v	z		ɣ		
m						
		r				
		l				
		ɹ	**j**		**w**	

[+son, –syl, –hi subgl. press.]

i. Edo						
p		**t**		**k**	**k͡p**	
b		**d**		**g**	**g͡b**	
	f	s		x		h
	v	z		ɣ		
m						
		r̥				
		r				
		l				
		l̰				
	ʋ		**j**		**w**	

[+son, +voice, –hi subgl. press., +cont, –syl] ∨ [–nasal, –cont]

Figure 7.6. Nasalizing consonants in Edoid languages, generally requiring [+continuant] laterals

Elugbe (1989) reconstructs Proto-Edoid with phonemically nasalized consonants and allophonically nasalized vowels, as in several modern Edoid languages such as Auchi, Egene, Emhalhe, Ghotuo, Ibilo, Isoko, Oloma, Uhami, and Uneme (Elugbe 1989). The nasalization patterns in the languages in Figure 7.6 must then have resulted from restructuring. This restructuring appears to have occurred differently in different languages and without the guidance of an innate feature set. Speakers of some of these languages have passed up numerous classes which are characterizable with a conjunction of distinctive features (e.g., [+voice], [+sonorant], [+voice, +sonorant]), in favor of classes which are not.

The segments which participate in this sound pattern vary between languages. In addition to /l/, (traditionally continuant) glides nasalize in all but one language (Figure 7.6e), and a nonlateral flap nasalizes in three languages (Figure 7.6a-c). A single bilabial fricative or stop nasalizes in three languages (Figure 7.6d-f), while a velar fricative nasalizes in one (Figure 7.6g). /h/, a lateral flap, or the set of all oral stops are each affected in one language each (Figure 7.6h-i). The segments involved in these processes cannot be formally related within or between languages if their feature specifications are universally determined. This is because universal feature set predicts that, for example, fricatives such as /h/, /β/, and /ɣ/ should be systematically included or excluded depending on whether or not features such as [sonorant] are targeted by the nasalization process. What appears actually to be the case is that the restructuring process in each language caused the pattern to be generalized to a set of phonetically similar segments which is different in different languages.

If the consonant nasalization is innovative, as Elugbe (1989) argues, then the innovation appears to have occurred multiple times, because all four major branches of the Edoid family contain languages with consonant nasalization, as shown in Figure 7.7.[2] This suggests that the innovation, and accompanying generalization to a class of consonants, occurred at least four separate times after Proto-Edoid split into four branches. Further, languages which include at least one obstruent in the class of

[2] The same would be true if vowel nasalization turned out to be innovative, because languages with vowel nasalization also occur in all four major branches of the Edoid family.

nasalizing consonants also occur in all four major branches, and for the most part, the consonant or consonants which are included are different in each sub-family (/β/ in Northwestern, stops (or /h/) in North-Central, (/b/ in Southwestern, and /ɣ/ in Delta), also supporting the notion that four or more separate changes occurred.

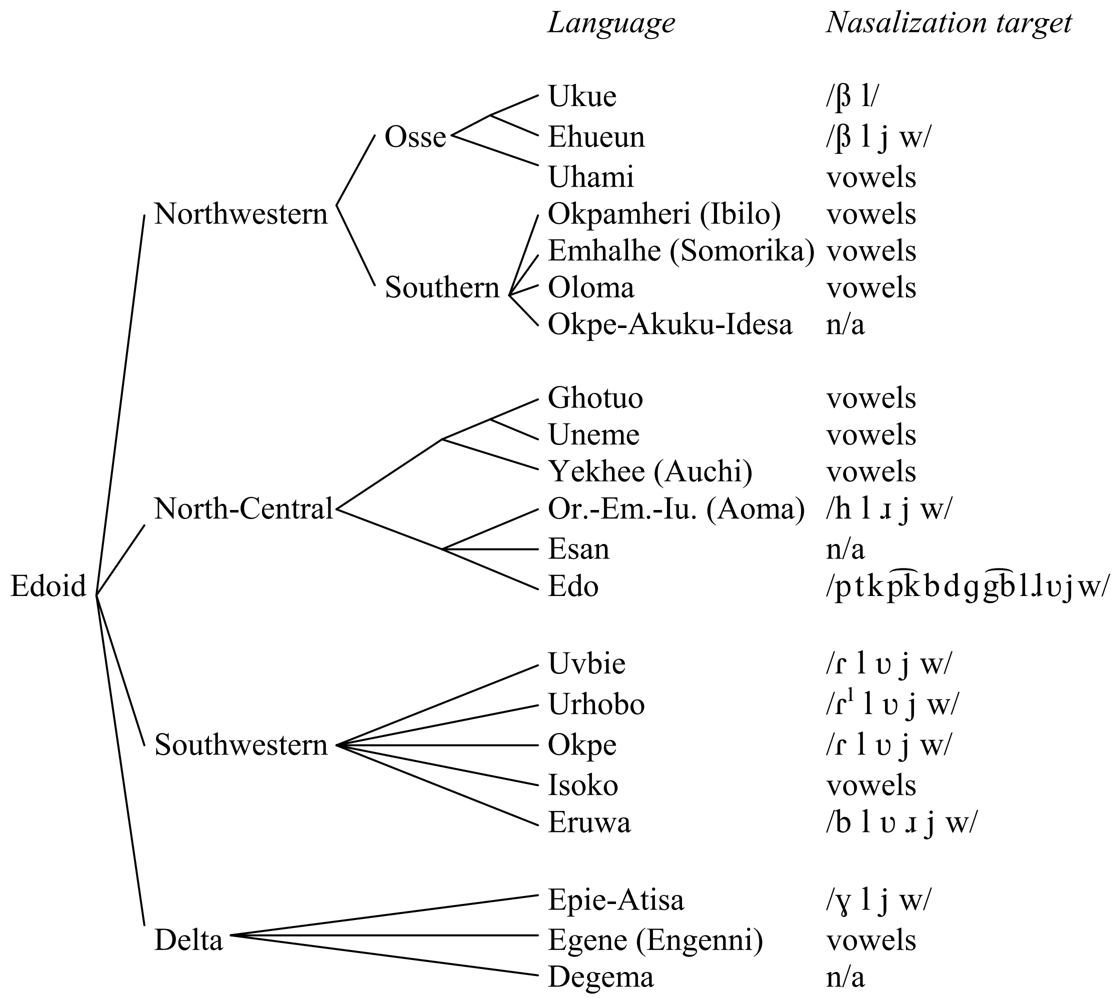


Figure 7.7. The genetic relationships among Edoid languages (Elugbe 1989)

There is a very similar case in some Bantu languages, where a similar array of consonants is involved in a different process. In this case, various consonants are strengthened to stops after nasals (Austen 1974, Besha 1989, Brown 1972, Cole 1967, Fivaz 1986, Madan 1906, Mutonyi 2000, Ngunga 2000, Odden 1996, Poulos 1990, Rubongoya 1999, Takizala 1974, van Sambeek 1966). An example from Runyoro-Rutooro is shown in (36).

(36) Postnasal strengthening of /h l r/ in Runyoro-Rutooro

/nleka/ → [ndeka]	'leave me alone'
/nragiira/ → [ndagiira]	'show me'
/oranha/ → [orampa]	'I am hearing'

As in the Edoid example, /β/, /ɣ/, /h/, and other fricatives exhibit ambivalent behavior; in the languages where these sounds occur, they participate in the sound pattern in some cases and not in others. In both cases, these segments share some but not all properties, with the sonorant consonants which consistently participate, more so than the segments which never participate. The patterning of glides and /r/ is not completely consistent from language to language, either. The Bantu classes can be described in various ways: e.g., nonnasal sonorant consonants in Ganda, Wisa (Lala-Bisa), and Ciyao (Yao)[3] (Figure 7.8a-c), nonnasal sonorants and fricative in Kimatuumbi (Figure 7.8d), lateral and voiced fricative in Bemba (nonlabial oral stops also turn into voiced stops after nasals) (Figure 7.8e), nonnasal sonorants and bilabial fricative in Lumasaaba (Masaba) and Bukusu[4] (Figure 7.8f-g), nonnasal sonorants and voiced velar fricative in Oshindonga (Figure 7.8h), palatal glide, velar, and glottal fricatives in Shambala (Figure 7.8i), liquids and voiceless fricatives in Kihungan[5] (Figure 7.8j), liquids and glottal

[3] /l/ and /j/ become nasal stops in Ciyao and /w/ only strengthens after prefix /n/ in Wisa.
[4] Austen (1974) treats [β] in Bukusu as an intervocalic allophone of /b/, whereas Mutonyi (2000) treats [b] as a postnasal allophone of /β/ (and posits no voiced stop phonemes). In either case, the distributional pattern for /β/~/b/ matches /w/~/b/, /j/~/dʒ/, /l/~/d/, and /r/~/d/).
[5] /f/, /s/, & /h/ become voiceless affricates, and /t/ and /k/ become aspirated after nasals in Kihungan.

fricative in Runyooro-Rutooro (Figure 7.8k), and liquids, labiovelar glide, and assorted fricatives in Venda (Figure 7.8l). /h/ strengthens to [p] in Shambala, Runyoro-Rutooro, and Venda.

a. Ganda

p		t	c	k
b		d	ɟ	g
	f	s		
	v	z		
m		n	ɲ	ŋ
		l		
w			**j**	

[–syl, –nasal, +son]

b. Wisa (Lala-Bisa)

p		t	tʃ	k
b		d		g
	f	s		
	v	z		
m		n	ɲ	ŋ
		l		
w			**j**	

[–syl, –nasal, +son]

c. Ciyao (Yao)

p		t	tʃ	k
b		d	dʒ	g
		s		
m		n	ɲ	ŋ
		l		
w	**ʋ**		**j**	

[–syl, –nasal, +son]

d. Kimatuumbi

p	t	tʃ		k
	s			
m	n		ɲ	ŋ
	l			
w			**j**	

[–syl, –nasal, +cont]

e. Bemba

p		t	tʃ	k
	f	s	ʃ	
β				
m		n	ɲ	ŋ
		l		
w			j	

[+voice, +cons, +cont]

f. Lumasaaba (Masaba)

p		t		k
b		d		g
	f	s		
β		z		
m		n		ŋ
		l		
			j	

[–syl, –strid, +cont]

g. Bukusu

p			tʃ	k	
b		d	dʒ	g	
	f	s		x	
β					
m		n	ɲ	ŋ	N
		l			
		r			
w			**j**		

[–syl, –strid, +cont]
(assuming /r/ is [+cont])

h. Oshindonga

p			t		k	ʔ
			ts			
	f	θ	s	ʃ	x	h
	v	ð	z		**ɣ**	
m			n	ŋ		
			l			
w				**j**		

[+high,+voice,–nasal,–voc] (/j w ɣ/)
∨ [+ant, –nasal, +son] (/l w/)

i. Shambala

p		t	tʃ	k	
b		d	dʒ	g	
	f	s	ʃ		**h**
	v	z		**ɣ**	
m		n	ɲ	ŋ	
		l			
w			j		

[–high, +son, +cont, –syl] (/h l/)
∨ [–strid, +cons, +cont] (/l ɣ/)

j. Kihungan

p^{h}		t^{h}		k^{h}	
		t		k	
b		d		g	
	f	**s**			**h**
	v	z			
m		n		ŋ	
		l			
		r			
w			j		

[–voi, +cont] ∨ [+lat]

k. Runyoro-Rutooro

p		t̪				k	
b			d			g	
				tʃ			
				dʒ			
	f		s				**h**
β	v		z				
m			n		ɲ		
			l				
			r				
w					j		

[–high, +son, +cont, –syl]

l. Venda

p^{h}		t̪^{h}	t^{h}			k^{h}	p^{hw}	
p’		t̪’	t’			k’	p^{w}’	
b		d̪	d	d^{j}		g	b^{w}	
	pf^{h}		ts^{h}	tʃ^{h}	ts^{wh}			
	bv		dz	dʒ	dz^{w}			
ɸ	f		**s**	**ʃ**	s^{w}	**x**		**h**
β	v		z	ʒ	z^{w}			
m		n̪	n	ɲ		ŋ	$ŋ^{w}$	
		l̪	**l**					
			r					
				j			**w**	

[–voice,+cont,–round] (/f h s x ɸ ʃ/)
∨ [+ant, –strid, +cont] (/l l̪ r w ɸ β/)

Figure 7.8. Consonants that undergo postnasal strengthening in some Bantu languages, generally requiring [+continuant] laterals

As in Edoid, the class of segments which undergo postnasal strengthening appears to have been generalized differently in the different languages. The voiceless fricatives which participate in Kihungan, Runyoro-Rutooro, and Venda are the result of a separate historical process (Odden p.c.). The participation of voiced fricatives is interesting, in that they are less consistent participants than the liquids, and that only the noncoronal voiced fricatives participate, i.e., those which are most similar to sonorants. The genetic relationships between these languages (Ethnologue, Grimes, Grimes, and Pittman 2000) suggest either that similar changes occurred many times in different branches of the Bantu family or that contact is responsible for some of the shared features. Voiceless fricatives strengthen in H, P, and S branches of Central Bantu (Kihungan, Kimatuumbi, and Venda, respectively), but not in Ciyao, which also belongs to the P branch. /h/ strengthens in G, H, J, and S (Shambala, Kihungan, Runyoro-Rutooro, and Venda), but not in, e.g., Ganda, which like Runyoro-Rutooro is in the Nyoro-Ganda branch of the J classification. /β/ strengthens in Lumasaaba and Bukusu (both of the Masaba-Luyia branch of J), Bemba (M), and Venda (S), but not in the aforementioned Nyoro-Ganda branch, or in Wisa (M). /ɣ/ strengthens in Shambala (G) and Oshindonga (R), which are no more closely related to each other than to the other branches represented here. While it is difficult to speculate without knowing more about the contact situation, it appears that the similar events may have occurred in different families multiple times, with the result of including segments which are similar phonetically, but not featurally, to the common members of the classes.

This case in Bantu, along with sonorant pre-stopping in Pama-Nyungan and consonant nasalization in Edoid, supports the idea that classes of segments arise as a result of generalizations involving segments which are frequently phonetically similar to each other. Both similarities and differences between the phonologically active classes in related languages, and the nature of the particular classes which are active in each language support the idea that these classes were formed by historical events which occurred under similar linguistic and environmental circumstances, and neither supports the idea that they are attributable to innate features.

7.5. Discussion

Both nasals and lateral liquids are phonetically ambiguous with respect to the letter and/or the spirit of the feature [continuant], and it has been argued here that this may account for their phonological ambivalence. If features emerge as the result of the phonologization of phonetic similarities, it is expected that these phonetically ambiguous segments would be phonologically ambivalent, and that other less ambiguous segments would not be.

For the same reason, however, it is *surprising* that lateral liquids and nasals pattern together so frequently in classes which require the feature [continuant] to define them. Neither is a prototypical example of either end of the phonetic dimension(s) represented by the feature [continuant]. Therefore, it is likely that some other phonetic factor is relevant for these classes. While nasals and lateral liquids are ambiguous in the 'continuancy' dimension, they cluster together phonetically, to the exclusion of other segments, in other ways. For example, laterals and nasals are articulatorily similar, in that both obstruct airflow in the mid-sagittal region of the oral tract without actually obstructing airflow enough to prevent spontaneous voicing, and they are similar acoustically, both having side cavities that generate antiformants (see also Flemming 2002). Given these facts, it is not surprising to see lateral liquids and nasals patterning together to the exclusion of all other segments in so many cases. Since these properties are mostly unique to nasals and laterals, if the classes are generalized to other segments, this would necessarily be on the basis of other shared phonetic properties.

Ambivalent segments are only puzzling in the context of the assumption that distinctive features "must be determined absolutely, within general linguistic theory, and independently of the grammar of any particular language" (Chomsky and Halle 1968:164). This assumption is routinely ignored by descriptive grammarians, in order for internally-consistent feature analyses to be possible. Abandoning the assumption completely does not automatically lead to a nihilistic theory of phonology. Many interesting questions remain, such as "Which segments can be ambivalent and why?"

While some sounds may stray from what have been argued to be their universal feature specifications, when they pattern in ways not predicted by universal distinctive feature theory, they nevertheless seem to pattern with sounds that share an acoustic or articulatory property, often one that is characteristic of the feature they appear to be sharing. For example, [l] has clear articulatory similarities with continuants as well as noncontinuants. Consequently, inductive generalization involving phonetic properties may take it in either direction. Like [–continuant] sounds, [l] has a "blockage of airflow past the primary stricture" (Chomsky and Halle 1968). But like [+continuant] sounds, [l] lacks a total blockage of airflow (Chomsky and Halle 1968).

The same is true of other segments and other features. Like [–continuant] sounds, [r] and [ɾ] involve 'interruption of the air stream during at least part of the duration of the sound' (Chomsky and Halle 1968:318). On the other hand, like [+continuant] sounds, airflow is not actually blocked—the trill/flap itself is a secondary result of narrowing, caused by the Bernoulli effect (Chomsky and Halle 1968:318). Similarly, nasals such as [m] and [n] have a total blockage of airflow in the oral cavity but lack a total blockage of airflow across the entire vocal tract. Like [–sonorant] sounds, [h] does not allow spontaneous voicing, but like [+sonorant] sounds, it does not have a supralaryngeal constriction that produces increased intraoral pressure. [β] and [ɣ] do have a supralaryngeal constriction that produces intraoral pressure increase, but may often be realized without it (see Lavoie 2001 for an in-depth study).

As we have seen, the segments which most frequently exhibit ambivalent behaviour are those which are non-prototypical examples of either pole of the relevant opposition (e.g., [l] is neither a prototypical continuant nor a prototypical noncontinuant). If phonologically active classes result from inductive generalization, segments which share phonetic properties with segments at either pole of an opposition would be expected to be able to pattern phonologically with segments on either end.

This chapter has provided evidence that the long-standing indecision over the continuancy of lateral liquids is well-founded. Lateral liquids and nasals pattern with continuants as well as noncontinuants, and also participate in numerous phonetically natural and unnatural classes. The recurrent classes involve phonetically similar segments, even when they cannot be characterized with traditional distinctive features, and the segments that tend to be ambivalent are the ones that are not prototypical examples of the + or – value of a relevant feature. Universal distinctive features are most reliable for predicting the behaviour of phonetically unambiguous segments. This is precisely the domain in which universal features are least necessary, because phonologically active classes can be predicted on the basis of phonetic similarities. In the phonetic gray areas, where universal features would be expected to define clear boundaries between two values of a feature, the phonological patterning of sounds is as varied as the phonetic cues are ambiguous.

CHAPTER 8

THE EMERGENCE OF LINGUISTIC STRUCTURE

This chapter proposes a general model for the emergence of linguistic structure. It is based in part on Hume and Johnson's (2001c) model of the interplay of external factors and phonology, Blevins' (2004) Evolutionary Phonology, and various innatist approaches, combined with several new elements. Many aspects of this model are also largely compatible with and inspired by work in historical linguistics (see e.g. Labov 1994, 2001, Hale 2003, Janda 2003, Janda and Joseph 2003, Kiparsky 2003, and references in Joseph and Janda 2003). The purpose of the general model is to provide a formal means of accounting for linguistic patterns and generalizations which can be accounted for in terms of language change and factors which are external to the language faculty. The role of Universal Grammar in accounting for linguistic structure is not rejected, but included alongside many other potential factors. Consequently, these competing mechanisms can be compared in the same terms in an effort to see which components of the model are best able to account for observed linguistic patterns.

This general model is then used to address specific questions about phonologically active classes and phonological features. While the general model is capable of attributing the emergence of natural class behavior to biological evolution (i.e.

the evolution of Universal Grammar) or to language change (via external factors included in the model), it will be seen that much of the evidence points to external factors and language change. This is the basis of Emergent Feature Theory, which takes external factors as the starting point, and leaves open the possibility that Universal Grammar could be invoked to account for facts which have no other explanation. By taking this approach, nothing is assumed to be accounted for by innate features if it has an explanation elsewhere. The innate features approach proceeds in the opposite direction, using language change to account for facts which find no explanation in innate features. This may not be the best direction in which to approach these different factors, because language change and external factors are independently motivated, and innate features are motivated only by the need to account for phonological patterns. If language change and external factors are explored adequately, then these motivations may disappear.

The emergentist approaches reviewed in chapter 3 focus on the emergence of structure through the use of language and exposure to environmental factors, but this is not the only way in which structure could have emerged. All of the theories which assume Universal Grammar components such as an innate set of distinctive features posit the existence of structure which emerged in a different way, i.e., through the development of the human "language organ" through natural selection or divine intervention. The use of "emergence" in this chapter refers both to emergence of structure in language use/change or in biological evolution, and the existence of linguistic structure should make it uncontroversial that this structure did indeed emerge in some way. The question of emergence is not *YES OR NO?*, but *WHEN AND HOW?*.

In generative grammar, the formalism used to represent synchronic linguistic patterns has been intimately tied to a model of cognitive language processing. An example of this is the notion of innate distinctive features. The features are not simply the formal means of representing speech sounds and sound patterns, they are claimed to be what speech sounds and sound patterns are *made of* in the human mind. Constraining the set of formally statable phonological patterns to the set of common phonological patterns amounts to a hypothesis about what phonological patterns the human language faculty is capable of dealing with. When the only way to account for typological observations about phonological patterns is to manipulate the model of the phonological component of Universal Grammar, incorporating other means of accounting for typology is difficult. In this chapter, synchronic language processing will be dealt with separately from accounting for typological observations. This is not to rule out the possibility that the two are tied to one another, but to allow for the possibility that there can be instances where they are not.

8.1. Formalization

Considering explanation to be independent of the cognitive representation of language allows for the possibility of a wide range of methods for formalizing synchronic phonological patterns. These formalisms may be capable of representing languages which are unattested, but this is not problematic as long as independent explanation exists for accounting for the non-occurrence of unattested phonological patterns. More importantly, the formalism must be able to represent all *possible* phonological patterns. Formalisms which have variants that are capable of representing a very wide range of phonological patterns include rule-, constraint-, and lexicon-based approaches, which are summarized briefly in the next few paragraphs. The issue of choosing between these formalisms has been clouded by efforts to make the synchronic formalisms responsible for typological predictions. The model proposed in this chapter is intended to remove this responsibility from the synchronic grammar, and this should have the effect of making the choice between formalisms a clearer one, as discussed at the end of the section.

Powerful rule-based formalisms in the style of SPE may be desirable if unattested or rare patterns are ruled out elsewhere. Vaux (2002) argues for such an approach to synchronic grammar, over approaches such as Optimality Theory and Articulatory Phonology (Browman and Goldstein 1992 *inter alia*). Vaux argues that by trying to incorporate explanation for phonological patterns directly into the grammar, Optimality Theory is unable to deal with many arbitrary phonological patterns which have clear historical origins but do not fall out easily from synchronic interaction between faithfulness and markedness constraints. Reiss (2003) argues that Feature Geometry is not powerful enough to handle all phonological patterns and suggests that it should be abandoned in favor of incorporating existential and universal quantifiers into the synchronic grammar, something he argues is necessary anyway. Both of these rule-based approaches to synchronic phonology are intended to allow the representation of a wide variety of attested and unattested phonological patterns, with the understanding that explanations for general typological facts and specific synchronically arbitrary phonological patterns may be found outside the synchronic grammar.

A powerful constraint-based formalism may possibly work as well as a powerful rule-based approach. Again, the most important criterion for choosing a synchronic formalism is the ability of the formalism to represent all possible phonological patterns. As Vaux (2002) points out, representing all of a language's phonological patterns with a single constraint ranking is difficult when there are synchronically arbitrary processes, for which Optimality Theory "is forced to postulate a Byzantine ranking that does not interact with the rest of the phonological system and is not independently motivated or verifiable; this runs counter to the fundamental spirit of OT" (Vaux 2002:11). While it may be counter to the spirit of OT, such an approach is able to account for observed patterns with liberal use of indexed constraints (e.g., Pater 2004). Separating explanation from synchronic formalization may be more difficult or pointless in OT than in a rule-based approach, because the interaction of general (explanatory) constraints is more fundamentally integrated into the workings of the synchronic grammar.

Lexicon-based approaches to synchronic phonology (Bybee 1998, Pierrehumbert 2001, etc.) are also compatible with a model of phonology in which synchronic representations are not the only source of explanation. In lexicon-based models, rich lexical representations of words allow more redundancy to be stored, and phonological patterns are essentially generalizations over the lexicon, rather than formally distinct constructs. Similar words exhibit similar phonological behavior as a result of analogy, but do not necessarily behave identically, due to differences in factors such as frequency.

When synchronic formalisms are no longer assumed to be responsible for making typological predictions, the issue of choosing between competing models of synchronic grammar is changed. If typological observations are readily explained by diachronic facts, the choice of synchronic formalisms should be informed more by synchronic facts about variation and performance.

8.2. Explanation

As argued in previous chapters, the typological facts which have been used to motivate universal distinctive features may also be approached diachronically. Common phonological patterns are those which result from common diachronic changes. This section examines some approaches to diachronic accounts of common synchronic patterns.

The importance of language change as an explanation for synchronic typological facts has been argued for by, e.g., Ohala (1981, 2003, etc.), Hyman (2001), and many others. Two recent approaches by Hume and Johnson (2001c) and Blevins (2004) are superficially different from each other, but as will be argued in this section, the models are quite compatible and both are integral and largely separate parts of a more general model of diachronic phonology.

Hume and Johnson (2001c) argue that external filters (e.g., perception, production, generalization, conformity) impact language change. The filters are not part of the language user's linguistic competence, but simply a way of formalizing the idea that, for example, a perceptually indistinct contrast may tend to be misheard.

Blevins (2004) argues that sound patterns that are common are the result of recurrent sound changes, or the result of more than one type of sound change. Sound patterns that are rare simply don't have as many common diachronic changes that result in them, or they result only from a sequence of common changes. No synchronic markedness theory is necessary, because history is used to account for what is common and what is rare.

A useful formal device for illustrating these models is to conceptualize language change as a Markov chain. The states represent possible languages or possible types of languages, and transitions between states represent the probability that a particular language or type of language will change into something else. Figure 8.1 shows an example in which possible languages are divided into three categories according to their morphological properties. After some arbitrary period of time, one of three things may have happened to any of the languages represented by these states: it may have remained at the same state, or it may have passed to one of the other two states.

There is a probability associated with each of these three events, and the sum of the probabilities (the arrows leading out of a given state) is equal to 1. The arbitrary interval of time chosen will have an effect on the weights of the transitions. The shorter the amount of time, the higher the weight on the transition leading back into the same state (i.e. the greater the likelihood that a language remains in the same state). The nine weights relevant to this three-state Markov chain may be determined by examining historical changes or by examining what is known about the factors which contribute to the likelihood of certain morphological changes. One of the interesting pieces of information that can be represented in this model is the observation that the counterclockwise circuit is more likely than the clockwise one (Vennemann 1974).

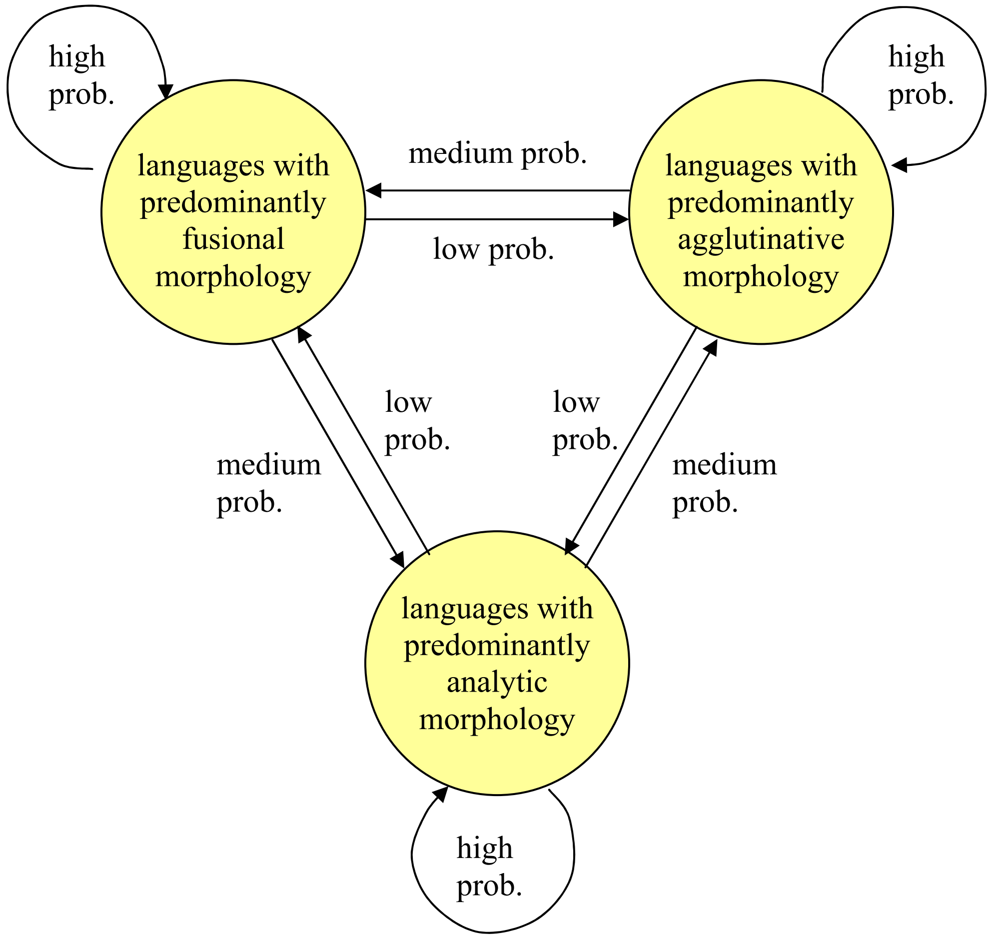


Figure 8.1. Language change as a Markov chain: morphological properties

The illustration in Figure 8.1 is able to show an observation about diachronic change, and this is not the same as accounting for *why* the counterclockwise circuit is more common than the clockwise one. This account is described below.

Another set of observations which can be illustrated with a Markov chain concerns the status of click consonants in the segment inventories of the world's languages. Clicks are found only in Khoisan and (to a limited extent) in Bantu languages spoken in southern Africa. Clicks are crosslinguistically rare, but they do not seem to be particularly disfavored in the languages where they occur, and there does not seem to be a tendency for them to be eliminated from languages which have them. Indeed, they are perceptually robust and articulatorily non-challenging for native speakers. But there are few if any known sound changes which result in clicks where there were none before (see e.g. Engstrand 1997), and known instances of clicks being introduced into an inventory involve language contact. Since most languages with no clicks are not in contact situations with languages that do have clicks, the probability of a given language without clicks developing them is very small. The probability of a language with clicks losing them also appears very small. These observations are illustrated with the Markov chain in Figure 8.2. If it is true that the earliest human languages did not have clicks or were predominantly clickless, then it is completely expected, based on the observations represented in Figure 8.2, that clicks would be very rare, because languages rarely travel between the two states, without ever invoking markedness or attributing anything to the formalization of the synchronic grammar.

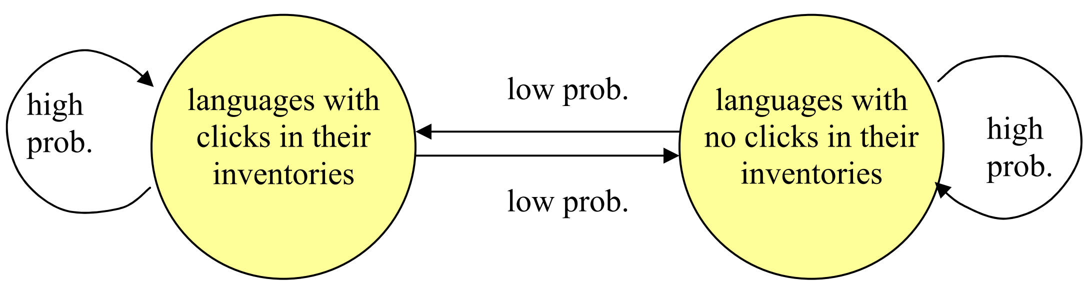


Figure 8.2. A small number of (stable) languages with clicks

Stating an observation such as the one represented in Figure 8.2 is not the same as accounting for it, and this representation allows a clear distinction. The presence of weights on the transitions in the network and their implications of typology do not explain themselves. Accounting for why the weights are as they are is a matter for a theory of language change, one which involves many external factors that are often invoked directly in phonetically-grounded phonological models.

It is conceivable, if not implementable, to create a Markov chain with a state for every logically possible language. For every language, there is a probability that it will change into each of the other languages. Knowing all the probabilities would amount to knowing all there is to know about language change. Knowing all the probabilities as well as the original proto-language(s) (an initial state) would amount to knowing all there is to know about typology. The Markov chain model is intended to represent complete (and unattainable) knowledge about language change. Various theoretical approaches to attaining this knowledge (both innatist and emergentist) can be illustrated in this model.

The probability of a language changing into an impossible language is zero. While it is difficult to find positive evidence that a particular language is impossible, it is straightforward to illustrate this type of prediction in this model; Universal Grammar and theories of what logically possible aspects of language are physically or cognitively impossible amount to assertions as to what languages have zero possibility of being the result of change from any of the other states (Figure 8.3).

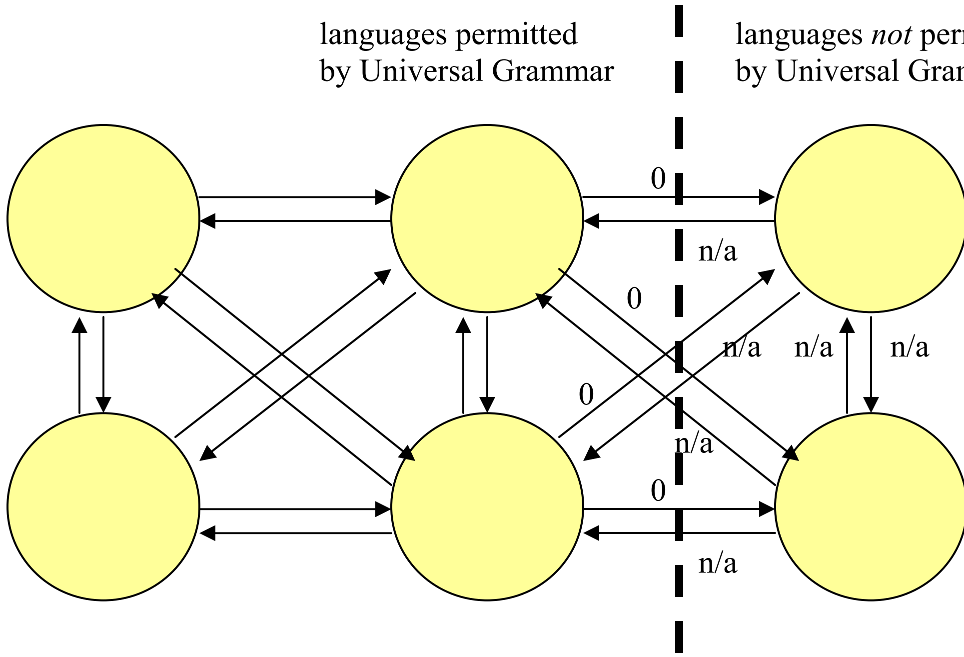


Figure 8.3. Universal Grammar in a Markov model of language change.

Realistically, an investigation into the role of language change in predicting typology would involve a much smaller number of states corresponding to more broadly-defined collections of properties, much like those in Figures 8.1 and 8.2. The goal of constructing this type of model is to account for observations about language by filling in the probabilities of as many transitions as possible. There is more than one way to fill in the probabilities, and they correspond to different research programs currently under way.

8.2.1. The Macro Model

The first, which is called the Macro Model, is to investigate historical changes which are believed to have occurred, and to fill in the probabilities based on actual rates of change from languages with certain properties to languages with other properties. This is similar to Blevins' (2004) approach, which is to explain typological observations about phonology in terms of the record of historical sound changes.

Blevins' (2004) CCC model of sound change takes into account the ways in which sound change actually occurs. Blevins divides sound change into three types: CHANGE, CHANCE, and CHOICE. CHANGE occurs when one form is misperceived and the misperceived form gradually becomes the norm. CHANCE occurs when the underlying representation of a form is misanalyzed and the new analysis becomes the norm. CHOICE occurs when a new form along the hypoarticulated-hyperarticulated continuum (Lindblom 1990b) is taken as the new norm.

This approach tackles the Markov weights directly, by examining attested diachronic changes. As a result, Blevins is able to account for typological facts on the bases of common and uncommon changes, obviating the need for some synchronic constraints on phonological patterns. For example, Blevins (to appear) argues that consonant epenthesis is not a response to any universal constraints favoring syllables with onsets. This is because synchronic epenthesis sound patterns can be accounted for in terms of the diachronic changes which produce them. The most common changes related to synchronic epenthesis patterns, according to Blevins, are reinterpretation of vowel-to-vowel transitions and marking prosodic boundaries with laryngeal features, and less commonly the fortition of weak phonetically-natural epenthetic segments or rule inversion following the loss of weak coda consonants. None of these diachronic changes involve reference to syllable onsets or universal syllabification constraints.

By breaking sound change into different types and exploring the mechanisms by which it occurs, some of the reasons behind these weights can also be discovered. Exploring the reasons behind the weights is done more directly in what is called the Micro Model.

8.2.2. The Micro Model

The Micro Model, seeks to find out *why* some changes are more common than others, by hypothesizing about the factors that make some changes more likely than others, and then filling in the weights according to the hypothesis (which can then be tested with available typological and historical data). This approach is represented by Hume and Johnson's (2001c) model of the interplay of phonology with external factors and also by approaches based in Universal Grammar. The model described in this chapter is intended to include all of the sources of explanation discussed in earlier chapters, i.e., it is the union of all of the models implied in these approaches. The individual submodels can be derived from this model by omitting unused components and weighting the remaining ones. The purpose of constructing such a "Supermodel" is to allow a clear means of comparing different models in the same context and terminology, and of illustrating their assumptions and implications. With a clear understanding of what is claimed and predicted by these models, it will be easier to proceed to the next section, which tests some of the predictions. Since this model is being constructed for expository rather than scientific purposes, all that is necessary for a component to be included in the model is for it to have been argued for in the above literature, not for there to be clear evidence for its existence in reality.

For a simple mathematical metaphor, suppose that we are trying to uncover the nature of a mysterious function *L(x)*, and three competing reductionist hypotheses, termed F, G, and H, have been proposed, which we formalize as *F(x)*, *G(x)*, and *H(x)*. We are certain that the correct characterization of *L(x)* involves one of these three hypotheses, or some combination of them, and nothing else. Without knowing any more than this, we can make the true statement in (37).

(37) $L(x) = k_1 F(x) + k_2 G(x) + k_3 H(x)$

Now stating the correct model is a matter of choosing the right coefficients (k_1, k_2, k_3) for the three competing hypotheses. Determining the coefficients may be a very complicated process, but the representation of the explanatory value of each hypothesis is simple. If the correct characterization of L turns out to be precisely Hypothesis F, and Hypotheses G and H are both completely wrong, then a more explicit version of (37) can be given as in (38):

(38) $L(x) = 1 \cdot F(x) + 0 \cdot G(x) + 0 \cdot H(x)$ i.e., $L(x) = F(x)$

If Hypothesis F is completely wrong, Hypothesis G explains 99% of L, and Hypothesis H explains the remaining 1%, then (39) is the correct model.

(39) $L(x) = 0 \cdot F(x) + \frac{99}{100} G(x) + \frac{1}{100} H(x)$ i.e., $L(x) = \frac{99}{100} G(x) + \frac{1}{100} H(x)$

Choosing the correct model here is a matter of choosing the correct coefficients. By constructing a general model of the emergence of linguistic structure, and in effect determining the "coefficients" of all the components, we can arrive at the correct model or at least get closer to it.

We begin with a traditional model of language acquisition and the emergence of structure (Figure 8.4). The adult cognitive representation of language results from the collision of the language acquisition device (UG) with ambient language data (e.g., Chomsky 1965). If no other explanation is available, we assume that the language acquisition device is highly structured, and that its structure is reflected in the cognitive representation of language that it generates. This highly structured language acquisition device must in turn be generated by the human genome. If another explanation for language structure is available, the language acquisition device could simply record the ambient data and impose no innate structures upon it.

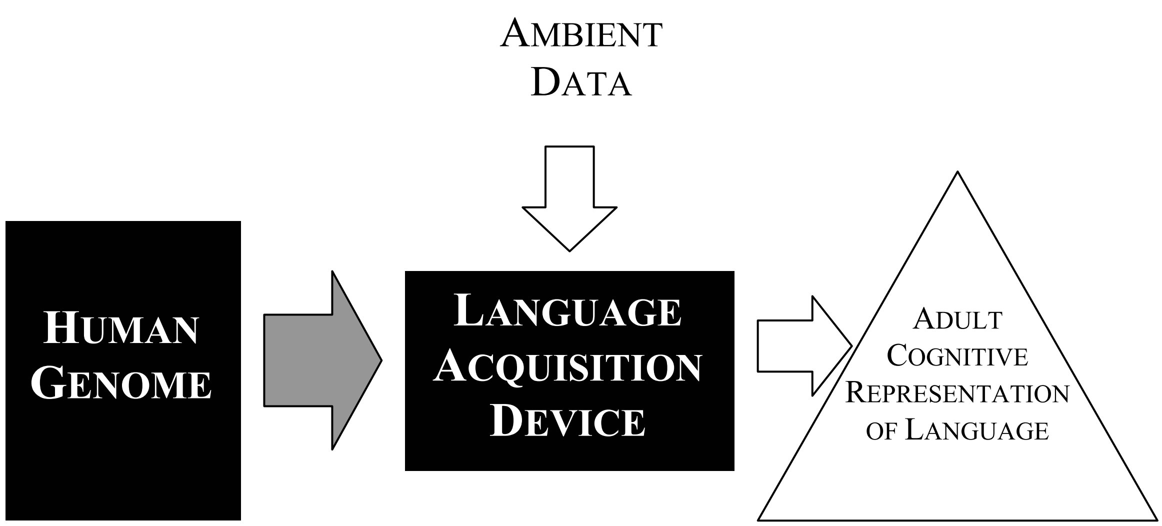


Figure 8.4 The human genome generates the language acquisition device, which generates the cognitive representation of language, with the help of ambient data.

In many of the approaches to distinctive features discussed in earlier chapters, the language acquisition device contains a small number of distinctive features, and phonological patterns must be statable in terms of these patterns in order to be learned. As a result, the phonological component of the cognitive representation of each language will be in terms of these features, and a typology will be predicted based on what patterns are statable and what patterns are not. If innate, these features are by definition specified in the human genome, and to be in the human genome they must have resulted from natural selection.

If the structure responsible for recurrent patterns in language is hard-wired into humans, it must have evolved as a result of an advantage in terms of survival and/or reproduction which is held by humans with more highly developed Universal Grammars, as shown in Figure 8.5.

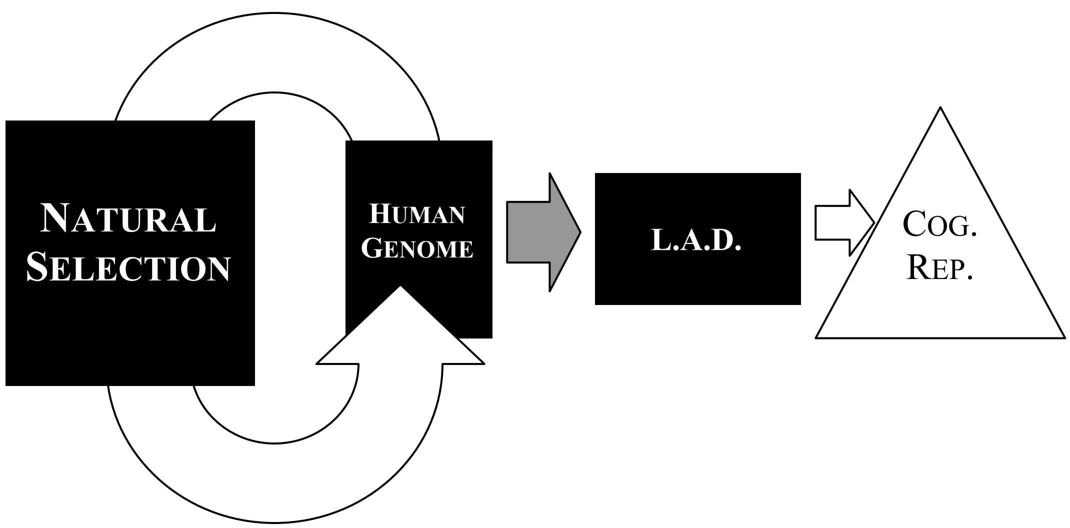


Figure 8.5. Innate language properties from biological evolution

Innate distinctive features could not exist without emerging from biological evolution, but this is rarely if ever discussed in the literature on innate distinctive features. Steels (1997:16) observes a critical flaw in the idea that phonological properties emerged from biological evolution:

> The main problem is that if a new sound (or a new distinctive feature) originates in a single individual by genetic mutation, it does not give this individual any advantage. It is only when a sufficient number of individuals undergo the same mutation, which is exceedingly unlikely, that the shared sound is beneficial. The evolution of language differs in this sense drastically from the evolution of other biological features.

Recognizing that there are many reasons to suspect that internal factors attributable to the human genome do not provide an exhaustive account of human language competence or performance, it is appropriate to explore some of the external factors commonly exploited in explanations for linguistic phenomena.

In the terms used above, the ambient data which allows the language acquisition device to generate the cognitive representation does not come from nowhere, but is generated by other cognitive representations, similar to the one being generated by the language acquisition device on the basis of this data (Figure 8.6). This familiar scenario is discussed in such works as Andersen (1973), Anttila (1977) and Janda (2003).

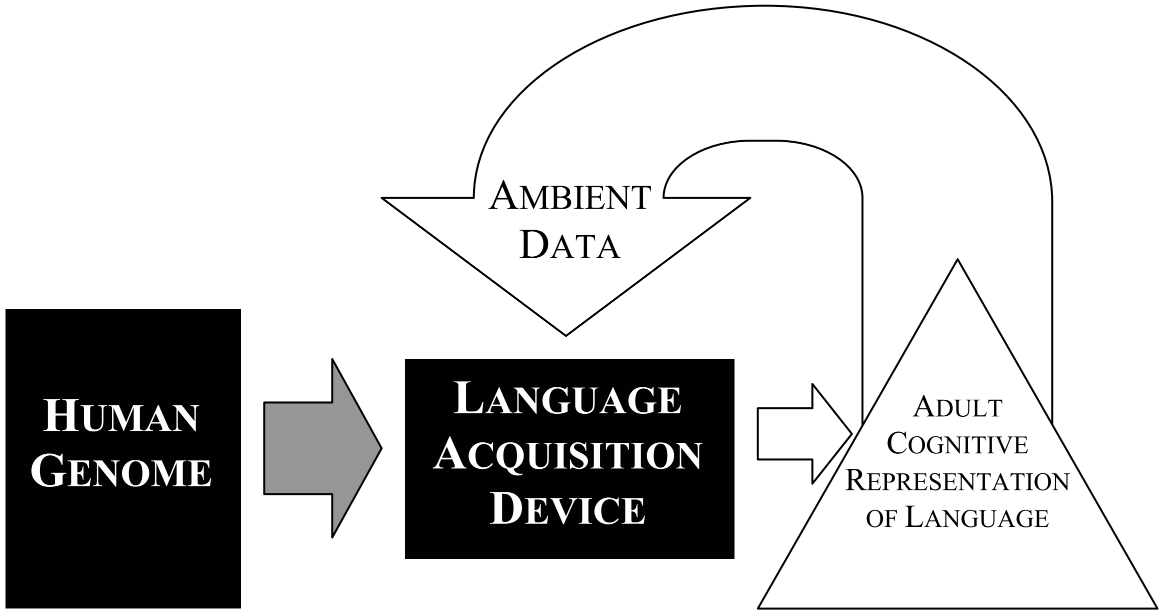


Figure 8.6. The ambient data does not come from outer space.

Further, the data which is generated by other cognitive representations is not transmitted directly from the mind of the speaker to the mind of the learner/listener, but rather it is filtered and distorted by environmental factors (Figure 8.7). These factors are not random, and some are likely to be universal.

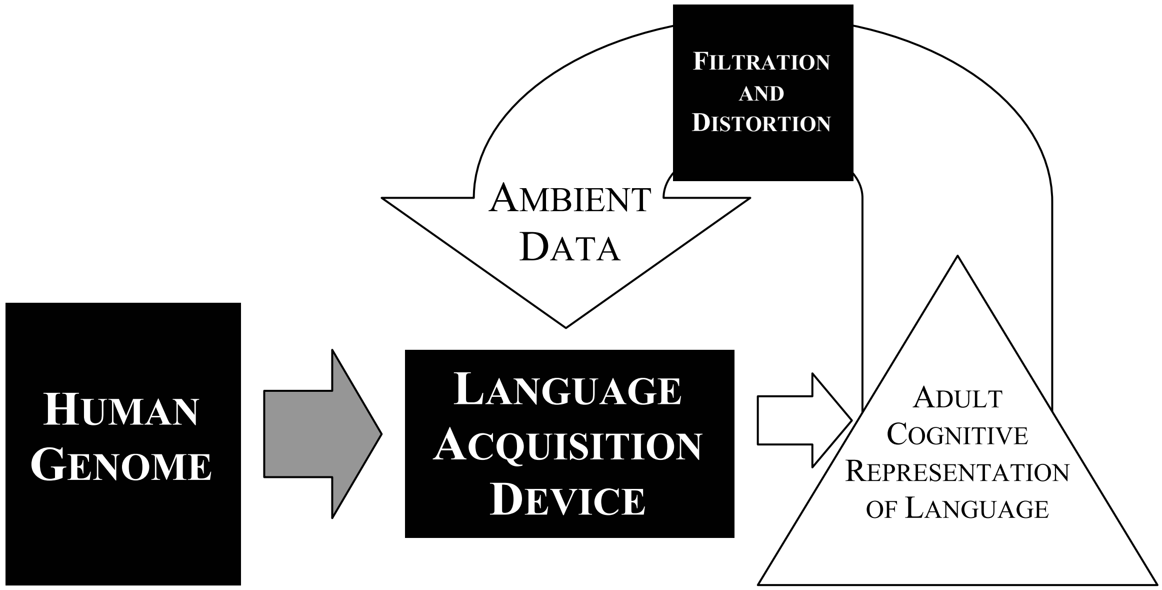
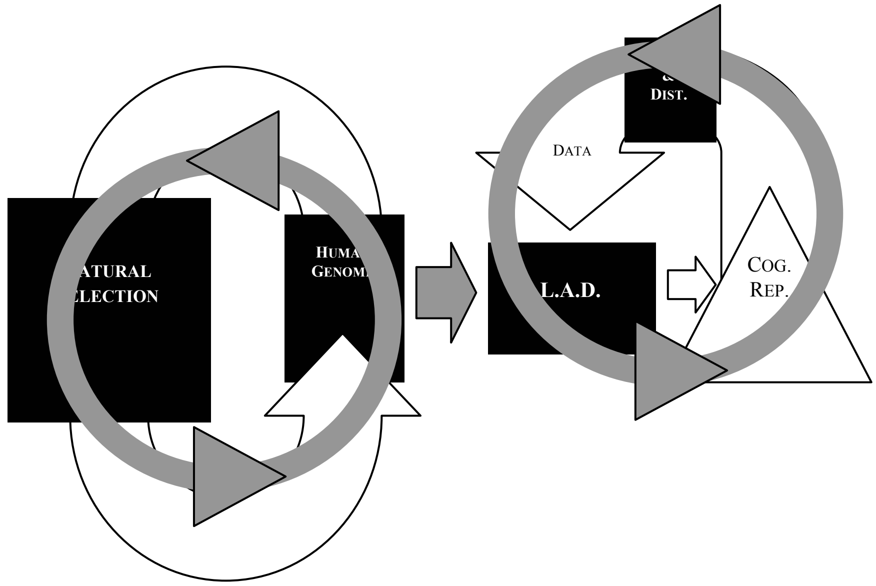


Figure 8.7. The ambient data is a filtered version of the output of the cognitive representation.

The way internal and external factors relate to each other can be schematized as two loops, illustrated in Figure 8.8. The result of the factors' influence is constantly fed back in to be influenced again. One loop involves the language acquisition device, which generates the cognitive representation of language, which generates data, which is the input on which the language acquisition device bases the generation of the cognitive representation. Noise in transmission is amplified as language data is constantly fed back through the noise sources. The Noise in Transmission loop involves the external factors that are argued to influence language as it is used. When speech is transmitted from one speaker to another, the social, production, perception, and cognitive factors all impact the signal along the way, possibly causing the listener to develop a different representation of what the speaker produced, and leading to language change in a direction preferred by one or more of the external filters. The language acquisition device is generated by the human genome, and this requires a Genetic Change loop involving natural selection.



Genetic change feedback loop

Noise in Transmission feedback loop

Figure 8.8. Feedback loops

A number of external factors participate in the filtration and distortion of the ambient data received by the learner/listener. These are constraints that are generally not assumed to be part of the "language faculty" proper, but act as external filters, as in Hume and Johnson (2001c). They include social and cognitive factors, as well as constraints on speech production and perception.

8.2.2.1. Production filters

Factors involved in speech production may cause certain types of sound change to be more common than others. These factors may be viewed (following Hume and Johnson 2001c) as filters acting on the transmission of language (e.g., from one generation to the next). Production-oriented filters can be separated into universal factors and factors which may be influenced by the language being produced by the speaker. Aerodynamics and physiology are universal factors within a particular modality. The laws of physics are expected to apply to the vocal tracts of all spoken language speakers and the body parts of all signed language speakers. For example, articulators in both modalities are subject to inertia, and consequently the potential for gestural undershoot or gesture mistiming, which may be conventionalized by subsequent speakers. The Bernoulli Principle plays a role in the production of all spoken language, by causing narrow constrictions to be narrowed further by the drop in air pressure caused by fast-moving air, and leading to recurrent changes in the production of consonants. Because vocal fold vibration depends on the Bernoulli Principle, voicing is antagonistic with a complete closure in the vocal tract, which causes pressure buildup and ultimately stops the flow of air across the vocal folds (Ohala 1983, Keating 1984). Thus the tendency for stops with closure voicing to be more likely at fronter places of articulation is universal, if only conventionalized in certain languages (Maddieson 2001). The fact that pressure buildup can force an opening in a closed vocal tract is due to universal physical laws, and so is the crosslinguistic tendency for voiced velar stops to be devoiced or to be vented either in the oral cavity or in the nasal cavity, resulting in a universal tendency for velar stops to be devoiced, approximated, or nasalized, which is conventionalized in some languages.

The laws of physics which are expected to affect languages similarly are conceptualized as a filter/prism in Figure 8.9. As a filter, it causes some aspects of the input to be less likely to be represented in the output, and as a prism, it causes elements to appear in the output which may differ from the input. The filter/prism is very coarse, and allows most linguistic patterns to pass through unchanged. But repeated cycling, through language use and language transmission between generations, causes certain patterns which are favored by physical laws (e.g. velar approximants and nasals rather than voiced velar stops) to be more likely to remain. In addition to universal laws of physics, there are production-related factors which may to differ from language to language. It is conceivable that gesture timing and mistiming may be influenced by the sound systems already present in a language.

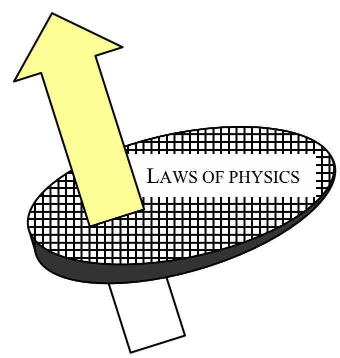


Figure 8.9. The laws of physics filter/prism

The external factors represented as filter/prisms are to be interpreted as acting upon the speech stream, and consequently indirectly affecting the trajectory of language change. External factors do not direct language change in predictable directions, but disrupt the transmission of language from generation to generation. Among the changes which result, some are more likely than others, and this likelihood can be understood in terms of filter/prisms on the language transmission process.

This account of the motivation for language change to move in certain directions is analogous to Einstein's explanation for Brownian motion, the erratic movement of floating dust particles which is attributed to collisions with smaller, less readily-observable air molecules. The air molecules do not push the dust particles in predictable directions, but the movement of the dust particles can be understood on the basis of an understanding of the properties of the gas in which they are suspended.

8.2.2.2. Perception filters

The perception of language is also subject to universal and language-specific factors which make some changes more likely than others. Among the universal factors are vision, which is relevant for perceiving both signed and spoken language, and audition, which is relevant for perceiving spoken language. Presumably the way in which light and sound waves are transmitted to the optical and auditory nerves are not influenced by specific languages, but the non-transparent way in which this happens may influence the path of language change. For example, the response of the auditory nerve to stimuli is nonlinear in more than one dimension. The ear is more sensitive to some frequencies than to others, and the auditory nerve is more sensitive to the onsets of stimuli than to the offsets. This asymmetry in the auditory system can explain asymmetries in sound patterns. All else being equal, consonant-vowel transitions are more salient than vowel-consonant transitions (Fujimura, Macchi, and Streeter 1978, Ohala 1992), and accordingly postvocalic consonants are more prone to alteration than prevocalic consonants (Steriade 1997, 2001). Similarly in sign languages, because the three-dimensional space in which signing occurs must be projected onto two dimensions to be viewed, information is lost as gestures obscure each other. The way in which language is converted into a nerve impulse thus helps direct the path of language change, due to the fact that certain features of language are more likely than others to be obscured, and therefore more prone to being lost.

At a higher level of processing, language-specific factors play a role in language perception. Speakers of different languages may attend to different aspects of a speech signal for cues to identifying sounds and signs. It is the role of attention that contributes to crosslinguistic differences in the perceptibility of contrasts. While the auditory (or optical) nerve may deliver the same signal in two different listeners, the way it is perceived depends on which parts of the signal are expected to contain distinctive information. For example, if a listener whose native language contrasts stops according to voice onset time and a listener whose native language contrasts stops according to closure voicing hear two utterances that differ only in the closure voicing stop, the first listener is less likely to notice the difference, because the change did not affect a cue that is important for distinguishing words in the listener's language. Consequently, this language is more likely to tolerate subtle changes in closure voicing, because these changes have a relatively small impact on word recognition. It has been shown experimentally that the precise nature of what counts as non-salient (and therefore goes unnoticed) varies according to the system in which the changes are viewed (e.g., Hume *et al.* 1999, Hume 2004, Mielke 2003), and so the influence of perception on phonological patterns involves language-specific components.

To the extent that the mental representation of language is organized and/or condensed, rather than consisting of a list of every utterance encountered, this organization impacts the way language is treated. A certain amount of stimulus generalization is necessary for a speaker to identify two different acoustic signals as examples of the same phoneme. Further, similar sounds, whether instances of the same phoneme or different phonemes which share properties, tend to pattern similarly. If a speaker expects this, then the categorization of sounds will cause sounds which are similar to tend to be treated similarly, even without explicit evidence to support it.

8.2.2.3. Generalization

If a speaker is more likely to assume that /t/ will pattern with /k/ than to assume that /t/ will pattern with /o/, then it is more likely that a sound pattern involving /k/ will be generalized to include /t/ than that a sound pattern involving /o/ will be generalized to include /t/. If this is the case, then generalization acts as a filter which favors processes in which similar sounds pattern similarly. This filter is expected to occasionally filter out processes which violate this expectation and introduce processes which meet it.

This is illustrated quite clearly in the ability of language listeners to group together acoustically non-identical tokens of what is considered to be the same speech sound, and to be prepared to correctly categorize new tokens which are identical to none of the previously-heard tokens. Generalization is necessary for learning abstract phonemes from clouds of actual tokens can easily be extended to the learning of phonologically significant classes from clusters of different phonemes.

In his work on stereotypes, Hinton (2000:33-34) describes how children develop their knowledge of categories through experience, something which is a component of the way that children are thought to acquire knowledge of phonological categories from exposure to specific instances of those categories:

> Essentially, children are developing their knowledge of categories through a process of induction: that is, generalizing from the collection of personal experiences they have had. For example, an adult points to a small four-legged creature in a park and says to the child 'dog'. On another day in the park the child sees a different four-legged creature – this time it is bigger and of a different colour. The child points at it and says 'dog'. The adult says 'yes, a dog'. The adult has confirmed that this second creature is also a dog. From the child's point of view the question is: what are the *characteristics or features* that make it a 'dog'? It is clearly not the colour or the size as these have differed across the two examples. The child must reason out what defines the category dog…. However, when the child sees a cat and points at it and says 'dog' (an overextension) the adult replies 'no, that is a cat'. This new experience is a problem for the child: it must redefine the category 'dog'. Through the combination of encountering different animals, plus the *feedback* from the adult, the child over time gains a wider range of experiences of what is, and what is not, a dog.

The formation of stereotypes is also the result of generalization. Attributes observed in one person may be attributed to another who does not possess the attribute but shares a different salient attribute with the first person. Experimental evidence shows a cognitive basis for stereotype formation. For example, in other work on stereotypes, Van Knippenberg and Dijksterhuis (1996) find that information that is inconsistent with a stereotype is more difficult to recall than information that is consistent with the stereotype. Snyder, Campbell, and Preston (1982) and Johnston (1996) find that people tend to seek information that confirms stereotypes rather than information that disconfirms them. Thus, the mistaken overgeneralization that results in stereotypes is the result of the same adaptive strategies that allow knowledge to be generalized at all, as described by Fox (1992:140) in her work on prejudice as a residue from an earlier stage of adaptation:

> The essence of stereotypical thinking is that it is fast and gives us a basis for immediate action in uncertain circumstances. But its legacy is that we are happier and more comfortable when thinking in ways that promise immediate survival than in ways that appear to threaten it. This may no longer make much sense, but unfortunately our brain doesn't know that, or, if it can be persuaded of it, it still has a hard time bucking a system that got it to this point in the first place. Presented with the need for a quick decision, it will prefer stereotype to logic (Fox 1992:140).

Stereotypes which are inconsistent with observable facts (such as many stereotypes about people) may eventually disappear, that is, overgeneralizations can be corrected, given enough time to coexist with the conflicting reality. Overgeneralizations about language are a different matter in an interesting way, because language is culturally transmitted and arbitrary. An overgeneralization about people, even if it is widely held, will always have the opportunity to be compared with reality and to possibly be corrected, but an overgeneralization about language structure that is widely held often *becomes* the reality that it would be compared to. Because language is arbitrary and many attributes of people are not, an overgeneralization in the domain of language structure stands a much greater chance of being a self-fulfilling prophecy. For example, if 75% of the population starts to believe (mistakenly) that the other 25% is good at math (based on evidence from only a small fraction of that 25%), there will always be opportunities for this belief to be challenged by facts and discredited. If a generation of speakers believes that all voiced consonants are devoiced word-finally, when in reality most of the population has only been devoicing word-final voiced *obstruents*, it is quite possible that when that generation reaches old age, it will be *true* that most of the population devoices all word-final consonants.

Another cognitive factor related to generalization is cognitive complexity. Culicover and Nowak (2003) argue that many typological observations about language (such as the preference for binary branching among syntactic constituents) are the result of differences in cognitive complexity. Patterns that are easier to process are favored slightly, and as a result of social factors which encourage some language varieties to overwhelm others, the more complex patterns are more likely to disappear.

The social context in which language is used also influences language patterns. For example, the tendency to conform to specific linguistic norms causes the outputs of individuals' grammars to become more like each other or more like a particular set of grammars. In the course of conforming to an unfamiliar norm, an undergeneralization or overgeneralization may also occur. The social identity filter filters out phonological patterns according to the social identity of the speaker. Trudgill (2002) has suggested that isolated communities with dense social networks are better able to sustain complex alternations and relatively non-natural sound changes that might not survive in communities with larger and less dense networks. In the Hume and Johnson model, the elimination of complex alternations and non-natural sound changes can be attributed to an increased role of the conformity and generalization filters in communities with sparse networks. This is not to say that conformity cannot also lead to an increased role for complex or non-natural patterns, but that the opportunity for these patterns to be eliminated in communities with sparse networks may be greater.

8.2.2.4. Supermodel

Putting all of the external factors together with the genetic factors results in the supermodel, shown in Figure 8.10. The human genome provides a (not necessarily very detailed) mechanism for learning language, and this is represented in the initial states of language learners, whose cognitive representations of language are represented in Figure 8.10 by triangles. The initial cognitive representation develops into the adult cognitive representation "p", and development is represented by movement to the right. An adult cognitive representation produces an output which passes through filter/prisms before being the ambient data available to the learner. This data is passed through further filter/prisms as it is received by the learner, and four of the six filter/prisms are influenced by the cognitive representation (indicated by the faint arrows in the figure), as discussed above. Such a model allows phonological patterning to be accounted for by external factors or by innate features. Specific submodels can be illustrated by removing or discounting components of the supermodel. Importantly, these possibly mutually-exclusive models can be illustrated in the same terms.

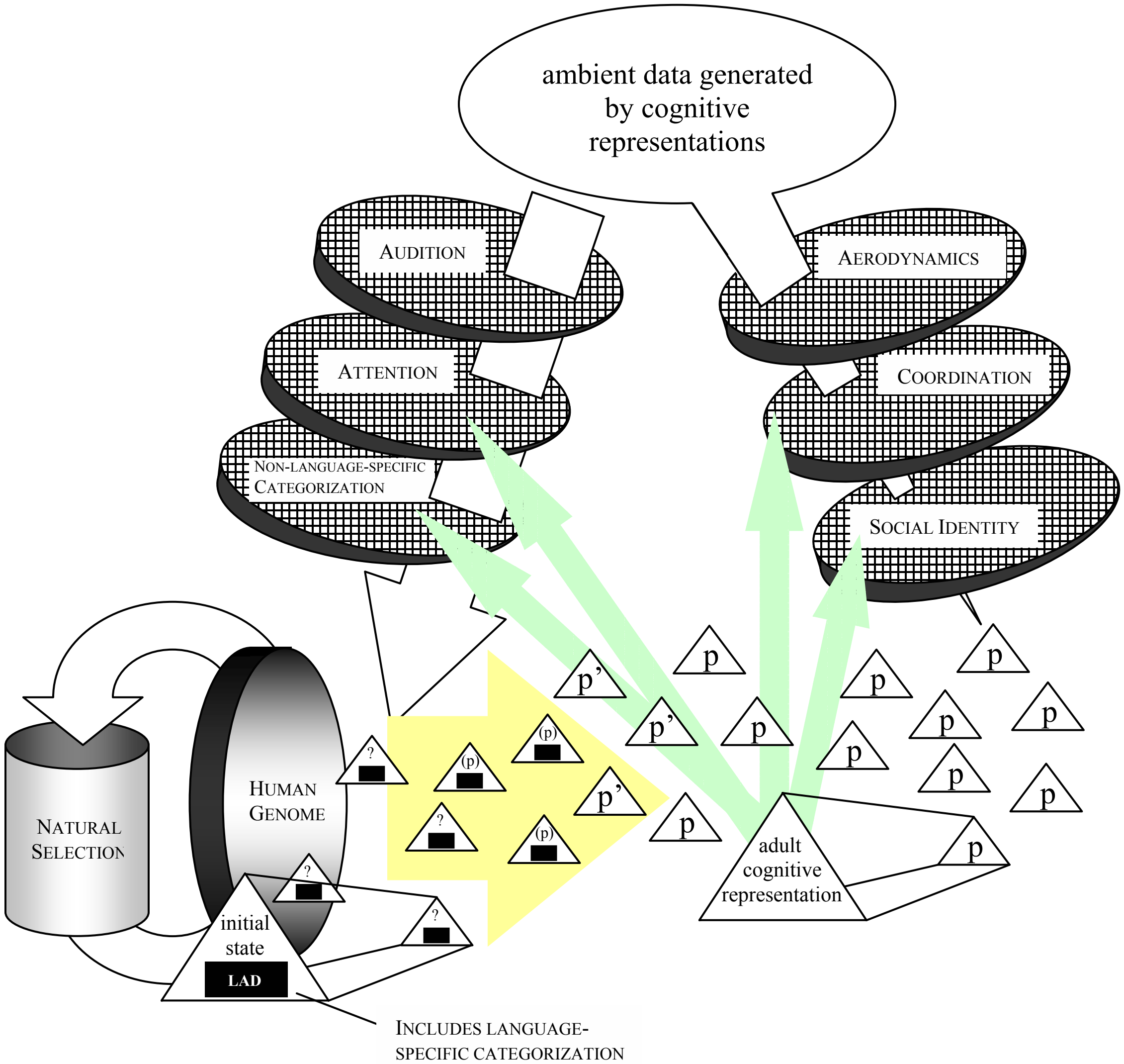


Figure 8.10. The supermodel of internal and external influences on language structure

The emergence of phonological patterns necessarily involves more than one filter/prism, but not necessarily in the sequence shown in Figure 8.10. The filter/prisms in the figure are sequenced according to when they apply in the production and perception of speech. Representing the emergence of a phonological pattern may involve abstracting over many production-perception cycles, and so the pertinent actions of the filter/prisms represented in the figure do not necessarily occur in the same cycle. When a listener miscategorizes a speech sound as a consequence of a speaker's misarticulation, then both factors are present in the same loop. But whether this miscategorization spreads and becomes the norm for a community, depends on the social identity filter/prisms of many other speakers at later points in time.

As an example, a vowel harmony process can emerge over time as a result of repeated cycling through via the external factors shown in Figure 8.10. First, coarticulation between vowels occurs as a result of gesture mistiming. Utterances produced with overlapping gestures are favored over those in which gestures associated with segments are completely segregated in time. This is represented by the coordination filter/prism, which tends to admit forms with gestural overlap. The result of this gesture mistiming may be phonetically rounded vowels which would be unrounded if not for the presence of a rounded vowel nearby. These phonetically rounded vowels are perceptually similar to contrastively rounded vowels, as a result of limitations of the human auditory system and the attention of the listener to specific points in the waveform. This is represented by the audition and attention filter/prisms. Because speakers group sounds into categories according to their phonetic properties, the vowels which are perceived as similar to phonologically rounded vowels may be categorized as rounded vowels by some speakers. The four factors invoked to this point would all be relevant in the same cycle. The result is that a speaker produces a vowel which is intended to be unrounded and the listener hears a rounded vowel.

Over time, the rounding harmony takes on social significance and spreads throughout a community. Speakers choose to produce round vowels in the environments where they have appeared as a result of four other factors, and this choice is represented by the social identity filter/prism. In the end, the language contains a rule of vowel harmony.

This description has made use only of the language change loop, and bypassed the genetic change loop. The genetic change loop is also able to produce a story for the emergence of vowel harmony. Through the process of natural selection, humans with more highly developed innate language faculties are more fit for survival or reproduction. If a speaker has a cognitive entity [round] or [Labial] which refers to rounded vowels, she will have an easier time communicating with other people, and consequently, the argument goes, she will be more successful in other aspects of life.

After many generations come and go, the result is a human population with a set of phonological distinctive features. A vowel harmony rule may emerge as a result of the feature [round] which is associated with a particular vowel being associated to another vowel. Whether this results from a superfluous association line in a speaker's head or from external events is not a concern of the genetic change-based innate features account. Ultimately, learners construct a vowel harmony rule or a constraint ranking that results in the feature [round] being associated to two segments.

In summary, the model in Figure 8.12 contains redundancy. Both the genetic change and language change loops are independently able to produce a story for the emergence of vowel harmony and other phonological patterns. This means that one or the other may be expendable. To evaluate the components of the supermodel, it is necessary to examine the submodels more closely.

8.2.2.5. Submodels

Models of phonology can be derived from the supermodel (Figure 8.10) by omitting parts of it. Each proposed submodel addresses the question of how much of the observations about recurrent phonological patterns are attributable to the Noise in Transmission feedback loop and how much is the result of the Genetic Change feedback loop. More influence from the Genetic Change loop requires a more specific language acquisition device (Universal Grammar). More influence from the Noise in Transmission loop means that less information needs to be provided to the language learner by Universal Grammar.

A specific language acquisition device/strong Universal Grammar requires natural selection to cause the evolution of the genetic code needed to produce it. For this to be true, humans with more developed language acquisition devices must be more fit for survival and better able to produce offspring than humans with less developed language acquisition devices. This must also be the case for a long enough period of time for the LAD to be highly developed enough to generate the regularity attributed to it (contra Worden 1995). The leading argument for Universal Grammar is that it explains facts that have no explanation elsewhere. Given the problems surrounding the account of biological evolution of the language faculty, if language change can explain the observed similarity between languages, this explanation is preferable to an explanation based on biological evolution.

Models of phonology which are rooted in innate distinctive features cancel out or diminish the importance of external factors and the Noise in Transmission feedback loop in favor of internal factors and the Genetic Change feedback loop. The human genome provides the language learner with an innate feature set which is used to construct a grammar based on the data received. Noise in transmission is of little importance for the core data for the theory, but may be invoked when the innate feature set fails to account for a particular phonological pattern. Therefore the Noise in Transmission loop is likely to be present for all theories of innate feature, but it plays only a tangential role in determining what are likely phonological patterns. The null hypothesis is that it is absent, but it is clear in much of the work on innate features that these factors are necessary in order to deal with exceptions.

Figure 8.11 shows a submodel corresponding to the innate features approach. The language acquisition device is highly structured and contains the features necessary to categorize speech sounds and signs and to formulate rules. The external factors are de-emphasized, because they are not the primary source of explanation for generalizations about phonological patterns. But they are not removed completely, because they will be necessary to account for phonological patterns that innate features are unable to account for, as seen above.

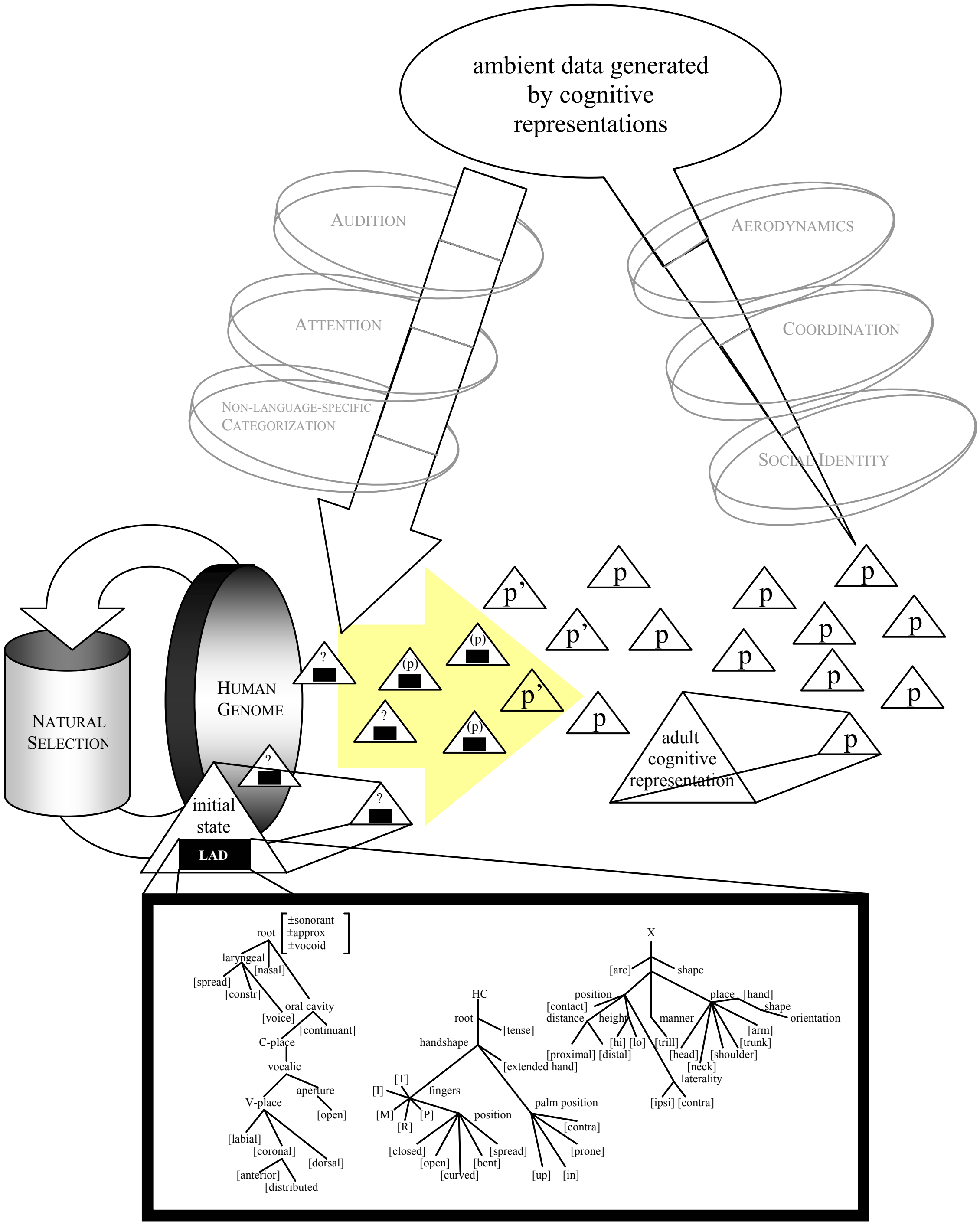


Figure 8.11. The innate features submodel

This approach to phonology has allowed the formulation of many generalizations about phonological patterns. The innate features approach has not converged on a single set of features which are innate and universal. Even among the phenomena reported in the phonology literature, there are phonological patterns which require external explanation. By taking innate features as the null hypothesis, it is very difficult for this approach to discover how many phenomena which may be accounted for with innate features may also be accounted for with external factors. Most of the generalizations produced by innate feature theory are informative to an emergentist approach, because the phonetic facts that the formal innate features model is grounded in are covered by the external factors in the model.

The emergent features approach takes the external factors as the null hypothesis. Thus, emergentist approaches to phonology cancel out or diminish the importance of internal factors and the Genetic Change feedback loop in favor of external factors and the Noise in Transmission feedback loop, as shown in Figure 8.14. Nothing needs to be hypothesized to be in Universal Grammar that has an independent explanation from noise in transmission and language change. However, it is not known at this time whether all constraints on phonological patterns can be accounted for in this way. If it is discovered that a certain type of phonological pattern which is not ruled out by any known external factors does not occur, and that its absence is statistically significant, then this is grounds for hypothesizing that Universal Grammar may be responsible. It is assumed, however, that most typological observations can be accounted for by external factors. The null hypothesis is that the Genetic Change feedback loop plays no role that is specific to language.

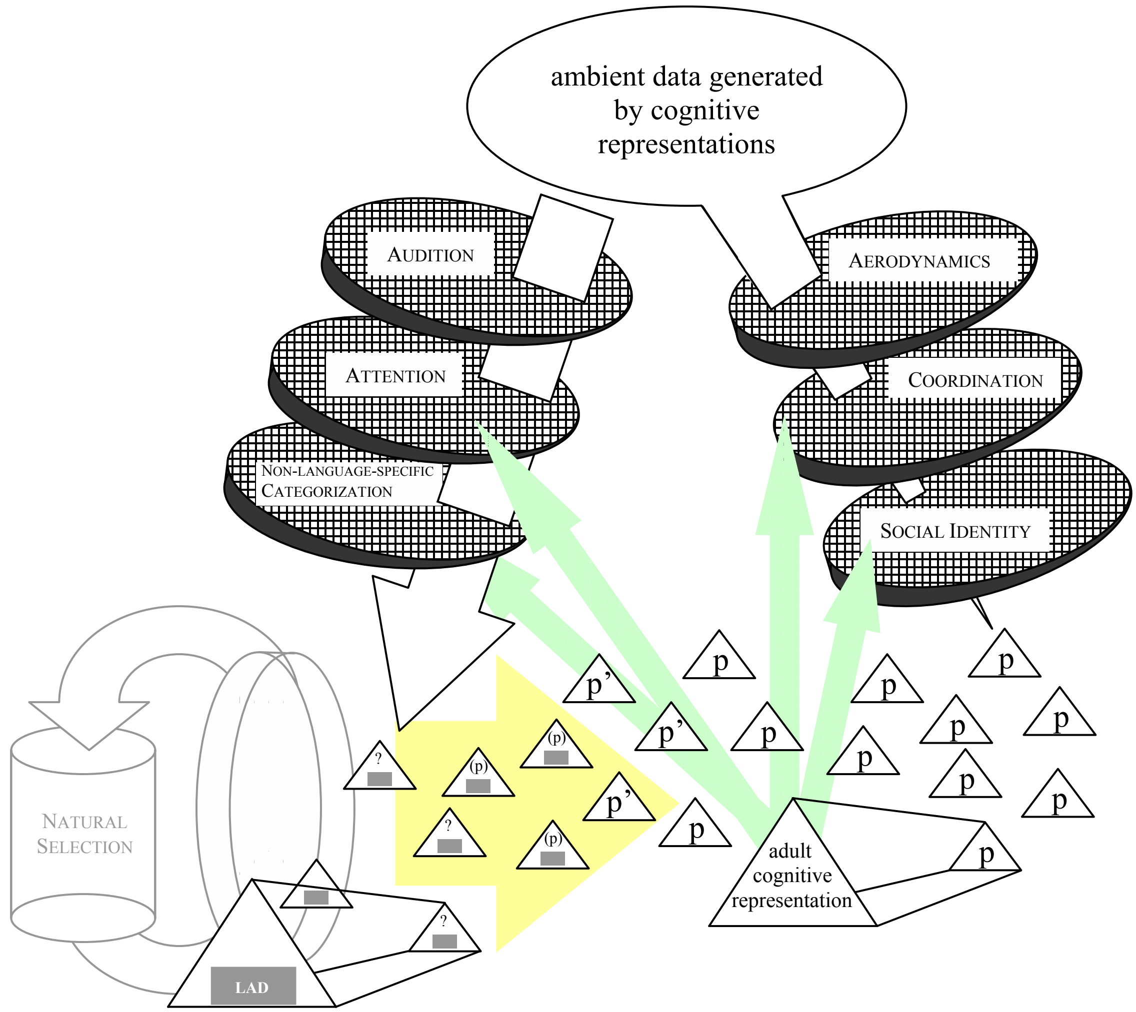


Figure 8.12. The emergent features submodel

8.3. Summary

This chapter proposed a general framework in which natural classes, distinctive features, and other linguistic phenomena can be explored. Formalization of the cognitive representation of language is separated from explanation, and Markov chains are proposed as a means of formalizing typological observations without placing them in the cognitive representation. Two approaches to filling in transition weights in this model are the Macro Model, which investigates actual diachronic changes, and the Micro Model, which explores why some weights would be expected to be different from others. The Micro Model has many components with overlapping coverage, including components attributed to biological evolution and components attributable to language change. The relative importance of these components is investigated by testing the predictions they make about the nature of the linguistic patterns they both try to account for.

8.4. Conclusions

This dissertation has proposed and argued for Emergent Feature Theory. It has been shown that there are many reasons to be suspicious of the idea that distinctive features are innate. There are major differences between features for signed and spoken languages which innate features account for, and the common denominator between the features used in these two modalities is cognitive categories, and as Jakobson (1942 *et seq*.) demonstrated cognitive categories are learned and exploited by non-human animals. The arguments for innate features have not been accompanied by sufficient evidence, either in terms of crosslinguistic phonological patterning or in terms of a clear hypothesis about how much of this patterning should be accounted for by features and how much would be expected from other factors. It has been seen that about one fourth of phonologically active classes are not accounted for by innate feature theories, but many of them are predicted by Emergent Feature Theory on the basis of phonetic similarity and phonetically-driven sound change. Further, the classes accounted for by innate feature theory are just as easily accounted for by Emergent Feature Theory. Given all of these facts, there is little reason to believe that innate features add insights that are not already provided by other sources of explanation, but the enterprise of innate feature theory has been quite successful in clarifying many of these other sources of explanation.

Just as it can be useful to neglect air resistance when making physics calculations, it is useful to neglect the language-specific differences in phonological features when developing a theory of crosslinguistic phonological tendencies until the field has advanced far enough that these simplifying assumptions can be abandoned. Indeed, innate feature theories have helped foster an understanding of the many external factors which they model abstractly, and the result is that it is now possible to move beyond innate features. The insights of innate features are portable, and as has been shown in this dissertation, they can be incorporated into Emergent Feature Theory. Removing the assumptions of innateness allows feature theory to deal with the wide range of "exceptions" which can now be dealt with in just the same way as any other naturally-occurring linguistic phenomena. Emergent Feature Theory is part of a larger theory of the emergence of linguistic structure, and part of a larger movement to move beyond some of the assumptions which were fundamental to advancing the study of language, assumptions which have worked so effectively that much of their work is now complete.

APPENDIX A

LANGUAGES IN THE SURVEY

!Xóõ (Traill 1985)	Khoisan
Abaza (Colarusso 1988)	North Caucasian
Abkhaz (Colarusso 1988)	North Caucasian
Abujhmaria (Natarajan 1985)	Dravidian
Abun (Berry and Berry 1998)	West Papuan
Acehnese (Durie 1985)	Austronesian
Adyghe (Bzhedukh dialect) (Colarusso 1988)	North Caucasian
Af Tunni Somali (Tunni) (Tosco 1997)	Afro-Asiatic
Afar (Bliese 1981)	Afro-Asiatic
Afrikaans (Donaldson 1993)	Indo-European
Agarabi (Bee, Luff, and Goddard 1973)	Trans-New Guinea
Agta (Healey 1960)	Austronesian
Ainu (Tamura 2000, Shibatani 1990)	Language Isolate
Akan (Akuapem, Asante, and Fante) (Dolphyne 1988)	Niger-Congo
Alabama (Lupardus 1982)	Muskogean
Albanian (Mathiassen 1974)	Indo-European
Alyawarra (Yallop 1977)	Australian
Amele (Roberts 1987)	Trans-New Guinea
Amharic (Leslau 2000)	Afro-Asiatic
Angami (Giridhar 1980)	Sino-Tibetan
Anywa (Anuak) (Reh 1996)	Nilo-Saharan
Ao (Ao Naga) (Gowda 1991)	Sino-Tibetan
Aoma (Elugbe 1989)	Niger-Congo
Apatani (Abraham 1985)	Sino-Tibetan
Arabana (Hercus 1994)	Australian
Arabic, Abha (Nakshabandi 1988)	Afro-Asiatic
Arabic, Bedouin, North Israel (Rosenhouse 1984)	Afro-Asiatic
Arabic, Egyptian (Broselow 1976)	Afro-Asiatic
Arabic, Jordanian (Al-Sughayer 1990)	Afro-Asiatic
Arabic, Libyan (Abumdas 1985)	Afro-Asiatic
Arabic, Moroccan (Keegan 1986)	Afro-Asiatic
Arabic, Muscat (Glover 1989)	Afro-Asiatic
Arapesh (Fortune 1977)	Torricelli
Arbore (Hayward 1984)	Afro-Asiatic
Argobba (Leslau 1997)	Afro-Asiatic
Armenian (Vaux 1998) (incl. Agn, Agulis, Homshetsma, Karchevian, Kirzan, Marash, Standard Eastern Armenian)	Indo-European
Ashuku (Shimizu 1980a)	Niger-Congo

Asmat (Flamingo Bay Dialect) (Voorhoeve 1965)	Trans-New Guinea
Assiniboine (Levin 1961)	Siouan
Assyrian Neo-Aramaic (Fox 1997, Odisho 1988) (incl. Iraqi Koine, Jilu)	Afro-Asiatic
Auca (Waorani: 'Auca' is offensive) (Saint & Pike 1962)	Unclassified
Auchi (Yekhee) (Elugbe 1989)	Niger-Congo
Auyana (McKaughan and Marks 1973)	Trans-New Guinea
Awa (Loving 1973)	Trans-New Guinea
Axininca Campa (Asháninca) (Payne 1981)	Arawakan
Aymara (Davidson 1977)	Aymaran
Azari, Iranian (South Azerbaijani) (Dehghani 2000)	Altaic
Bagri (Gusain 2000)	Indo-European
Balangao (Shetler 1976)	Austronesian
Banoni (Lincoln 1976)	Austronesian
Bare (Baré) (Aikhenvald 1995)	Arawakan
Basque (Saltarelli *et al.* 1988)	Austronesian
Bata (Boyd 2002)	Afro-Asiatic
Batibo Moghamo (Meta') (Stallcup 1978)	Niger-Congo
Beaver, Halfway River (Randoja 1990)	Na-Dene
Belizian Creole (Greene 1999)	Creole
Bemba (van Sambeek 1966)	Niger-Congo
Bengali (Ray 1966)	Indo-European
Berber, Tamazight (Abdel-Massih 1968, Jilali 1976) (incl. Ait Ayache, Ayt Ndhir)	Afro-Asiatic
Berber, Tarifit (McClelland 2000)	Afro-Asiatic
Berber, Tashlhiyt (Tachelhit) (Dell and Elmedlaoui 2002) (incl. Haha, Imdlawn)	Afro-Asiatic
Berbice Dutch Creole (Kouwenberg 1994)	Creole
Bikele (dialect of Kol) (Begne 1980)	Niger-Congo
Binumarien (Oatridge and Oatridge 1973)	Trans-New Guinea
Biri (Terrill 1998)	Australian
Bisu (Xu 2001)	Sino-Tibetan
Blackfoot (Frantz 1991)	Algic
Boko-Busa (Jones 1998)	Niger-Congo
Boruca (Constenla 1981)	Chibchan
Brahui (Andronov 1980)	Dravidian
Breton (Press 1986)	Indo-European
Bribri (Constenla 1981)	Chibchan
Bukiyip (Conrad and Wogiga 1991)	Torricelli
Bukusu (Austen 1974)	Niger-Congo
Bulgarian (Scatton 1984)	Indo-European
Burgenland-Romani (Halwachs 2002)	Indo-European
Buriat (Poppe 1960)	Altaic
Burmese (Okell 1969)	Sino-Tibetan
Cabécar (Constenla 1981)	Chibchan

Cahuilla (Seiler 1977)	Uto-Aztecan
Cantonese (Hashimoto 1972)	Sino-Tibetan
Capanahua (Loos 1967)	Panoan
Casiguran Negrito (Vanoverbergh 1937)	Austronesian
Catalan (Wheeler 1979)	Indo-European
Cavineña (Key 1968)	Tacanan
Cayapa (Chachi) (Lindskoog and Brend 1962)	Barbacoan
Cebuano (Bunye and Yap 1971)	Austronesian
Central South-Lappish (Saami) (Hasselbrink 1965)	Uralic
Central Yupik (St. Clair 1974)	Eskimo-Aleut
Chakosi (Anufo) (Stanford 1970)	Niger-Congo
Chama (Esse Ejja: 'Chama' is objectionable) (Key 1968)	Tacanan
Chamorro (Topping 1973)	Austronesian
Chemehuevi (dialect of Ute-Southern Paiute) (Press 1975)	Uto-Aztecan
Cheremis, Eastern (Sebeok 1961)	Uralic
Cherokee (King 1975, Walker 1975) (incl. Oklahoma, Qualla dialect)	Iroquoian
Chichewa (dialect of Nyanja) (Bentley & Kulemeka 2001)	Niger-Congo
Chinantec, Comaltepec (Anderson 1989)	Oto-Manguean
Chinantec, Lealao (Lealao Chinanteco) (Rupp 1989)	Oto-Manguean
Chinantec, Tepetotutla (Westley 1991)	Oto-Manguean
Chomo (Dhu, Como Karim) (Shimizu 1980a)	Niger-Congo
Chontal Maya (Tabasco Chontal) (Knowles 1984)	Mayan
Chori (Cori) (Dihoff 1976)	Niger-Congo
Chrau (Thomas 1971)	Austro-Asiatic
Ciyao (Yao) (Ngunga 2000)	Niger-Congo
Coeur d'Alene (Johnson 1975)	Salishan
Cofan (Cofán) (Borman 1962)	Chibchan
Comanche (Charney 1993)	Uto-Aztecan
Creole of São Tomé (Sãotomense) (Ferraz 1979)	Creole
Cuna (San Blas Cuna?) (Sherzer 1975)	Chibchan
Czech (Harkins 1953)	Indo-European
Daga (Murane 1974)	Trans-New Guinea
Dàgáárè (Bodomo 2000)	Niger-Congo
Dahalo (Tosco 1991)	Afro-Asiatic
Dani, Lower Grand Valley (Bromley 1961)	Trans-New Guinea
Danish (Jones and Gade 1981)	Indo-European
Dagur (Martin 1961)	Altaic
Degema (Elugbe 1989)	Niger-Congo
Delaware (Unami) (Goddard 1979)	Algic
Desano (Kaye 1970)	Tucanoan
Dhaasanac (Daasanach) (Tosco 2001)	Afro-Asiatic
Dholuo (Luo) (Okoth-Okombo 1982)	Nilo-Saharan
Diegueño (Kumiái) (Gorbet 1976)	Hokan
Dieri (Diyari) (Austin 1981)	Australian

Diola-Fogny (Jola-Fogny) (Sapir 1965)	Niger-Congo
Djinang/Djinba (Waters 1989)	Australian
Dominican Creole (Edward 1980)	Creole
Doyayo (Wiering and Wiering 1994)	Niger-Congo
Dutch (Booij 1995)	Indo-European
Dyirbal (Dixon 1972)	Australian
Edo (Elugbe 1989)	Niger-Congo
Efate/Nguna, North (Schütz 1969)	Austronesian
Efik (Ward 1933)	Niger-Congo
Egene (Engenni) (Elugbe 1989)	Niger-Congo
Ehueun (Elugbe 1989)	Niger-Congo
Ejagham (Watters 1981)	Niger-Congo
Ekigusii (Gusii) (Cammenga 2002)	Niger-Congo
Emhalhe (Somorika/Okpamheri) (Elugbe 1989)	Niger-Congo
English (Jensen 1993, McMahon 2002)	Indo-European
Epie (Elugbe 1989)	Niger-Congo
Eruwa (Elugbe 1989)	Niger-Congo
Estonian (Harms 1962)	Uralic
Evenki (Nedjalkov 1997)	Altaic
Ewe (Ansre 1961)	Niger-Congo
Faranah-Maninka (Spears 1965)	Niger-Congo
Faroese (Lockwood 1955)	Indo-European
Fe'Fe'-Bamileke (Hyman 1972)	Niger-Congo
Fehan Tetun (van Klinken 1999)	Austronesian
Fijian, Boumaa (Dixon 1988)	Austronesian
Finnish (Sulkala and Karjalainen 1992)	Uralic
French (Valdman 1976, Casagrande 1984)	Indo-European
Fulfulde (dialect of Mali) (McIntosh 1984)	Niger-Congo
Fyem (Nettle 1998)	Niger-Congo
Gã (Zimmermann 1858)	Niger-Congo
Gade (Pieter 1977)	Niger-Congo
Gadsup (Frantz and Frantz 1973)	Trans-New Guinea
Ganda (Cole 1967)	Niger-Congo
Ganggulida (Holmer 1988)	Australian
Garawa (Bundjil/Wandji) (Holmer 1988)	Australian
Garo (Burling 1961)	Sino-Tibetan
Garwa (Holmer 1988)	Australian
Georgian (Cherchi 1999)	South Caucasian
German (Fox 1990)	Indo-European
Ghotuo (Elugbe 1989)	Niger-Congo
Gikuyu (Mugane 1997)	Niger-Congo
Giziga (Rossing 1978)	Afro-Asiatic
Godoberi (Kibrik 1996)	North Caucasian
Gondi, Adilabad (Subrahmanyam 1968)	Dravidian
Gondi, Koya (Subrahmanyam 1968)	Dravidian

Gooniyandi (McGregor 1990)	Australian
Grebo (Innes 1966)	Niger-Congo
Greek (Joseph and Philippaki-Warburton 1987)	Indo-European
Greenlandic, West (Greenlandic Inuktitut) (Fortescue 1984)	Eskimo-Aleut
Guatuso (Maléku Jaíka) (Constenla 1981)	Chibchan
Gugu-Bujun (Gugu Badhun) (Holmer 1988)	Australian
Gujarati (Cardona 1965)	Indo-European
Gunin/Kwini (Kwini) (McGregor 1993)	Australian
Gwari (Gbagyi) (Hyman and Magaji 1970)	Niger-Congo
Haitian Creole (Hall 1953)	Creole
Hakka/Kejia (Hashimoto 1973, Chung 1989)	Sino-Tibetan
Halkomelem, Chilliwack (Galloway 1977)	Salishan
Harari (Leslau 1958)	Afro-Asiatic
Hatam (Reesink 1999)	West Papuan
Hausa (Jaggar 2001)	Afro-Asiatic
Hebrew (Shmuel 1972)	Afro-Asiatic
Higi (Kamwe) (Mohrlang 1972)	Afro-Asiatic
Hiligaynon (Spitz 2001)	Austronesian
Hindi (Shukla 2000)	Indo-European
Hixkaryana (Derbyshire 1985)	Carib
Hungarian (Abondolo 1988)	Uralic
Hurza/Ndreme/Vame(Pelasla) (Rossing 1978)	Afro-Asiatic
Ibilo (Elugbe 1989)	Niger-Congo
Icen (Shimizu 1980a) (Etkywan)	Niger-Congo
Igbo (Emananjo 1978)	Niger-Congo
Ijo, Kolkuma dialect (Williamson 1965)	Niger-Congo
Ikalanga (Mathingwane 1999)	Niger-Congo
Ilocano (Rubino 2000)	Austronesian
Indonesian, Bahasa (Lapowila 1981)	Austronesian
Ingessana (Gaam) (Crewe 1975)	Nilo-Saharan
Inor (dialect of West Gurage) (Chamora and Hetzron 2000)	Afro-Asiatic
Inuktitut (Lowe 1996)	Eskimo-Aleut
Inupiatun, North Alaskan (Barrow Inupiaq) (Kaplan 1981)	Eskimo-Aleut
Iraqw (Nordbustad 1988)	Afro-Asiatic
Irish (Irish Gaelic) (Ó Siadhail 1989)	Indo-European
Irula (Zvelebil 1973)	Dravidian
Isoko (Uzere dialect) (Elugbe 1989)	Niger-Congo
Italian (Castiglione 1957)	Indo-European
Itzaj Maya (Itzá) (Hofling 2000)	Mayan
Izi (Meier, Meier, and Bendor-Samuel 1975)	Niger-Congo
Jacaltec (Day 1973)	Mayan
Jamaican Creole (Bailey 1966)	Creole
Jamul Tiipay (dialect of Kumiái) (Miller 2001)	Hokan
Japanese (Vance 1987)	Japanese
Jaqaru (Hardman 2000)	Aymaran

Javanese (Suharno 1982)	Austronesian
Jiru (Wuyar) (Shimizu 1980a)	Niger-Congo
Jukun (Jukun Takum) (Shimizu 1980a, b) (Wukari dialect)	Niger-Congo
Kabardian (Colarusso 1988)	North Caucasian
Kalengin (Toweett 1979)	Nilo-Saharan
Kalispel (dialect of Kalispel-Pend d'Oreille) (Vogt 1940)	Salishan
Kamba (Lindblom 1925)	Niger-Congo
Kana (Khana) (Ikoro 1996)	Niger-Congo
Kanakuru (Dera) (Newman 1974)	Afro-Asiatic
Kannada (Sridhar 1990)	Dravidian
Kanuri (Cyffer 1998)	Nilo-Saharan
Kapampangan (Pampangan) (Forman 1971)	Austronesian
Karanga (Central & Victoria dialects) (Marconnès 1931)	Nilo-Saharan
Karao (Brainard 1994)	Austronesian
Karimojong (Karamojong) (Novelli 1985)	Nilo-Saharan
Karo Batak (Woollams 1996)	Austronesian
Kashaya (Buckley 1994)	Hokan
Kashmiri (Wali and Koul 1997)	Indo-European
Kayah Li, Eastern (Eastern Kayah) (Solnit 1997)	Sino-Tibetan
Kedang (Samely 1991)	Austronesian
Kharia (Bilgiri 1965)	Austro-Asiatic
Khmer (Gorgoniyev 1966)	Austro-Asiatic
Khmuˀ (Smalley 1961)	Austro-Asiatic
Kickapoo (Voorhis 1974)	Algic
Kihungan (Hungana) (Takizala 1974)	Niger-Congo
Kilivila/Kiriwina (Lawton 1993)	Austronesian
Kimatuumbi (Matumbi) (Odden 1996)	Niger-Congo
Kinande/Nandi (Creider and Creider 1989)	Niger-Congo
Kinnauri (Sharma 1988)	Sino-Tibetan
Kinyamwezi (Maganga & Schadeberg 1992)	Niger-Congo
Kinyarwanda (Rwanda) (Kimenyi 1979)	Niger-Congo
Kiowa (Watkins 1984)	Kiowa Tanoan
Kirghiz (Hebert and Poppe 1963)	Altaic
Kiribati (Groves, Groves, and Jacobs 1985)	Austronesian
Kisar (Christenson and Christenson 1992)	Austronesian
Kisi (Childs 1990)	Niger-Congo
Klamath (White 1973)	Penutian
Koiari (Dutton 1996)	Trans-New Guinea
Kolami (Emeneau 1961)	Dravidian
Kombai (de Vreis 1993)	Trans-New Guinea
Koraga, Mudu (Bhat 1971)	Dravidian
Koraga, Onti (Bhat 1971)	Dravidian
Koraga, Tappu (Bhat 1971)	Dravidian
Korean (Yi 1989)	Language Isolate

Koromfé (Rennison 1997)	Niger-Congo
Korowai (van Enk and de Vries 1997)	Trans-New Guinea
Koyukon, Central Outer (Kroul 1980)	Na-Dene
Kpan (Kente dialect) (Shimizu 1980a)	Niger-Congo
Kpelle (Westerman and Melzian 1974)	Niger-Congo
Kporo (Shimizu 1980a)	Niger-Congo
Kristang (Malaccan Creole Portuguese) (Baxter 1988)	Creole
Kriyol (Upper Guinea Crioulo) (Kihm 1994)	Creole
Kui (Winfield 1928)	Dravidian
Kukú (dialect of Bari) (Cohen 2000)	Nilo-Saharan
Kuku-Yalanji Kantyu/Koko-Yalandji (Holmer 1988)	Australian
Kurmanji (Kurdish) (Kahn 1976)	Indo-European
Kurux (Gordon 1976)	Dravidian
Kutep (Lissam dialect) (Shimizu 1980a)	Niger-Congo
Kuvi (Israel 1979)	Dravidian
Kwamera (Lindstrom and Lynch 1994)	Austronesian
Lakota (Patterson 1990)	Siouan
Lama (Ourso 1989)	Niger-Congo
Lango (Noonan 1992)	Nilo-Saharan
Lao (Morev, Moskalev, and Plam 1979)	Tai-Kadai
Larike (Laidig 1992)	Austronesian
Latvian (Mathiassen 1997)	Indo-European
Lele (Frajzyngier 2001)	Afro-Asiatic
Lezgian (Lezgi) (Haspelmath 1993)	North Caucasian
Ligurian, Miogliola (Ghini 2001)	Indo-European
Limbu (Weidert and Subba 1985)	Sino-Tibetan
Lingala (Odhner 1981)	Niger-Congo
Lithuanian (Ambrazas *et al.* 1997)	Indo-European
Lomongo (Mongo-Nkundu) (Ruskin and Ruskin 1934)	Niger-Congo
Loniu (Hamel 1994)	Austronesian
Lorma (Loma) (Dwyer 1981)	Niger-Congo
Lotha (Lotha Naga) (Acharya 1983)	Sino-Tibetan
Louisiana Creole French (Klingler 1992)	Creole
Lumasaaba (Masaba) (Brown 1972)	Niger-Congo
Lusi (Counts 1969)	Austronesian
Maale (Male) (Amha 2001)	Afro-Asiatic
Maasai (Hollis 1971)	Nilo-Saharan
Macuxi (Macushi) (Carson 1982)	Carib
Mada (Rossing 1978)	Afro-Asiatic
Madurese (Davies 1999)	Austronesian
Maithili (Yadav 1996)	Indo-European
Malay (Teoh 1988)	Austronesian
Malayalam (Asher and Kumari 1997)	Dravidian
Maldivian, Dhivehi (Cain and Gair 2000)	Indo-European
Maltese (Borg and Azzopardi-Alexander 1997)	Afro-Asiatic

Mam (Northern Mam) (England 1983)	Mayan
Mandan (Mixco 1997)	Siouan
Mandarin (Chao 1968, Bodman and Stimson 1961)	Sino-Tibetan
Mandinkakan (Guinea Bissau dialect) (Ngom 2000)	Niger-Congo
Mandinkakan (Pakawu dialect) (Ngom 2000)	Niger-Congo
Mangap-Mbula (Bugenhagen 1995)	Austronesian
Manipuri (Meitei) (Bhat and Ningomba 1997)	Sino-Tibetan
Maori (Harlow 1996)	Austronesian
Marathi (Ghatage 1971, Jha 1980) (incl. Cochin, Kosti)	Indo-European
Margi (Marghi Central) (Hoffmann 1963)	Afro-Asiatic
Marshallese (Bender 1969)	Austronesian
Martuthunira (Dench 1995)	Australian
Masalit (Edgar 1989)	Nilo-Saharan
Maya (Yucatan) (Straight 1976)	Mayan
Mbili (Bambili) (Ayuninjam 1998)	Niger-Congo
Melanesian Pidgin English (Tok Pisin) (Hall 1943)	Creole
Melayu Betawi (Ikranagara 1975)	Creole
Mende (Sengova 1984)	Niger-Congo
Menomini (Miner 1975)	Algic
Meriam (Mer) (Holmer 1988)	Trans-New Guinea
Michigan German (Born 1994)	Indo-European
Mikasuki (Boynton 1982)	Muskogean
Mikir (Jeyapaul 1987)	Sino-Tibetan
Mishmi (Sastry 1984)	Sino-Tibetan
Mising (Prasad 1991)	Sino-Tibetan
Mixe, Lowland (Wichmann 1995) (incl. Guichicovi, Coatlán Mixe, San José El Paraíso Mixe, San Juan el Paraíso Mixe (Dieterman & Haitsma 1976))	Mixe-Zoque
Mixe, Midland (Wichmann 1995) (incl. Atitlán Mixe, Cacalotepec Mixe, Cotzocón Mixe, Jaltepec Mixe, Juquila Mixe, Matamoros Mixe, Muxmetacán Mixe, Puxmetacán Mixe)	Mixe-Zoque
Mixe, North Highland (Totontepec) (Wichmann 1995)	Mixe-Zoque
Mixe, South Highland (Wichmann 1995) (incl. Mixistlán Mixe, Tepantlali Mixe, Tepuxtepec Mixe, Tlahuitoltepec Mixe)	Mixe-Zoque
Mixtec, Coatzospan (Coatzospan Mixteco) (Gerfen 1999)	Oto-Manguean
Mofu (Rossing 1978)	Afro-Asiatic
Mohawk (Michelson 1983)	Iroquoian
Mojave (Mohave) (Munro 1976)	Hokan
Mokilese (Harrison 1976)	Austronesian
Moloko (Melokwo) (Rossing 1978)	Afro-Asiatic
Mong Njua (Green Miao) (Lyman 1979)	Hmong-Mien

Mongolian (Halh Mongolian) (Bosson 1964)	Altaic
Montagnais (Cyr 1996)	Algic
Muktile (Matal) (Rossing 1978)	Afro-Asiatic
Mumuye (Zing dialect) (Shimizu 1983)	Niger-Congo
Muna (Berg 1989)	Austronesian
Mundari (Cook 1974)	Austro-Asiatic
Mupun (Mwaghavul) (Frajzyngier 1993)	Afro-Asiatic
Muruwari (Oates 1988)	Australian
Muyang (Rossing 1978)	Afro-Asiatic
Mwera (Harries 1950)	Niger-Congo
Nagamese (Naga Pidgin) (Boruah 1993)	Creole
Nahuatl, Huasteca (Beller and Beller 1979)	Uto-Aztecan
Nahuatl, Michoacán (Michoacán Nahual) (Sischo 1979)	Uto-Aztecan
Nahuatl, North Puebla (Brockway 1979)	Uto-Aztecan
Nahuatl, Tetelcingo (Tuggy 1979)	Uto-Aztecan
Nalik (Volker 1998)	Austronesian
Nangikurrunggurr (Hoddinott and Kofod 1988)	Australian
Navaho (Navajo) (Reichard 1974)	Na-Dene
Ndebele, Northern Transvaal (Ziervogel 1959)	Niger-Congo
Ndyuka (Huttar and Huttar 1994)	Creole
Ngiti (Kutsch Lojenga 1994)	Nilo-Saharan
Ngiyambaa (Donaldson 1980)	Australian
Ngura (Holmer 1988)	Australian
Nhanda ~Yinggarda (Blevins 2001)	Australian
Nigerian English (Faraclas 1996)	Creole
Nimboran (Anceaux 1965)	Trans-New Guinea
Nisgha (Nisga'a) (Tarpent 1987)	Penutian
Nkore-Kiga (Chiga) (Taylor 1985)	Niger-Congo
Noni (Noone) (Hyman 1981)	Niger-Congo
Noon (Soukka 2000)	Niger-Congo
Nootka, Tsishaath (Nuuchahnulth) (Stonham 1999)	Wakashan
Nuer (Crazzolara 1933)	Nilo-Saharan
Nyangumata (O'Grady 1964)	Australian
Nyanja (Price 1958)	Niger-Congo
Nyulnyul (McGregor 1996)	Australian
Ojibwa, Central (Rhodes 1976)	Algic
Ojibwa, Eastern (Bloomfield 1956)	Algic
Okpe (Elugbe 1989)	Niger-Congo
Oloma (Elugbe 1989)	Niger-Congo
Oluta Popoluca (Wichmann 1995)	Mixe-Zoque
Oneida (Michelson 1983)	Iroquoian
Onondaga (Michelson 1983)	Iroquoian
Oriya, Kotia (Adivasi Oriya) (Gustafsson 1974)	Indo-European
Orma (Stroomer 1987)	Afro-Asiatic
Oromo, Boraana (Borana-Arsi-Guji) (Stroomer 1987)	Afro-Asiatic

Oromo, Harar (Eastern Oromo) (Owens 1985)	Afro-Asiatic
Oromo, Waata (Sanye) (Stroomer 1987)	Afro-Asiatic
Oshindonga (Ndonga) (Fivaz 1986)	Niger-Congo
Ostyak, Eastern (Khanty) (Gulya 1966)	Uralic
Pa'anci (Skinner 1979)	Afro-Asiatic
Paiute, Northern (Snapp, Anderson, and Anderson 1979)	Uto-Aztecan
Palauan (Josephs 1975)	Austronesian
Papago (O'odham) (Saxton 1979)	Uto-Aztecan
Papiamentu (Kouwenberg and Murray 1994)	Creole
Passamaquoddy-Maliseet (Leavitt 1996)	Algic
Pawnee (Parks 1976)	Caddoan
Pech (Paya) (Holt 1999)	Chibchan
Pengo (Burrow and Bhattacharya 1970)	Dravidian
Pero (Frajzyngier 1989)	Afro-Asiatic
Persian (Dehghani 2002)	Indo-European
Pileni (Næss 2000)	Austronesian
Pima Bajo (Fernández 1996)	Uto-Aztecan
Pitjantjatjara/Western Desert Language (Douglas 1964)	Australian
Polish (Swan 1983)	Indo-European
Portuguese (Mateus and d'Andrade 2000) (Brazilian and European)	Indo-European
Pulaar (Paradis 1992)	Niger-Congo
Pulu Annian (Oda 1977)	Austronesian
Punjabi (Bhatia 1993)	Indo-European
Purik (Rangan 1979)	Sino-Tibetan
Quechua, Cuzco (Cuzco Kechua) (Davidson 1977)	Quechuan
Quechua, Ecuadorean Highland (Lombeida-Naranjo 1976)	Quechuan
Quechua, Huallaga 'Huanaco' (Weber 1983)	Quechuan
Quechua, San Pedro de Cajas (Adelaar 1977)	Quechuan
Quechua, Tarma (Adelaar 1977)	Quechuan
Quichoa, Chimborazo (Beukema 1975)	Quechuan
Quichua, Ecuador (Puyo Pongo (E. Ecuador)) (Orr 1962)	Quechuan
Quichua, Imbabura Highland (Carpenter 1982)	Quechuan
Rabaul Creole German (Unserdeutsch) (Volker 1982)	Creole
Rao (Stanhope 1980)	Sepik-Ramu
Rapanui (Du Feu 1996)	Austronesian
Resigaro (Resígaro) (Allin 1976)	Arawakan
Romanes (Sinte) (Holzinger 1995)	Indo-European
Romanian (Chitoran 2002)	Indo-European
Rotuman (Vamarasi 2002)	Austronesian
Runyankore (Nyankore) (Morris and Kirwan 1957)	Niger-Congo
Runyoro-Rutooro (Nyoro/Tooro) (Rubongoya 1999)	Niger-Congo
Russian (Unbegaun 1957)	Indo-European
Sacapultec (Sacapulteco) (Dubois 1981)	Mayan
Sahaptin, Northern (Jacobs 1931)	Penutian

Saibai (Kala Lagaw Ya) (Holmer 1988)	Australian
Sango (Samarin 1967)	Creole
Santali (Neukom 2001)	Austro-Asiatic
Sawai (Whisler 1992)	Austronesian
Sayula Popoluca (Wichmann 1995)	Mixe-Zoque
Secoya (Johnson and Peeke 1962)	Tucanoan
Sekani (Hargus 1988)	Na-Dene
Selepet (McElhanon 1970)	Trans-New Guinea
Sema (Sreedhar 1980)	Sino-Tibetan
Senoufo, Cebaara (Mills 1984)	Niger-Congo
Senoufo, Supyire (Carlson 1994)	Niger-Congo
Sentani (Cowan 1965)	Trans-New Guinea
Sepečides-Romani (Cech and Heinschink 1996)	Indo-European
Serbo-Croatian (Cres Čakavian) (Houtzagers 1985)	Indo-European
Shambala (Besha 1989)	Niger-Congo
Shekhawati (dialect of Marwari) (Gusain 2001)	Indo-European
Shilluk (Gilley 1992)	Nilo-Saharan
Shiriana Yanam (Ninam) (Gómez 1990)	Yanomam
Shona (Zezuru, Central and Eastern) (Doke 1931)	Niger-Congo
Shoshoni, Western (Crum and Dayley 1993)	Uto-Aztecan
Sie (Crowley 1998)	Austronesian
Si-Luyana (Luyana) (Givon 1970)	Niger-Congo
Sinaugoro (Tauberschmidt 1999)	Austronesian
Siona (Wheeler and Wheeler 1962)	Tucanoan
Slavey, North (Rice 1989) (incl. Bearlake, Hare, Mountain)	Na-Dene
Slavey, South (Slavey) (Rice 1989)	Na-Dene
Slovak (Rubach 1993)	Indo-European
Slovene (Herrity 2000)	Indo-European
So (Soo) (Carlin 1993)	Nilo-Saharan
Somali (Saeed 1987)	Afro-Asiatic
Sonora Yaqui (Dedrick and Casad 1999)	Uto-Aztecan
Sotho (Southern dialect) (Doke and Mofokeng 1957)	Niger-Congo
Southeastern Tepehuan (Tepehuán Suroeste) (Willett 1988)	Uto-Aztecan
Spanish (European) (Cressey 1978)	Indo-European
Sre (Manley 1972)	Austro-Asiatic
Sri Lanka Creole Portuguese (Smith 1981)	Creole
St. Lucian Creole (Carrington 1984)	Creole
Straits Salish, Samish dialect (Galloway 1990)	Salishan
Svan (Tuite 1997)	South Caucasian
Swahili (Ashton 1969)	Niger-Congo
Swazi (Swati) (Ziervogel 1952)	Niger-Congo
Swedish (McClean 1987)	Indo-European
Tacana (Key 1968)	Tacanan
Tagalog (Ramos 1971)	Austronesian

Talysh, Northern (Schulze 2000)	Indo-European
Tamasheq (Sudlow 2001)	Afro-Asiatic
Tamil (Schiffman 1999)	Dravidian
Tangale (Kidda 1985)	Afro-Asiatic
Tangkhul (Tangkhul Naga) (Arokianathan 1987)	Sino-Tibetan
Tarangan, West, River (Nivens 1992)	Austronesian
Tauya (MacDonald 1990)	Trans-New Guinea
Tawala (Ezard 1997)	Austronesian
Telugu (Lakshmi 1982)	Dravidian
Temne (Wilson 1961)	Niger-Congo
Tepecano (Mason 1917)	Uto-Aztecan
Tepehuan, Northern (Bascom 1979)	Uto-Aztecan
Teribe (Quesada 2000)	Chibchan
Thai (Palikupt 1983) (incl. Central, Northeastern)	Tai-Kadai
Thompson (Thompson and Thompson 1992)	Salishan
Tibetan (Dawson 1980)	Sino-Tibetan
Tigre (Raz 1983)	Afro-Asiatic
Tigrinya (Pam 1973)	Afro-Asiatic
Tiri/Tinrin (Osumi 1995)	Austronesian
Tiriyó (Trió) (Meira 2000)	Carib
Tirmaga (Suri) (Bryant 1999)	Nilo-Saharan
Tiv (Abraham 1968)	Niger-Congo
Toba (Klein 2001)	Mataco-Guaicuru
Tojolabal Maya (Brody 1982)	Mayan
Tokelauan (Hooper 1996)	Austronesian
Tolkapaya (Western Yavapai) (Hardy 1979)	Hokan
Tongan (Churchward 1985)	Austronesian
Totonac, Misantla (MacKay 1999) (incl. San Marcos, Yecuatla)	Totonacan
Trinidadian Creole English (Winer 1993)	Creole
Tsakhur (Schulze 1997)	North Caucasian
Tsimshian, Coast (Dunn 1979[1995])	Penutian
Tswana (Cole 1955)	Niger-Congo
Tukangbesi (Donohue 1999)	Austronesian
Turkana (Dimmendaal 1983)	Nilo-Saharan
Turkish (Lewis 1967)	Altaic
Turkmen (Frank 1995)	Altaic
Tuvaluan (Besnier 2000)	Austronesian
Tyvan (Tuvin) (Anderson and Harrison 1999)	Altaic
Tzotzil (Huixtán Tzotzil) (Cowan 1968)	Mayan
Tzutujil (Western Tzutujil) (Dayley 1981)	Mayan
Ubykh (Colarusso 1988)	North Caucasian
Uhami (Okpamheri) (Elugbe 1989)	Niger-Congo
Ukrainian (Bidwell 1967-68)	Indo-European

Ukue (Elugbe 1989:99)	Niger-Congo
Umbundu (Schadeberg 1990)	Niger-Congo
Uneme (Elugbe 1989)	Niger-Congo
Ura (Crowley 1996)	Austronesian
Ura (Crowley 1999)	East Papuan
Urdu, Dakkhini (Mustafa 2000)	Indo-European
Urhobo (Elugbe 1989)	Niger-Congo
Usarufa (Bee and Glasgow 1973)	Trans-New Guinea
Uvbie (Elugbe 1989)	Niger-Congo
Vei (Vai) (Koelle 1968[1854])	Niger-Congo
Venda (Poulos 1990)	Niger-Congo
Vietnamese (Nguyên 1997)	Austro-Asiatic
Waffa (Stringer and Hotz 1973)	Trans-New Guinea
Wambaya (Nordlinger 1998)	Australian
Wangkangurru (Hercus 1994)	Australian
Warembori (Donohue 1996)	Lower Mamberamo
Warlpiri (Nash 1986)	Australian
Warrwa (McGregor 1994)	Australian
Welsh (Thorne 1993)	Indo-European
Wichita (Rood 1976)	Caddoan
Wirangu (Hercus 1998)	Australian
Wisa (Lala-Bisa) (Madan 1906)	Niger-Congo
Wiyot (Reichard 1925)	Algic
Wolaytta (Lamberti and Sottile 1997)	Afro-Asiatic
Woleaian (Sohn 1975)	Austronesian
Wolio (Anceaux 1952)	Austronesian
Wolof (Ka 1994)	Niger-Congo
Xakas (Khakas) (Anderson 1998)	Altaic
Xhosa (McLaren 1906)	Niger-Congo
Yapese (Jensen 1977)	Austronesian
Yavapai (Shaterian 1983)	Hokan
Yiddish (Katz 1987)	Indo-European
Yidiɲ (Dixon 1977)	Australian
Yinggarda (Dench 1998)	Australian
Yir-Yoront (Alpher 1991)	Australian
Yom (Pila) (Beacham 1968)	Niger-Congo
Yoruba (Awobuluyi 1978)	Niger-Congo
Yuchi (Ballard 1975)	Language Isolate
Yukuben (Shimizu 1980a)	Niger-Congo
Yurok (Robins 1958)	Algic
Zina Kotoko (Odden 2002)	Afro-Asiatic
Zulgo (Zulgwa) (Rossing 1978)	Afro-Asiatic
Zulu (Malcolm 1966)	Niger-Congo
Zway (Leslau 1999)	Afro-Asiatic

BIBLIOGRAPHY

Abdel-Massih, Ernest T. (1968) *Tamazight Verb Structure: A Generative Approach*. Bloomington/The Hague: Mouton & Co./Indiana University.

Abondolo, D. M. (1988) *Hungarian Inflectional Morphology*. Budapest: Akadémiai Kiadó.

Abraham, P. T. (1985) *Apatani Grammar*. Mysore: Central Institute of Indian Languages.

Abraham, R. C. (1968) *The Principles of Tiv*. Farnborough, England: Gregg International Publishers.

Abumdas, Abdul Hamid Ali (1985) *Libyan Arabic Phonology*. Ann Arbor: UMI.

Acharya, K. P. (1983) *Lotha Grammar*. Mysore: Central Institute of Indian Languages.

Adelaar, W. F. H. (1977) *Tarma Quechua grammar, texts, dictionary*. Lisse: The Peter de Ridder Press.

Aiello, Leslie C. (1996) Hominine preadaptations for language and cognition. In Paul Mellars and Kathleen Gibson (eds.) *Modelling the Early Human Mind*. Cambridge: McDonald Institute Monographs. pp. 89-99.

Aikhenvald, Alexandra (1995) *Bare*. Muenchen: Lincom Europa.

Allin, Trevor R. (1976) *A Grammar of Resígaro*. Summer Institute of Linguistics. High Wycombe, England: Summer Institute of Linguistics.

Alpher, Barry (1991) Y*ir-Yoront Lexicon: Sketch and Dictionary of an Australian Language*. New York: Mouton de Gruyter

Al-Sughayer, Khalil Ibrahim (1990) *Aspects of Comparative Jordanian and Modern Standard Arabic Phonology*. Ann Arbor: UMI.

Ambrazas, Vytautas, Emma Geniušienė, Aleksas Girdenis, Nijolė Sližienė, Dalija Tekorienė, Adelė Valeckienė, and Elena Valiulytė (1997) *Lithuanian Grammar*. Lithuania: Baltos Lankos.

Amha, Azeb (2001) *The Maale language*. Leiden: Research School of Asian, African, and Amerindian Studies, Universiteit Leiden.

Anceaux, Dr . J. C. (1952) *The Wolio Language*. 'S-Gravenhage: Martinus Nijhoff.

Anceaux, J.C. (1965) *The Nimboran Language*. 'S-Gravenhage – Martinus Nijhoff.

Andersen, Henning (1972) Diphthongization. *Language* 48: 11-50.

Andersen, Henning (1973) Abductive and deductive change. *Language* 49: 765-93.

Anderson, Gregory D.S. (1998) *Xakas*. Muenchen: Lincom Europa.

Anderson, Gregory David, and K. David Harrison (1999) *Tyvan*. Muenchen: Lincom Europa.

Anderson, Judi Lynn (1989) *Comaltepec Chinantec Syntax. Studies in Chinantec Languages Volume 3*. Arlington, TX: Summer Institute of Linguistics and the University of Texas at Arlington.

Anderson, R.W., (1990) *Papiamentu tense-aspect, with special attention to discourse*. In Singler J. (ed.) Pidgin and creole tense-mood-aspect systems. Amsterdam: John Benjamins. pp. 59-96.

Anderson, Stephen R. (1981) Why Phonology Isn't "Natural". *Linguistic Inquiry 12(4).* 493-539.

Andronov, M. S. (1980) *The Brahui Language*. Moscow: Nauka Publishing House.

Ansre, Gilbert (1961) *The Tonal Structure of Ewe*. Hartford: Hartford Studies in Linguistics.

Anttila, Raimo (1977) *Analogy*. The Hague: Mouton.

Anttila, Raimo (2003) Analogy: The Warp and Woof of Cognition. In Joseph and Janda (2003). 425-440

Anttila, Raimo, and Warren A. Brewer (1977) *Analogy: A Basic Bibliography*. Amsterdam: John Benjamins.

Archangeli, Diana, and Douglas Pulleyblank (1994) *Grounded Phonology*. Cambridge, Mass.: The MIT Press.

Arokianathan, S (1987) *Tangkhul Naga Grammar*. Mysore: Central Institute of Indian Languages.

Asher, R.E. and T.C. Kumari (1997) *Malayalam*. New York: Routledge

Ashton, E. O. (1969) *Swahili Grammar*. London: Longmans.

Aslin, Richard N., and David B. Pisoni (1980) Some Developmental Processes in Speech Perception. in Yeni-Komshian, Grace H., James, F. Kavanaugh, and Charles A. Ferguson (eds.) *Child Phonology Volume 2: Perception*. New York: Academic Press. pp. 67-96.

Austen, Cheryl Lynn (1974) *Aspects of Bukusu Syntax and Phonology*. Ann Arbor: UMI.

Austin, Peter (1981) *A Grammar of Diyari, South Australia*. Cambridge: Cambridge University Press.

Avery, Peter, and William J. Idsardi (2001) Laryngeal dimensions, completion and enhancement. In Hall (2001). 41-70.

Awobuluyi, Oladele (1978) *Essentials of Yoruba*. Ibadan: Oxford University Press Nigeria.

Ayuninjam, Funwi F. (1998) *A Reference Grammar of Mbili*. Lanham: University Press of America, Inc.

Bach, Emmon, and Robert T. Harms (1972) How Do Languages Get Crazy Rules. In R.P. Stockwell and R.K.S. Macauley (eds.), *Linguistic Change and Generative Theory*. Bloomington, Indiana: Indiana University Press.

Bailey, Beryl Loftman (1966) *Jamaican Creole Syntax: A Transformational Approach*. Cambridge: Cambridge University Press.

Ballard, W. L. (1975) Aspects of Yuchi morphophonology. In Crawford (1975)

Bascom, Burton (1979) Northern Tepehuan. In Langacker (1979).

Baxter, Alan N. (1988) A Grammar of Kristang (Malacca Creole Portuguese). *Pacific Linguistics Series B* – No. 95. Canberra: Pacific Linguistics.

Beacham, Charles Gordon Jr. (1968) *The Phonology and Morphology of Yom*. Ann Arbor: UMI.

Beckman, Mary, and Janet Pierrehumbert (2003) Interpreting 'phonetic interpretation' over the lexicon. in J. Local, R. Ogden, and R. Temple (eds.) *Papers in Laboratory Phonology VI*, Cambridge University Press. 13-37.

Beckman, Mary E., Yoneyama, Kiyoko, and Edwards, Jan (2003). Language-specific and language-universal aspects of lingual obstruent productions in Japanese-acquiring children. *Journal of the Phonetic Society of Japan* 7: 18-28.

Beddor, Patrice Speeter (1991) Predicting the Structure of Phonological Systems. *Phonetica* 48 (2-4): 83-107.

Bee, Darlene, and Kathleen Barker Glasgow (1973) Usarufa Tone and Segmental Phonemes. In McKaughan (1973)

Bee, Darlene, Lorna Luff, and Jean Goddard (1973) Notes on Agarabi Phonology. In McKaughan (1973)

Begne, Leopold Prosper (1980) *The Phonology of Bikele, A Cameroonian Language*. Ann Arbor: UMI.

Beller, Richard, and Patricia Beller (1979) Huastaca Nahauatl. In Langacker (1979).

Bellugi, Ursula (1968) Linguistic mechanisms underlying child speech. In E. Zale, ed., *Language and language behavior*, 36-50. New York: Croofts.

Bender, Byron W. (1969) *Spoken Marshallese*. Honolulu: University of Hawaii Press.

Bendor-Samuel, John T. (1961) The Verbal Piece in Jebero. Supplement to *Word*, volume 17.

Bentley, Mayrene, and Andrew Kulemeka (2001) *Chichewa*. Muenchen: Lincom Europa.

Berg, René van den (1989) *A grammar of the Muna language*. Dordrecht: Foris.

Berry, Keith, and Christine Berry (1998) *A description of Abun: a West Papuan language of Irian Jaya*. Canberra: Pacific Linguistics.

Besha, Ruth Mfumbwa (1989) *A Study of Tense and Aspect in Shambala*. Berlin: Dietrich Reimer Verlag.

Besnier, Niko (2000) *Tuvaluan*. New York: Routledge.

Best, Catherine T., Gerald W. McRoberts, and Nomathemba M. Sithole (1988) Examination of Perceptual Reorganization for Nonnative Speech Contrasts: Zulu Click Discrimination by English-Speaking Adults and Infants. *Journal of Experimental Psychology: Human Perception and Performance* Vol. 14, No. 3, pp. 345-360.

Beukema, Ronald William (1975) *A Grammatical Sketch of Chimborazo Quichoa*. Ann Arbor: UMI.

Bevington, Gary Loyd (1974) *Albanian Phonology*. Wiesbaden: Otto Harrassowitz.

Bhat, D. N. S. (1971) *The Koraga Language*. Poona: Deccan College Postgraduate and Research Institute.

Bhat, D. N. S., and M. S. Ningomba (1997) *Manipuri Grammar*. Newcastle: Lincom Europa.

Bhatia, Tej K. (1993) *Punjabi*. New York: Routledge.

Bickerton, D. (1974) *Dynamics of a Creole System*. Cambridge: Cambridge University Press.

Bickerton, Derek (1981) *Roots of Language*. Ann Arbor: Karoma Publishers, Inc.

Bickerton, Derek (1984) The language bioprogram hypothesis. Behavioral and Brain Sciences 7. 212-218.

Bickerton, Derek (1990) *Language and species*. Chicago: University of Chicago Press.

Bickerton, Derek (1999) How to Acquire Language Without Positive Evidence. in DeGraff (ed.) *Language Creation and Language Change*. Cambridge, Mass.: MIT Press. pp. 49-74.

Bidwell, Charles E. (1967-68) *Outline of Ukrainian Morphology*. University of Pittsburgh.

Bilgiri, H. S. (1965) *Kharia: Phonology, Grammar, and Vocabulary*. Poona: Deccan College Postgraduate and Research Institute.

Blevins, Juliette (2001) *Nhanda, an Aboriginal Language of Western Australia*. Honolulu: University of Hawai'i Press.

Blevins, Juliette (2004) *Evolutionary Phonology*. Cambridge: Cambridge University Press.

Blevins, Juliette (to appear) Consonant epenthesis: natural and unnatural histories. In Jeff Good (ed.) *Proceedings of the Workshop on Explaining Linguistic Universals*. Oxford: Oxford University Press.

Bliese, Loren F. (1981) *A Generative Grammar of Afar*. Arlington: Summer Institute of Linguistics and the University of Texas at Arlington.

Bloomfield, Leonard (1956) *Eastern Ojibwa: Grammatical Sketch, Texts, and Word Lis*t. Ann Arbor: The University of Michigan Press

Bodman, Nicholas C., and Hugh M. Stimson (1961) *Mandarin Chinese: units 1-6*. Washington: Center for Applied Linguistics of the Modern Language Association of America.

Bodomo, Adams B. (2000) *Dàgáárè*. Muenchen: Lincom Europa.

Bolozky, Shmuel (1972) *Categorial Limitations on Rules in the Phonology of Modern Hebrew*. Ann Arbor: UMI.

Booij, Geert (1995) *The Phonology of Dutch*. Oxford: Clarendon Press.

Borg, Albert, and Marie Azzopardi-Alexander (1997) *Maltese*. New York: Routledge.

Borman, M. B. (1962) Cofan Phonemes. In Elson (1962)

Born, Renate (1994) *Michigan German In Frankenmuth: Variation And Change In An East Franconian Dialect*. Columbia, SC: Camden House.

Boruah, B. K. (1993) *Nagamese: The Language of Nagaland*. New Delhi: Mittal Publications.

Bosson, James E. (1964) *Modern Mongolian: A Primer and Reader*. Bloomington/The Hague: Mouton & Co./Indiana University.

Boyd, Raymond (2002) *Bata Phonology*: A Reappraisal. Muenchen: Lincom Europa.

Boynton, Sylvia S. (1982) *Mikasuki Grammar in Outline*. Ann Arbor: UMI.

Bradshaw, Mary (1999) *A Crosslinguistic Study of Consonant-Tone Interaction.* Ohio State University PhD dissertation.

Brainard, Sherri (1994) *The Phonology of Karao, The Philippines*. Canberra: Pacific Linguistics.

Brent, Michael (1993) From grammar to lexicon: Unsupervised learning of lexical syntax. *Computational Linguistics* 19: 243-262.

Brentari, Diane (1990) Licensing in ASL handshape. In Lucas, C. (ed.) *Sign language research: Theoretical issues*. Washington, D.C.: Gallaudet University Press.

Brentari, Diane (1995) Sign Language Phonology: ASL. In Goldsmith, John A. (ed.) *The Handbook of Phonological Theory*. Cambridge, Mass.: Blackwell. 615-639.

Brentari, Diane (1998) *A prosodic model of sign language phonology*. Cambridge, MA: MIT Press.

Bright, William (1972) The Enunciative Vowel. *International Journal of Dravidian Linguistics* 1.1, 26-5.

Brockway, Earl (1979) North Puebla Nahauatl. In Langacker (1979).

Brody, Mary Jill (1982) *Discourse Processes of Highlighting in Tojolabal Maya Morphosyntax*. Ann Arbor: UMI.

Bromley, H. Myron (1961) *The Phonology of Lower Grand Valley Dani*. 'S-Gravenhage – Martinus Nijhoff.

Broselow, Ellen I. (1976) *Phonology of Egyptian Arabic*. UMass PhD dissertation.

Browman, Catherine, and Louis Goldstein (1992) Articulatory Phonology: An Overview. *Phonetica* 49:155-180.

Brown, Gillian (1972) *Phonological Rules and Dialect Variation*. Cambridge: Cambridge University Press.

Brown, Roger (1973) *A first language*. Cambridge, Mass.: Harvard University Press.

Bryant, Michael Grayson (1999) *Aspects of Tirmaga Grammar*. Ann Arbor: UMI.

Buckley, Eugene (1994) *Theoretical Aspects of Kashaya Phonology and Morphology*. Stanford, CA: CSLI Publications.

Buckley, Eugene (2000) What should phonology explain? Handout from SUNY Buffalo linguistics colloquium.

Bugenhagen, Robert D. (1995) *A Grammar of Mangap-Mbula: An Austronesian Language of Papua New Guinea*. Canberra: Pacific Linguistics.

Bunye, Maria Victoria R., and Elsa Paula Yap (1971) *Cebuano Grammar Notes*. Honolulu: University of Hawaii Press.

Burling, Robbins (1961) *A Garo Grammar*. Poona: Deccan College Postgraduate and Research Institute.

Burquest, Donald A. and Wyn D. Laidig (1992) *Phonological Studies in Four Languages of Maluku*. Arlington: Summer Institute of Linguistics.

Burrow, T. and S. Bhattacharya (1970) *The Pengo Language*. Oxford: Clarendon Press.

Bybee, Joan (1998) Usage-based Phonology. in M. Darnell, E. Moravcsik, F. Newmeyer, M. Noonan, and K. Wheatley (eds.) *Functionalism and Formalism in Linguistics Volume 1: General Papers*. Amsterdam: John Benjamins. 211-242.

Bybee, Joan (2001) Main clauses are innovative, subordinate clauses are conservative:consequences for the nature of constructions. in J. Bybee and M. Noonan (eds.) Complex sentences in grammar and discourse: Essays in honor of Sandra A. Thompson. Amsterdam: John Benjamins.1-17.

Cain, Bruce D., and James W. Gair (2000) *Dhiveni (Maldivian)*. Muenchen: Lincom Europa.

Cammenga, Jelle (2002) *Phonology and Morphology of Ekigusii*. Köln: Rüdiger Köppe Verlag.

Capell, A. (1962) *The Polynesian Language of Mae (Emwae), New Hebrides*. Auckland: Linguistic Society of New Zealand.

Cardona, George (1965) *A Gujarati Reference Grammar*. Philadelphia: The University of Pennsylvania Press.

Carlin, Eithne (1993) *The So Language*. Köln: Institut für Afrikanistik – Universität zu Köln.

Carlson, Robert (1994) *A grammar of Supyire*. Berlin: Mouton de Gruyter.

Carpenter, Lawrence Kidd (1982) Ecu*adorian Quichua: Descriptive Sketch and Variation*. Ann Arbor: UMI.

Carrington, Lawrence D. (1984) *St. Lucian Creole: A Descriptive Analysis of its Phonology and Morph-Syntax*. Hamburg: Helmut Buske Verlag.

Carson, Neusa Martins (1982) *Phonology and Morphosyntax of Macuxi (Carib)*. Ann Arbor: UMI.

Casagrande, Jean (1984) *The Sound System of French*. Washington, D.C.: Georgetown University Press.

Castiglione, Pierina Borrani (1957) *Italian Phonetics, Diction and Intonation*. New York: S. F. Vanni.

Catford, J. C. (1977) *Fundamental Problems in Phonetics*. Bloomington: Indiana University Press.

Cech, Petra, and Mozes F. Heinschink (1996) *Sepečides-Romani*. Muenchen: Lincom Europa.

Chalmers, David J. (1990) Thoughts on emergence. http://www.u.arizona.edu/~chalmers/notes/emergence.html

Chambers, J. K. (1995) Sociolinguistic theory: linguistic variation and its social significance. Cambridge, Mass.: Blackwell.

Chamora, Berhanu, and Robert Hetzron (2000) *Inor*. Muenchen: Lincom Europa.

Chang, Steve S., Madelaine C. Plauché, and John J. Ohala (2001) Markedness and Constraint Confusion Asymmetries. In Hume and Johnson (2001a) 79-102.

Chao, Yuen Ren (1968) *A grammar of spoken Chinese*. Berkeley: University of California Press.

Charney, Jean Ormsbee (1993) *A Grammar of Comanche*. Lincoln: University of Nebraska Press.

Chen, Matthew (1973) On the formal expression of natural rules in phonology. *Journal of Linguistics* 9. 223-49.

Cherchi, Marcello (1999) *Georgian*. Muenchen: Lincom Europa.

Childs, George Tucker (1990) *Phonology and Morphology of Kisi*. Ann Arbor: UMI.

Chitoran, Ioana (2002) *The Phonology of Romanian: A Constraint-Based Approach*. New York: Mouton de Gruyter.

Chomsky, Noam (1957) *Syntactic Structures*. Mouton & Co.

Chomsky, Noam (1965) *Aspects of the Theory of Syntax*. Cambridge, Mass.: MIT Press.

Chomsky, Noam (1968) *Language and Mind*. San Diego: Harcourt Brace Jovanovich.

Chomsky, Noam (1975) *Reflections on Language*. New York: Pantheon.

Chomsky, Noam (1980) *Rules and Representations*. Oxford: Basil Blackwell.

Chomsky, Noam (2000) Knowledge of Language: Its Nature, Origin, and Use. in Stainton, Robert J. (ed.), *Perspectives in the Philosophy of Language: A Concise Anthology*. Peterborough, Ontario: Broadview. pp. 3-44.

Chomsky, Noam, and Morris Halle (1968) *The Sound Pattern of English*. Cambridge, Mass.: MIT Press.

Christenson, John, and Sylvia Christenson (1992) Kisar Phonology. In Burquest and Laidig (1992).

Chung, Raung-Fu (1989) *Aspects of Kejia phonology*. UIUC dissertation. UMI.

Churchward, C. M. (1985) *Tongan Grammar*. Nuku'alofa: Vava'u Press Limited.

Clements, G.N. (1985) The geometry of phonological features. *Phonology Yearbook 2*. pp. 225-252.

Clements, G.N. (1990) Place of Articulation in Consonants and Vowels: a Unified Theory. expanded version of a paper presented at NELS 21.

Clements, G. N. (2001) Representational economy in constraint-based phonology. In Hall (2001). 71-146.

Clements, G. N. (2003) Feature economy in sound systems. *Phonology* 20.3. 287-333.

Clements, G.N. and Elizabeth V. Hume (1995) The Internal Organization of Speech Sounds. in Goldsmith, John (ed.) *The Handbook of Phonological Theory*. Cambridge Mass.: Blackwell. pp. 245-306.

Cohen, Kevin Bretonnel (2000) *Aspects of the Grammar of Kukú*. Muenchen: Lincom Europa.

Colarusso, John (1988) *The Northwest Caucasian Languages: A Phonological Survey*. New York: Garland Publishing.

Cole, Desmond T. (1955) *An Introduction to Tswana Grammar*. New York: Longmans, Green and Co.

Cole, Desmond T. (1967) *Some Features of Ganda Linguistic Structure*. Johannesburg: Witwatersrand University Press.

Cole, R. A., R. N. Haber, and B. D. Sales (1973) Mechanisms of aural encoding: VI. Consonants and vowels are remembered as subsets of distinctive features. *Perception & Psychophysics* 13: 87092.

Conrad, Robert J., and Kepas Wogiga (1991) *An Outline of Bukiyip Grammar*. Canberra: Pacific Linguistics.

Constenla, Adolfo (1981) *Comparative Chibchan Phonology*. Ann Arbor: UMI.

Cook, S.J., Rev. Walter Anthony (1974). *Structure of the Mundari Language*. Ann Arbor: Xerox University Microfilms.

Corina, David P., and Elizabeth Sagey (1989) In de Jong, Ken, and Yongkyoon No (eds.) *Proceedings of the Sixth Eastern States Conference on Linguistics*. pp. 73-83.

Counts, David R. (1969) *A Grammar of Kaliai-Kove*. Honolulu: University of Hawaii Press.

Cowan, H. K. J. (1965) *Grammar of the Sentani Language*. 'S-Gravenhage – Martinus Nijhoff.

Cowan, Marion M. (1968) *Tzotzil Grammar*. Norman: Summer Institute of Linguistics of the University of Oklahoma.

Crawford, James M. (1975) (ed.) *Studies in Southeastern Indian Languages*. Athens: The University of Georgia Press.

Crawford, John Chapman (1963) *Totontepec Mixe Phonotagmemics*. Norman: Summer Institute of Linguistics of the University of Oklahoma.

Crazzolara, Father J. P. (1933) *Outlines of a Nuer Grammar*. Wien: Verlag der Internationalen Zeitschrift.

Creider, Chet A. and Jane Tapsubei Creider (1989) *A Grammar of Nandi*. Hamburg: Helmut Buske Verlag.

Cressey, William W. (1978) *Spanish Phonology and Morphology: A Generative View*. Washington, D.C.: Georgetown University Press.

Crewe, W. J. (1975) *The Phonological Features of the Ingessana Language*. University of Khartoum: Institute of African and Asian Studies.

Crowley, Terry (1996) *Ura*. München: Lincom Europa.

Crowley, Terry (1998) *An Erromangan (Sye) Grammar*. Honolulu: University of Hawai'i Press.

Crowley, Terry (1999) *Ura: A disappearing language of southern Vanuatu*. Canberra: Pacific Linguistics.

Crum, Beverly, and John P. Dayley (1993) *Western Shoshoni Grammar*. Boise: Dept. of Anthropology, Boise State University.

Culicover, Peter W. and Andrzej Nowak (2003) Markedness, Antisymmetry and Complexity of Constructions. In Pierre Pica and Johann Rooryk (eds.) *Variation Yearbook*. John Benjamins, Amsterdam.

Culicover, Peter W. and Andrzej Nowak (2004). *Dynamical Grammar*. Oxford University Press.

Cyffer, Norbert (1998) *A Sketch of Kanuri*. Köln: Rüdiger Köppe Verlag.

Cyr, Danielle (1996) *Montagnais: an Ethnogrammatical Description*. In Maurais (1996)

Daelmans, Walter, Gert Durieux, and Steven Gillis (1994) The acquisition of stress: A data-oriented approach. *Computational Linguistics* 20: 421-451.

Darley, Vincent (1994) Emergent Phenomena and Complexity. In *Proceedings of the Alife IV Workshop*. Cambridge, Mass.

Davidson, Joseph O. Jr. (1977) *A Contrastive Study of the Grammatical Structures of Aymara and Cuzco Kechua*. Ann Arbor: UMI.

Davies, William (1999) *Madurese*. Newcastle: Lincom Europa.

Dawson, Willa (1980) *Tibetan Phonology*. Ann Arbor: UMI.

Day, Christopher (1973) *The Jacaltec Language*. Bloomington and The Hague: Indiana University and Mouton & Co.

Dayley, Jon Philip (1981) *Tzutujil Grammar*. Ann Arbor: UMI.

de Boer, Bart (2000) *The Origins of Vowel Systems*. Oxford: Oxford University Press.

de Boysson-Bardies, B., & Vihman, Marilyn May (1991). Adaptation to language: Evidence from babbling and first words in four languages. *Language* 67. 297-319.

de Hoon, Michiel Jan Laurens (2002) The C Clustering Library for cDNA microarray data. Laboratory of DNA Information Analysis, Human Genome Center, Institute of Medical Science, University of Tokyo.

de Vreis, Lourens (1993) *Forms and Functions in Kombai, an Awyu Language of Irian Jaya*. Canberra: Pacific Linguistics.

Dedrick, John M., and Eugene H. Casad (1999) *Sonora Yaqui Language Structures*. Tucson: University of Arizona Press.

Dehghani, Yavar (2000) *A Grammar of Iranian Azari*. Muenchen: Lincom Europa.

Dehghani, Yavar (2002) *Persian*. Muenchen: Lincom Europa.

Dell, François, and Mohamed Elmedlaoui (2002) *Syllables in Tashlhiyt Berber and Moroccan Arabic*. Boston: Kluwer Academic Publishers.

Dench, Alan (1998) *Yingkarta*. München: Lincom Europa.

Dench, Alan Charles (1995) *Martuthunira: A Language of the Pilbara Region of Western Australia*. Canberra: Pacific Linguistics.

Derbyshire, Desmond C. (1985) *Hixkaryana and Linguistic Typology*. Arlington: The Summer Institute of Linguistics and the University of Texas at Arlington.

Dieterman, Julia, and Van Haitsma (1976) *A Hierarchical Sketch of Mixe as spoken in San José El Paraíso*. Norman: Summer Institute of Linguistics of the University of Oklahoma.

Dihoff, Ivan Raymond (1976) *Aspects of the Tonal Structure of Chori*. Ann Arbor: UMI.

Dimmendaal, Gerritt Jan (1983) *The Turkana Language*. Cinnaminson: Foris Publications.

Disner, Sandra (1983) Vowel quality: the contribution of language particular and language universal factors. UCLA Working Papers in Linguistics 58. 1-154.

Dixon, R. M. W. (1977) *A Grammar of Yidiɲ*. New York: Cambridge University Press.

Dixon, R.M.W. (1972) *The Dyirbal Language of North Queensland*. Cambridge: Cambridge University Press.

Dixon, R.M.W. (1988) *A Grammar of Boumaa Fijian*. Chicago: The University of Chicago Press.

Doke, C. M., and S. M. Mofokeng (1957) *Textbook of Southern Sotho Grammar*. New York: Longmans, Green and Co.

Doke, Clement M. (1931) *A Comparative Study in Shona Phonetics*. Johannesburg: The University of the Witwatersrand Press.

Dolbey, A.E. and G.Ó. Hansson (1999) The source of naturalness in synchronic phonology. *CLS 35, Vol. 1*. Chicago: CLS. pp. 59-69.

Dolphyne, Florence Abena (1988) T*he Akan (Twi-Fante) Language: Its Sound Systems and Tonal Structure*. Accra: Ghana Universities Press.

Donaldson, Bruce C. (1993) *A Grammar of Afrikaans*. New York: Mouton de Gruyter.

Donaldson, Tamsin (1980) *Ngiyambaa: The Language of the Wangaaybuwan*. New York: Cambridge University Press.

Donohue, Mark (1996) *Warembori*. München: Lincom Europa.

Donohue, Mark (1999) *A Grammar of Tukang Besi*. New York: Mounton de Gruyter.

Douglas, W. H. (1964) *An Introduction to the Western Desert Language*. Sydney: The University of Sydney.

Dresher, Elan (2003) Contrast and Asymmetries in Inventories. In Di Sciullo, Anna Maria (ed.) *Asymmetry in Grammar*. 239-257.

Du Feu, Veronica (1996) *Rapanui*. New York: Routledge.

Dubois, John William (1981) *The Sacapultec Language*. Ann Arbor: UMI.

Dunn, John Asher (1979[1995]) *Sm'algyax: A Reference Dictionary and Grammar for the Coast Tsimshian Language*. Seattle: University of Washington Press.

Duponceau, Peter Stephen (1816) 'The translator's Preface' and 'Concluding note by the translator' in 'A grammar of the language of the Lenni Lenape or Delaware Indians…presented to the Society 2d December 1916' *TAPS* 3 (1830).

Durie, Mark (1985) *A Grammar of Acehnese on the Basis of a Dialect of North Aceh*. Cinnaminson, N.J.: Foris.

Dutton, Tom E. (1996) *Koiari*. München: Lincom Europa.

Dwyer, David James (1981) *A Reference Handbook of Lorma*. East Lansing: Michigan State University.

Edgar, John (1989) *A Masalit Grammar*. Berlin: Dietrich Reimer Verlag.

Edward, Amastae Jon (1980) *Dominican Creole Phonology*. Ann Arbor: UMI.

Eimas, P.D., E.R. Siqueland, P. Jusczyk, and J. Vigorito (1971) Speech Perception in Infants. *Science* 171, 303-306.

Elson, B. (1947) Sierra Popoluca syllable structure. *IJAL* 13. 13-17.

Elson, B. (1956) *Sierra Popoluca morphology*. Cornell PhD dissertation.

Elson, Benjamin (ed.) (1962) *Studies in Ecuadorian Indian Languages: I*. Norman: Summer Institute of Linguistics of the University of Oklahoma.

Elugbe, Ben Ohiomamhe (1989) *Comparative Edoid: Phonology and Lexicon*. Port: University of Port Harcourt Press.

Emananjro, E. Nolue (1978) *Elements of Modern Igbo Grammar: A Descriptive Approach*. Ibadan: Oxford University Press.

Emeneau, M. B. (1961) *Kolami: A Dravidian Language*. Annamalainagar: Annamalai University.

England, Nora C. (1983) *A Grammar of Mam, a Mayan Language*. Austin: University of Texas Press.

Engstrand, Olle (1997) Why are clicks so exclusive?. Papers from FONETIK-97, The Ninth Swedish Phonetics Conference, held in Umeå. Reports *from the Department of Phonetics, Umeå University (PHONUM)* 4. 191-194.

Engstrand, Olle (1999) Swedish. *In Handbook of the International Phonetic Association*. Cambridge: Cambridge University Press.

Ezard, Bryan (1997) *A Grammar of Tawala: an Austronesian language of the Milne Bay area*, Papua New Guinea. Canberra: Pacific Linguistics.

Faraclas, Nicholas G. (1996) *Nigerian Pidgin*. New York: Routledge.

Ferguson, C.A., and C.B. Farwell (1975) Words and sounds in early language acquisition. *Language* 51. 419-439.

Fernández, Zarina Estrada (1996) *Pima Bajo*. Muenchen: Lincom Europa.

Ferraz, Luiz Evans (1979) *The Creole of São Tomé*. Johannesburg: Witwatersrand University Press.

Ferreira, Fernanda (2003) The misinterpretation of noncanonical sentences. *Cognitive Psychology* 47. 164-203.

Fisch, Maria (1998) *Thimbukushu Grammar*. Windhoek: Out of Africa Publishers.

Fivaz, Derek (1986) *A Reference Grammar of Oshindonga (Wambo)*. Windhoek: Star Binder & Printers.

Flemming, Edward S. (1998) Natural Classes in Phonology. Handout of paper presented at phonology workshop.

Flemming, Edward S. (2002) *Auditory Representations in Phonology*. New York: Routledge.

Flikeid, K. (1988) Unity and diversity in Acadian phonology: An overview based on comparisons among Nova Scotia varieties. *Journal of the Atlantic Provinces Linguistic Association* 10: 64-110.

Forman, Michael L. (1971) *Kapampangan Grammar Notes*. Honolulu: University of Hawaii Press.

Fortescue, Michael (1984) *West Greenlandic*. Sydney: Croom Helm Descriptive Grammars.

Fortune, R. F. (1977) *Arapesh*. New York: J. J. Augustin Publisher.

Foster, M.L., and G.M. Foster (1948) *Sierra Popoluca speech*. Washington, D.C.: U.S. Government Printing Office, Smithsonian Institution, Institute of Social Anthropology.

Fox, Anthony (1990) *The Structure of German*. Oxford: Clarendon Press.

Fox, Robyn (1992) Prejudice and the unfinished mind: a new look at an old failing. *Psychological Inquiry, 3*, 137-152.

Fox, Samuel Ethan (1997) *The Neo-Aramaic Dialect of Jilu*. Wiesbaden: Harrassowitz Verlag.

Frajzyngier, Zygmunt (1989) *A Grammar of Pero*. Berlin: Dietrich Reimer Verlag.

Frajzyngier, Zygmunt (1993) *A Grammar of Mupun*. Berlin: Dietrich Reimer Verlag.

Frajzyngier, Zygmunt (2001) *A Grammar of Lele*. Stanford: CSLI Publications.

Frank, Allen J. (1995) *Turkmen Reader*. Kensington, MD: Dunwoody Press.

Frantz, Chester, and Marjorie Frantz (1973) Gadsup Phoneme and Toneme Units. In McKaughan (1973)

Frantz, Donald G. (1991) *Blackfoot Grammar*. Toronto: University of Toronto Press.

Fromkin, Victoria A. (1973) (ed.) *Speech errors as linguistic evidence*. The Hague: Mouton.

Fromkin, Victoria A. (1988) Grammatical aspects of speech errors. In Frederick J. Newmeyer (ed.) *Linguistics: The Cambridge Survey, Volume II, Linguistic Theory: Extensions and Implications*. Cambridge: Cambridge University Press. 117-138.

Fujimura, Osamu, Marian J. Macchi, and L.A. Streeter (1978) Perception of Stop Consonants with Conflicting Transitional Cues: A Cross-linguistic Study. *Language and Speech* 21: Part 4.

Galloway, Brent D. (1977) *A Grammar of Chilliwack Halkomelem*. Ann Arbor: UMI.

Galloway, Brent D. (1990) A Phonology, Morphology, and Classified Word List for the Samish Dialect of Straits Salish. Canadian Ethnology Service. *Mercury Series Paper 116*.

Gerfen, Chip (1999) *Phonology and Phonetics in Coatzospan Mixtec*. Dordrecht: Kluwer Academic Publishers.

Ghatage, A. M. (1971) *Marathi Dialect Texts I: Dialect of Cochin*. Poona: Deccan College.

Ghini, Mirco (2001) *Asymmetries in the Phonology of Miogliola*. New York: Mouton de Gruyter.

Gilley, Leoma G. (1992) *An Autosegmental Approach to Shilluk Phonology*. Arlington: Summer Institute of Linguistics.

Giridhar, P. P. (1980) *Angami Grammar*. Mysore: Central Institute of Indian Languages.

Gilmore, G.C., H. Hersh, A. Caramazza, and J. Griffin (1979) On the prediction of confusion matrices from similarity judgments. *Perception & Psychophysics* 25(5). 425-431.

Givon, Talmy (1970) *The Si-Luyana Language: A Preliminary Linguistic Description*. University of Zambia: Institute for Social Research.

Glover, Bonnie Carol (1989) *The Morphophonology of Muscat Arabic*. Ann Arbor: UMI.

Goddard, Ives (1979) *Delaware Verbal Morphology: A Descriptive and Comparative Study*. New York: Garland Publishing, Inc.

Goldinger, Stephen D. (1997) Words and Voices: Perception and Production in an Episodic Lexicon. In Keith Johnson and John W. Mullenix (eds.) *Talker Variability in Speech Processing*. San Diego: Academic Press. 33-66.

Goldstein, Louis (1977) Categorical features in speech perception and production. Prepared for the Working Group on slips of the Tongue, XIIth International Congress of Linguists, Vienna, Austria.

Gómez, Gale Goodwin (1990) *The Shiriana dialect of Yanam (northern Brazil)*. Ann Arbor: UMI.

Gopnik, Myrna (1994) Impairments of tense in a familial language disorder. *Journal of Neurolinguistics* 8: 109-133.

Gopnik, Myrna, Jenny Dalalakis, Suzy E. Fukuda, and Shinji Fukuda (1997) The Biological Basis of Language: Familial Language Impairment. In Myrna Gopnik (ed.) *The Inheritance and Innateness of Grammars*. 111-140.

Gorbet, Larry Paul (1976) *A Grammar of Diegueño Nominals*. New York: Garland Publishing, Inc.

Gordon, Kent H. (1976) *A Phonology of Dhangar-Kurux*. Kathmandu: Tribhuvan University Press.

Gorgoniyev, Y. A. (1966) *The Khmer Language*. Moscow: Nauka Publishing House

Gowda, K. S. Gurubasave (1991) *Ao Grammar*. Mysore: Central Institute of Indian Languages.

Graham, L. W. & A. S. House (1971) Phonological oppositions in children: A perceptual study. *Journal of the Acoustical Society of America* 49 (2): 559-566.

Green, Lisa (1998) Aspect and predicate phrases in African-American vernacular English. in Salikoko S. Mufwene (ed.) *African-American English: structure, history, and use*. New York: Routledge. pp. 85-109.

Greenberg, Joseph H. (1987) *Language in the Americas*. Stanford: Stanford University Press.

Greene, Laurie A. (1999) *A Grammar of Belizean Creole: Compilations from Two Existing United States Dialects*. New York: Peter Lang.

Grimes, Barbara F., Joseph E. Grimes, and Richard S. Pittman (eds.) (2000) *Ethnologue: Languages of the World, 14th Edition*. http://www.ethnologue.com. Summer Institute of Linguistics.

Groves, Terab'ata R., Gordon W. Groves, and Roderick Jacobs (1985) *Kiribatese*. Canberra: Pacific Linguistics.

Gulya, János (1966) *Eastern Ostyak Chrestomathy*. Bloomington/The Hague: Mouton & Co./Indiana University.

Gusain, Lakhan (2000) *Bagri*. Muenchen: Lincom Europa.

Gusain, Lakhan (2001) *Shekhawati*. Muenchen: Lincom Europa.

Gustafsson, Uwe (1974) *Kotia Oriya Phonemic Summary*. Nagpur, India: Summer Institute of Linguistics.

Guthrie, M. (1967-71) *Comparative Bantu*, vols. 1-4, Gregg International Publishers, Farnborough, Hants.

Guy, Gregory R. (2003) Variationist Approaches to Phonological Change. In Joseph and Janda (2003). 369-400.

Hajek, John (1997) *Universals of Sound Change in Nasalization*. Publications of the Phililogical Society 31. Oxford: Blackwell.

Hale, Mark (2003) Neogrammarian Sound Change. In Joseph and Janda (2003). 343-368.

Hale, Mark, and Charles Reiss (2000) Phonology as cognition. In N. Burton-Roberts, Philip Carr & Gerard Docherty (eds) *Phonological Knowledge: Conceptual and Empirical Foundations*. Oxford: Oxford University Press. pp. 161-184.

Hall, Robert A. Jr. (1943) *Melanesian Pidgin English: Grammar, Texts, Vocabulary*. Baltimore: Waverly Press, Inc.

Hall, Robert A. Jr. (1953) Haitian Creole: Grammar – Texts – Vocabulary. *Memoirs of the American Folklore Society*, Vol. 43. Philadelphia: American Folklore Society.

Hall, T. Alan (ed.) (2001) *Distinctive Feature Theory*. New York: Mouton de Gruyter.

Halle, Morris (1962) Phonology in a generative grammar. *Word* 18: 54-72.

Halle, Morris (1988) The immanent form of phonemes. In Hurst, William Jeffrey (ed.) *The making of cognitive science*. 167–183. Cambridge: Cambridge University Press.

Halle, Morris (1989) The intrinsic structure of speech sounds. MIT ms.

Halle, Morris (1992) Phonological features. In Bright, William (ed.) *International encyclopedia of linguistics*, vol. 3, 207–212. Oxford: Oxford University Press

Halle, Morris and G. N. Clements (1983) *Problem Book in Phonology*. Cambridge, Mass.: The MIT Press.

Halle, Morris and K.P. Mohanan (1985) Segmental phonology of modern English. Linguistic Inquiry 16. 57-116.

Halle, Morris and Kenneth N. Stevens (1979) Some reflections on the theoretical bases of phonetics. in B. Lindblom and S. Öhman (eds.) Frontiers of speech communication research. London: Academic Press. 335-353.

Halle, Morris, Bert Vaux, and Andrew Wolfe (2000) On Feature Spreading and the Representation of Place of Articulation. *Linguistic Inquiry* 31(3): 387-444.

Halwachs, Dieter W. (2002) *Burgenland-Romani*. Muenchen: Lincom Europa.

Hamel, Patricia J. (1985) *A Grammar of Loniu*. Ann Arbor: UMI.

Hamel, Patricia J. (1994) *A Grammar and Lexicon of Loniu, Papua New Guinea*. Canberra: Pacific Linguistics.

Hardman, MJ (2000) *Jaqaru*. Muenchen: Lincom Europa.

Hardy, Heather Kay (1979) *Tolkapaya Syntax: Aspect, Modality, and Adverbial Modification in a Yavapai Dialect*. Ann Arbor: UMI.

Hargus, Sharon (1988) *The Lexical Phonology of Sekani*. New York: Garland Publishing, Inc.

Harkins, William E. (1953) *A Modern Czech Grammar*. New York: King's Crown Press.

Harlow, Ray (1996) *Māori*. Muenchen: Lincom Europa.

Harms, Robert T. (1962) *Estonian Grammar*. Bloomington/The Hague: Mouton & Co./Indiana University.

Harries, Rev. Lyndon (1950) *A Grammar of Mwera*. Johannesburg: Witwatersrand University Press.

Harris, John (1994) *English Sound Structure*. Cambridge, Mass.: Blackwell.

Harrison, Sheldon P. (1976) *Mokilese Reference Grammar*. Honolulu: The University Press of Hawaii

Hashimoto, Mantaro J (1973) *The Hakka dialect; a linguistic study of its phonology, syntax, and lexicon*. Cambridge University Press.

Hashimoto, Oi-kan Yue (1972) *Phonology of Cantonese*. Cambridge University Press.

Haspelmath, Martin (1993) *A Grammar of Lezgian*. New York: Mouton de Gruyter.

Hasselbrink, Gustav (1965) *Alternative Analyses of the Phonemic System in Central South-Lappish*. Bloomington/The Hague: Mouton & Co./Indiana University.

Hawkins, John A. (1985) Complementary methods in universal grammar: a reply to Coopmans. *Language* 61. 569-587.

Hayward, Dick (1984) *The Arbore Language: A First Investigation, Including a Vocabulary*. Hamburg: Helmut Buske Verlag.

Healey, Phyllis M. (1960) *An Agta Grammar*. Manila: Bureau of Printing

Hebert, Raymond J. and Nicholas Poppe (1963) *Kirghiz Manual*. Bloomington/The Hague: Mouton & Co./Indiana University.

Hercus, Luise A. (1998) *A grammar of the Wirangu language from the west coast of South Australia*. Canberra: Pacific Linguistics.

Hercus, Luise A. (1994) *A Grammar of the Arabana-Wangkangurru Language, Lake Eyre Basin, South Australia*. Canberra: Pacific Linguistics.

Herrity, Peter (2000) *Slovene: A Comprehensive Grammar*. New York: Routledge.

Hinton, Perry (2000) *Stereotypes, Cognition and Culture*. Philadelphia: Taylor and Francis.

Hock, Hans Henrich (2003) Analogical Change. In Joseph and Janda (2003). 441-460.

Hock, Hans Henrich and Brian D. Joseph (1996) Language History, Language Change, and Language Relationship. New York: Mouton de Gruyter.

Hoddinott, W. G., and F. M. Kofod (1988) *The Ngankikurungkurr Language*. Canberra: Pacific Linguistics.

Hoffmann, Carl (1963) *A Grammar of the Margi Language*. London: Oxford University Press.

Hofling, Charles Andrew (2000) *Itzaj Maya Grammar*. Salt Lake City: University of Utah Press.

Hollis, Alfred C. (1971) *The Masai: Their Language and Folklore*. Freeport, NY: Books for Libraries Press.

Holmer, Nils M. (1988) *Notes on Some Queensland Languages*. Canberra: Pacific Linguistics.

Holt, Dennis (1999) *Pech (Paya)*. Muenchen: Lincom Europa.

Holzinger, Daniel (1995) *Romanes (Sinte)*. Muenchen: Lincom Europa.

Hombert, Jean-Marie, John J. Ohala, and William G. Ewan (1979) Phonetic explanations for the development of tones. *Language*. 55. 37-58

Hooper, Robin (1996) *Tokelauan*. Muenchen: Lincom Europa.

Houtzagers (1985) *The Čakavian Dialect of Orlec on the Island of Cres*. Amsterdam: Rodopi.

Huang, Tsan (2001) The Interplay of Perception and Phonology in Tone 3 Sandhi in Chinese Putonghua. in Hume and Johnson (2001b). 23-43.

Hulst, Harry van der (1995) The composition of handshapes. In *Working papers in linguistics* 23. Department of Linguistics, University of Trondheim, Dragvoll.

Hume, Elizabeth V. (1994) *Front vowels, coronal consonants and their interaction in nonlinear phonology*. New York: Garland.

Hume, Elizabeth V. (2002) Reconsidering the concept of markedness. Paper presented at les Journées Internationales du GDR, Grenoble.

Hume, Elizabeth V. (2004a) The Indeterminacy/Attestation Model of Metathesis. *Language* 80(2).

Hume, Elizabeth V. (2004b) Deconstructing Markedness: A Predictability-Based Approach. *BLS* 30.

Hume, Elizabeth V. and Keith Johnson (eds.) (2001a) *The Role of Speech Perception in Phonology*. New York: Academic Press.

Hume, Elizabeth V. and Keith Johnson (eds.) (2001b) Studies on the interplay of speech perception and phonology. *OSUWPL* 55.

Hume, Elizabeth V. and Keith Johnson (2001c) A model of the interplay of speech perception and phonology. In Hume and Johnson (2001c).

Hume, Elizabeth V., Keith Johnson, Misun Seo, Georgios Tserdanelis, and Stephen Winters (1999) A cross-linguistic study of stop place perception. *ICPhS99*. 2070-2073.

Hume, Elizabeth and David Odden (1996) Reconsidering [consonantal]. *Phonology* 13. 345-376

Hume, Elizabeth and Georgios Tserdanelis (2002) Labial unmarkedness in Sri Lankan Portuguese Creole. *Phonology* 19.1: 441-58.

Huttar, George L., and Mary L. Huttar (1994) *Ndyuka*. New York: Routledge.

Hyman, Larry M. (1972) *A Phonological Study of Fe'Fe'-Bamileke*. Ann Arbor: UMI.

Hyman, Larry M. (1978) Historical tonology. In Victoria A. Fromkin (ed.) *Tone: A Linguistic Survey*. New York: Academic Press. pp. 195-230.

Hyman, Larry M. (1981) Noni Grammatical Structure. *Southern California Occasional Papers in Linguistics* 9.

Hyman, Larry M. (2001) The Limits of Phonetic Determinism in Phonology: *NC Revisited. In Hume and Johnson (2001a).

Hyman, Larry M., and Daniel J. Magaji (1970) *Essentials of Gwari Grammar*. Ibadan: Ibadan University Press.

Hyman, Larry M., and Russel G. Schuh (1974) Universals of tone rules: evidence from West Africa. *Linguistic Inquiry 5*: 81-115.

Ikoro, Suano M. (1996) *The Kana Language*. Leiden: Research School CNWS.

Ikranagara, Kay (1975) *Melayu Betawi Grammar*. Ann Arbor: UMI.

Ingram, D. (1978) The Acquisition of Word-Initial Fricatives and Affricates by Normal and Linguistically Deviant Children." In A. Caramazza and E. B. Zurif (eds.) *Language Acquisition and Language Breakdown: Parallels and Divergences*. Baltimore: Johns Hopkins University Press.

Innes, Gordon (1966) *An Introduction to Grebo*. London: Luzac & Company, Ltd.

Israel, M. (1979) *A Grammar of the Kuvi Language*. Vanchiyoor: Dravidian Linguistics Association.

Jacobs, Melville (1931) *A Sketch of Northern Sahaptin Grammar*. Seattle: University of Washington Press.

Jaggar, Philip J. (2001) *Hausa*. Philadelphia: John Benjamins Publishing Company.

Jakobson, Roman (1942) The Concept of Phoneme. reprinted in Waugh, Linda R., and Monique Moville-Burston (eds.) *On Language* (1990) Cambridge Mass.: Harvard University Press. pp. 218-241.

Jakobson, Roman, C. Gunnar M. Fant, and Morris Halle (1954) *Preliminaries to speech analysis: the distinctive features and their correlates*. Cambridge, Mass.: MIT Press.

Jakobson, Roman, and Morris Halle (1956) *Fundamentals of Language*. The Hague: Mouton & Co.

Janda, Richard D. (1999) Accounts of phonemic split have been exaggerated – but not enough. *ICPhS* 14.

Janda, Richard D. (2001) Beyond "Pathways" and "Unidirectionality": on the Discontinuity of Language Transmission and the Counterability of Grammaticalization. *Language Sciences* 23: 2-3. 265-340.

Janda, Richard D. (2003) "Phonologization" as the Start of Dephoneticization – Or, On Sound-Change and its Aftermath: Of Extension, Generalization, Lexicalization, and Morphologization. In Joseph and Janda (2003). 401-422.

Janda, Richard D., and Brian D. Joseph (2001). Reconsidering the Canons of Sound-Change: Towards a Big Bang Theory, ms., OSU.

Janda, Richard D. and Brian D. Joseph (2003) On Language, Change, and Language Change – Or, Of History, Linguistics, and Historical Linguistics. Introduction to Joseph and Janda (2003). 3-180.

Jebbour, Abdelkrim (1985) La Labio-vélarisation en Berbère – Dialecte Tachelhit (Parler de Tiznit). *Mémoire de Phonologie*. Université Mohammed V, Rabat.

Jebbour, Abdelkrim (1987) La Labialisation Consonantique en Tachelhit. Talk presented at the First International Meeting of the Moroccan Linguistics Society, Rabat.

Jensen, John T. (1993) *English Phonology*. Philadelphia: John Benjamins Publishing Company.

Jensen, John Thayer (1977). *Yapese Reference Grammar*. Honolulu: The University Press of Hawaii.

Jeyapaul, V. Y. (1987) *Karbi Grammar*. Mysore: Central Institute of Indian Languages.

Jha, Aparna (1980) *Kosti – A Dialect of Marathi*. Pune: Deccan College Post-Graduate & Research Institute.

Jilali, Saib (1976) *A Phonological Study of Tamazight Berber: Dialect of the Ayt Ndhir*. Ann Arbor: UMI.

Johnson, Keith (1997) *Acoustic and Auditory Phonetics*. Cambridge, Mass.: Blackwell.

Johnson, Orville E., and Catherine Peeke (1962) Phonemic Units in the Secoya Word. In Elson (1962)

Johnson, Robert Erik (1975) *The Role of Phonetic Detail in Coeur d'Alene Phonology*. Ann Arbor: UMI.

Johnston, Lucy (1996) Resisting change: information-seeking and stereotype change. *European Journal of Social Psychology, 26*, 799-825.

Jones, Daniel (1928) *An English pronouncing dictionary*, revised edition. London: Dent and Sons.

Jones, Ross McCallum (1998) *The Boko/Busa Language Cluster*. München: Lincom Europa.

Jones, W. Glyn, and Kirsten Gade (1981) *Danish: A Grammar*. København: Gyldendal

Joseph, Brian D., and Richard D. Janda (2003) (eds.) *The Handbook of Historical Linguistics*. Cambridge, Mass.: Blackwell.

Joseph, Brian D., and Irene Philippaki-Warburton (1987) *Modern Greek*. Wolfeboro, NH: Croom Helm.

Josephs, Lewis S. (1975) *Palauan Reference Grammar*. Honolulu: The University Press of Hawaii.

Ka, Omar (1994) *Wolof phonology and morphology*. Lanham, Md: University Press of America.

Kahn, Margaret (1976) *Borrowing and variation in a phonological description of Kurdish*. Ann Arbor: UMI.

Kaplan, Lawrence D. (1981) *Phonological Issues in North Alaskan Inupiaq*. Alaska Native Language Center Research Papers.

Kari, Ethelbert E. (1997) *Degema*. München: Lincom Europa.

Katz, Dovid (1987) *Grammar of the Yiddish Language*. London: Duckworth.

Kaisse, Ellen M. (1992) Can [consonantal] spread? *Language* 68. 313-332.

Kaisse, Ellen M. (2000) Laterals are [-continuant]. Handout of talk presented at the University of Washington.

Kaisse, Ellen M. (ms) Laterals are [-continuant]. University of Washington ms.

Kaye, Jonathan Derek (1970) *The Desano Verb: Problems in Semantics, Syntax, and Phonology*. Ann Arbor: UMI.

Kayne, Richard S. (1994) The Antisymmetry of Syntax. Cambridge, Mass.: MIT Press.

Keating, Patricia (1984) Physiological effects on stop consonant voicing. *UCLA Working Papers in Phonetics* 59. 29-34.

Keegan, John M. (1986) *The Phonology and Morphology of Moroccan Arabic*. Ann Arbor: UMI.

Keel, William (1982) *Atomic Phonology and Phonological Variation*. Tübingen: Gunter Narr.

Key, Mary Ritchie (1968) *Comparative Tacanan Phonology*. The Hague: Mouton.

Kibrik, Alexander E. (1996) *Godoberi*. Muenchen: Lincom Europa.

Kidda, Mairo Elinor (1985) *Tangale Phonology: A Descriptive Analysis*. Ann Arbor: UMI

Kihm, Alain (1994) *Kriyol Syntax: The Portuguese-based Creole Language of Guinea-Bissau*. Philadelphia: John Benjamins.

Kimenyi, Alexandre (1979) *Studies in Kinyarwanda and Bantu Phonology*. Edmonton: Linguistic Research Inc.

King, Duane Harold (1975) *A Grammar and Dictionary of the Cherokee Language*. Ann Arbor: UMI.

Kiparsky, Paul (1965) *Phonological Change*. MIT PhD dissertation.

Kiparsky, Paul (2003) The Phonological Basis of Sound Change. In Joseph and Janda (2003). 313-342.

Kisseberth, C.W., and M.I. Abasheikh (1975) The perfect stem in Chi-Mwi:ni and global rules. *Studies in African Linguistics 6*. 249-266.

Klein, Harriet E. Manelis (2001) *Toba*. Muenchen: Lincom Europa.

Klingler, Thomas A. (1992) *A descriptive study of the Creole speech of Pointe Coupee Parish, Louisiana with focus on the lexicon*. Ann Arbor: UMI.

Kluender, K.R., R. Diehl, and P. Killeen (1987) Japanese quail can learn phonetic categories. Science 237. 1195-1197.

Knowles, Susan Marie (1984) *A Descriptive Grammar of Chontal Maya (San Carlos Dialect)*. Ann Arbor: UMI.

Kochetov, Alexei (2002) *Production, perception, and emergent phonotactic patterns: A case of contrastive palatalization*. New York: Routledge.

Koelle, S. W. (1968[1854]) *Outlines of a grammar of the Vei language : together with a Vei-English vocabulary and an account of the discovery and nature of the Vei mode of syllabic writing*. Farnborough, Eng.: Gregg International Publishers.

Kouwenberg, Silvia (1994) *A Grammar of Berbice Dutch Creole*. New York: Mouton de Gruyter.

Kouwenberg, Silvia, and Eric Murray (1994) *Papiamentu*. Muenchen: Lincom Europa.

Kroul, Mary Valentine (1980) *The Phonology and Morphology of the Central Outer Koyukon Athapaskan Language*. Ann Arbor: UMI.

Kuhl, P. K., and J. D. Miller (1975) 'Speech perception by the chinchilla: Voiced-voiceless distinction in the alveolar-plosive consonants,'' *Science* 190: 69–72.

Kuhl, P. K., and J. D. Miller (1978) Speech perception by the chinchilla: Identification functions for synthetic VOT stimuli. *Journal of the Acoustical Society of America* 63: 905-917.

Kutsch Lojenga, Constance (1994) *Ngiti: A Central-Sudanic Language of Zaire*. Köln: Rüdinger Köppe Verlag.

Labov, William (1994) *Principles of Linguistic Change: Internal Factors*. Oxford: Blackwell.

Labov, William (2001) *Principles of Linguistic Change: Social Factors*. Oxford: Blackwell.

Ladefoged, Peter (1984) 'Out of Chaos Comes Order'; Physical, biological, and structural patterns in phonetics. in Van den Broecke, M.P.R. and A. Cohen (eds.) *Proceedings of ICPhS 10.* Dordrecht: Foris Publications. pp. 83-95.

Ladefoged, Peter (1985) Introduction (interview with V.A. Fromkin). In Fromkin, Phonetic Linguistics. New York: Academic Press. p. 11.

Laidig, Carol J. (1992) Segments, Syllables, and Stress in Larike. In Burquest and Laidig (1992).

Lakshmi, V. Swarajya (1982) *A Descriptive Grammar of Cuddapah Dialect*. Hyderabad: Tekugu Akademi.

Lamberti, Marcello, and Roberto Sottile (1997) *The Wolaytta language*. Köln: Rüdiger Köppe Verlag.

Langacker, Ronald W. (ed.) (1979) *Studies in Uto-Aztecan Grammar*. Arlington: The Summer Institute of Linguistics and The University of Texas at Arlington.

Lapowila, Hans (1981) *A Generative Approach to the Phonology of Bahasa Indonesia*. Canberra: Pacific Linguistics.

Lass, Roger (1975) How intrinsic is content? Markedness, sound change, and 'family universals'. in D. Goyvaertz and G. Pullum (eds.), *Essays on The Sound Pattern of English*. Ghent, Belgium: E. Story-Scientia.

Lawton, Ralph (1993) *Topics in the Description of Kiriwina*. Canberra: Pacific Linguistics.

Leavitt, Robert M. (1996) *Passamaquoddy-Maliseet*. Muenchen: Lincom Europa.

Leslau, Wolf (1958) *The Verb in Harari (South Ethiopic)*. Berkeley: University of California Press.

Leslau, Wolf (1997) *Ethiopic Documents: Argobba Grammar and Dictionary*. Wiesbaden: Harrassowitz Verlag.

Leslau, Wolf (1999) *Zway Ethiopic Documents: Grammar and Dictionary*. Wiesbaden: Harrassowitz Verlag.

Leslau, Wolf (2000) *Introductory Grammar of Amharic*. Wiesbaden: Harrassowitz Verlag.

Levin, Norman Balfour (1961) *The Assiniboine Language*. Ann Arbor: UMI.

Lewis, G. L. (1967) *Turkish Grammar*. Oxford: Clarendon Press.

Liddell, Scott. (1984) THINK and BELIEVE: Sequentiality in American Sign Language. *Language* 60, 372-392.

Liddell, Scott and Robert Johnson (1989) American Sign Language: The phonological base. *SLS* 64: 197-277.

Lincoln, Peter Craig (1976) *Describing Banoni, an Austronesian Language of Southwest Bougainville*. Ann Arbor: UMI.

Lindblom, Björn (1983) Economy of speech gestures. In MacNeilage (ed.) The Production of Speech. New York: Springer Verlag

Lindblom, Björn (1984). Can the models of evolutionary biology be applied to phonetic problems?. In Van den Broecke, M.P.R. & Cohen, A. (eds.) Proceedings of the Tenth International Congress of Phonetic Sciences. Dordrecht: Foris: 67-81.

Lindblom, Björn (1986) Phonetic universals in vowel systems. In Ohala and Jaeger (eds.) *Experimental Phonology*. New Yok: Academic Press. pp. 13-44.

Lindblom, Björn (1990a) On the notion of 'possible speech sound'. *Journal of Phonetics* 18: 135-152.

Lindblom, Björn (1990b) Explaining phonetic variation: a sketch of the H&H theory. In Hardcastle & Marchal (eds.) *Speech production and speech modeling*. Dordrecht: Kluwer, pp. 403-439.

Lindblom, Björn (1999) Emergent Phonology. University of Stockholm/University of Texas at Austin ms.

Lindblom, Björn (2000) Developmental Origins of Adult Phonology: The Interplay between Phonetic Emergents and the Evolutionary Adaptations of Sound Patterns. University of Stockholm/University of Texas at Austin ms.

Lindblom, Gerhard (1925) *Notes on the Kamba Language*. Upsala: Appelbergs Boktryckeri Aktiebolag.

Lindskoog, John N., and Ruth M. Brend (1962) *Cayapa Phonemics*. In Elson (1962)

Lindstrom, Lamont, and John Lynch (1994) *Kwamera*. Muenchen: Lincom Europa.

Lockwood, W. B. (1955) *An Introduction to Modern Faroese*. København: Ejnar Munskgaard.

Lombeida-Naranjo, Ernesto Balmodero (1976) *Ecuadorean Highland Quechua Phonology*. Ann Arbor: UMI.

Loos, Eugene Emil (1967) *The Phonology of Capanahua and its Grammatical Basis*. Norman: Summer Institute of Linguistics of the University of Oklahoma.

Loving, Richard (1973) Awa Phonemes, Tonemes, and Tonally Differentiated Allomorphs. In McKaughan (1973)

Lowe, Ronald (1996) *Inuktitut*. In Maurais (1996)

Lubker, J. (1968) An EMG-cinefluorographic investigation of velar function during normal speech production. *Cleft Palate Journal* 5(1).

Lucci, V. (1972) Phonologie de l'Acadien. *Studia Phonetica* 7. Ottawa: Didier.

Lukas, J. (1970) *Studien zur Sprache der Gisiga*. Hamburg.

Lupardus, Karen Jacque (1982) *The Language of the Alabama Indians*. Ann Arbor: UMI.

Lyman, Thomas Amis (1979) *Grammar of Mong Njua (Green Miao): a descriptive linguistic study*. [S.l.]: The author.

MacDonald, Lorna (1990) *Tauya*. Berlin: Mouton de Gruyter.

MacKay, Carolyn J. (1999) *A Grammar of Misantla Totonac*. Salt Lake City: The University of Utah Press.

MacWhinney, Brian (1998) Emergent Language. in M. Darnell, E. Moravcsik, F. Newmeyer, M. Noonan, and K. Wheatley (eds.) *Functionalism and Formalism in Linguistics Volume 1: General Papers*. Amsterdam: John Benjamins. 361-386.

Madan, A.C. (1906) *Wisa Handbook*. Oxford: The Clarendon Press.

Maddieson, Ian (2001) Typological patterns-geographical distribution and phonetic explanation. Paper presented at the Conference on the Phonetics-Phonology Interface.

Maganga, Clement, and Thilo C. Schadeberg (1992) *Kinyamwezi: Grammar, Texts, Vocabulary*. Köln: Rüdinger Köppe Verlag.

Makashay, Matthew J. (2001) Lexical Effects in the Perception of Obstruent Ordering. in Hume and Johnson (2001b). pp. 88-116.

Malcolm, D. McK. (1966) *A new Zulu manual* (Revised by D. N. Bang). Cape Town: Longmans.

Manley, Timothy M. (1972) *Outline of Sre Structure*. University of Hawaii Press.

Marconnès, Rev. Francisque (1931) *A Grammar of Central Karanga*. Johannesburg: Witwatersrand University Press.

Martin, Samuel Elmo (1961) *Dagur Mongolian grammar, texts, and lexicon; based on the speech of Peter Onon*. Bloomington: Indiana University.

Martinet, André (1968) Phonetics and linguistic evolution. In Malmberg, Bertil (ed.) *Manual of Phonetics*. Amsterdam: North-Holland Publishing Company.

Mason, J. Alden (1917) *Tepecano, a Piman Language of Western Mexico*. New York: New York Academy of Sciences.

Mateus, Maria Helena, and Ernesto d'Andrade (2000) *The Phonology of Portuguese*. New York: Oxford University Press.

Mathiassen, Terje (1974) *A Short Grammar of Latvian*. Columbus, OH: Slavica Publishers, Inc.

Mathingwane, Joyce T. (1999) *Ikalanga Phonetics and Phonology: A Synchronic and Diachronic Study*. Stanford, CA: CSLI Publications.

Maurais, Jacques (1996) (ed.) *Quebec's Aboriginal Languages: History, Planning and Development*. Philadelphia: Multilingual Matters Ltd.

McCarthy, John. J. (1991) Semitic Gutturals and Distinctive Feature Theory. in Dunlap, Elaine, and Jaye Padgett (eds.) *UMOP 14*. pp. 29-50.

McCarthy, John J. (1994) The phonetics and phonology of Semitic pharyngeals. In Pat Keating (ed.) *Phonological Structure and Phonetic Form: Papers in Laboratory Phonology III*. Cambridge: Cambridge University Press. 191-251.

McCarthy, John J. and Alan Prince (1995) "Faithfulness and Reduplicative Identity," in J.N. Beckman, L. Walsh Dickey, S. Urbanczyk (eds.) *Papers in Optimality Theory*. Amherst : University of Massachussets. 249-384.

McClean, R. J. (1987) *Swedish*. Kent: Hodder and Stoughton.

McClelland, Clive W. III (2000) *The Interrelations of Syntax, Narrative Structure, and Prosody in a Berber Language*. Lewiston: The Edwin Mellen Press.

McElhanon, K. A. (1970) *Selepet Phonology*. Canberra: Pacific Linguistics.

McGregor, William (1990) *A Functional Grammar of Gooniyandi*. Philadelphia: John Benjamins Publishing Company.

McGregor, William (1994) *Warrwa*. München: Lincom Europa.

McGregor, William (1996) *Nyulnyul*. München: Lincom Europa.

McGregor, William B. (1993) *Gunin/Kwini*. München: Lincom Europa.

McIntosh, Mary (1984) *Fulfulde Syntax and Verbal Morphology*. Boston: KPI.

McKaughan, Howard (ed.) (1973) *The Languages of the Eastern Family of the East New Guinea Highland Stock*. Seattle: University of Washington Press.

McKaughan, Howard, and Doreen Marks (1973) Notes on Auyana Phonology and Morphology. In McKaughan (1973)

McLaren, J. (1906) *A Grammar of the Kaffir Language*. New York: Longmans, Green, and Co..

McMahon, April (2002) *An Introduction to English Phonology*. Oxford: Oxford University Press.

Meier, Paul, Inge Meier, and John Bendor-Samuel (1975) *A Grammar of Izi: An Igbo Language*. Norman: Summer Institute of Linguistics.

Meira, Sérgio (2000) *Reduplication in Tiriyó (Cariban)*. Muenchen: Lincom Europa.

Menn, Lise (1980) Phonological theory and child phonology. In Yeni-Komshian, Grace H., James, F. Kavanaugh, and Charles A. Ferguson (eds.) *Child Phonology Volume 1*. New York: Academic Press. 23-41.

Michelson, Karin Eva (1983) *A Comparative Study of Accent in the Five nations Iroquoian Languages*. Ann Arbor: UMI.

Mielke, Jeff (2001) Explaining Directional Asymmetry in Turkish [h] Deletion: A Crosslinguistic Study of Perceptibility. In Hume and Johnson (2001b). pp. 117-171.

Mielke, Jeff (2003) The Interplay of Speech Perception and Phonology: Experimental Evidence from Turkish. *Phonetica* 60.3: 208-229.

Mill, John Stuart. (1843). System of Logic. London: Longmans, Green, Reader, and Dyer.

Miller, Amy (2001) *A Grammar of Jamul Tiipay*. New York: Mouton de Gruyter

Miller, George A., and Patricia E. Nicely (1955) An Analysis of Perceptual Confusions Among Some English Consonants. *Journal of the Acoustical Society of America* 27. 338-352.

Mills, Elizabeth (1984) *Senoufo Phonology, Discourse to Syllable (A Prosodic Approach)*. Arlington: Summer Institute of Linguistics.

Milroy, Lesley (1980) *Language and Social Networks*. Oxford: Blackwell.

Miner, Kenneth Lee (1975) *Interference Relations in Menomini Phenology*. Ann Arbor: UMI.

Mixco, Maurice (1997) *Mandan*. Muenchen: Lincom Europa.

Mohrlang, Roger (1972) *Studies in Nigerian Languages No. 2. Higi Phonology*. Zaria: Institute for Linguistics.

Moll, K. L. (1962) Velopharyngeal closure in vowels. *Journal of Speech and Hearing Research* 5. 30-37.

Morev, L. N., A. A. Moskalev, and Y. Y. Plam (1979) *The Lao Language*. Moscow: U.S.S.R. Academy of Sciences Institute of Oriental Studies.

Morris, H. F., and B. E. R. Kirwan (1957) *A Runyankore Grammar*. Nairobi: The Eagle Press.

Mugane, John M. (1997) *Paradigmatic Grammar of Gĩkũyũ*. Stanford: CSLI Publications.

Munro, Pamela (1976) *Mojave Syntax*. New York: Garland Publishing, Inc.

Murane, Elizabeth (1974) *Daga Grammar from Morpheme to Discourse*. Glendale, CA: The Church Press.

Mustafa, Khateeb S. (2000) *A Descriptive Grammar of Dakkhini*. New Delhi: Munshiram Manoharlal Publishers Pvt. Ltd.

Myers, Scott (2002) Gaps in factorial typology: The case of voicing in consonant clusters, ms., University of Texas at Austin. ROA-509.

Nakshabandi, Anwar Mohammed H. (1988) *A descriptive study of the phonology and morphology of the Abha dialect*. Ann Arbor: UMI.

Nash, David (1986) *Topics in Warlpiri Grammar*. New York: Garland Publishing, Inc.

Næss, Åshild (2000) *Pileni*. Muenchen: Lincom Europa.

Natarajan, G. V. (1985) *Abujhmaria Grammar*. Mysore: Central Institute of Indian Languages.

Nedjalkov, Igor (1997) *Evenki*. New York: Routledge.

Nettle, Daniel (1998) *The Fyem Language of Northern Nigeria*. Muenchen: Lincom Europa.

Neukom, Lukas (2001) *Santali*. Meunchen: Lincom Europa.

Newman, Paul (1974) *The Kanakuru Language*. Ilkley: The Scolar Press Ltd.

Newmeyer, Frederick (1998) Language Form and Language Function. Cambridge Mass.: MIT Press.

Ngom, Fallou (2000) *Phonetic and Phonological Description of Mandinkakan Phonemes as spoken in Kajor (Ziguinchor)*. Muenchen: Lincom Europa.

Ngunga, Armindo (2000) *Phonology and morphology of the Ciyao verb*. Stanford, CA: CSLI Publications.

Nguyên Dình-Hoà (1997) *Vietnamese*. Amsterdam: John Benjamins.

Nivens, Richard (1992) Lexical Phonology of West Tarangan. In Burquest and Laidig (1992).

Noonan, Michael (1992) *A Grammar of Lango*. New York: Mouton de Gruyter.

Nordbustad, Frøydis (1988) *Iraqw grammar: an analytical study of the Iraqw*. Berlin: D. Reimer.

Nordlinger, Rachel (1998) *A Grammar of Wambaya*. Canberra: Pacific Linguistics.

Novelli, Bruno (1985) *A Grammar of the Karimojong Language*. Berlin: Dietrich Reimer Verlag.

Ó Siadhail, Mícheál (1989) *Modern Irish: Grammatical structure and dialectal variation*. New York: Cambridge University Press.

O'Grady, Geoffrey N. (1964) *Nyangumata Grammar*. Sydney: University of Sydney.

Oates, Lynette F. (1988) *The Muruwari Language*. Canberra: Pacific Linguistics.

Oatridge, Desmond and Jennifer Oatridge (1973) Phonemes of Binumarien. In McKaughan (1973)

Oda, Sachiko (1977) *The Syntax of Pulu Annian: A Nuclear Micronesian Language*. Ann Arbor: UMI.

Odden, David (1987) Dissimilation as Deletion in Chukchi. in Miller, Ann and Joyce Powers (eds.) *ESCOL* 4. pp. 235-246.

Odden, David (1996) *The Phonology and Morphology of Kimatuumbi*. Oxford: Clarendon Press.

Odden, David (2002a) Consonant-Tone Interaction in Zina Kotoko. Paper Presented at MCWOP, Indiana University.

Odden, David (2002b) The verbal tone system of Zina Kotoko. in Schmidt, Odden & Homberg (eds.) *Aspects of Zina Kotoko grammar*, München: Lincom Europa.

Odhner, John D. (1981) *English-Lingala Manual*. Washington, D.C.: University Press of America.

Odisho, Edward Y. (1988) *Sound System of Modern Assyrian (Neo-Aramaic)*. Wiesbaden: Harrassowitz Verlag.

Ohala, John J. (1981) The listener as a source of sound change. In C.S. Masek, R.A. Hendrik, and M.F. Miller (eds.) Papers from the parasession on language and behavior: Chicago Linguistic Society . Chicago: CLS. 178-203.

Ohala, John J. (1983) The origin of sound patterns of vocal tract constraints. In MacNeilage (ed.) *The production of speech*. New York: Springer. 189-216.

Ohala, John J. (1992) Alternatives to the Sonority Hierarchy for Explaining Segmental Sequential Constraints. *Chicago Linguistics Society: Papers from the Parasession on the Syllable*. Chicago: CLS 28: 319-338.

Ohala, John J. (1993) Sound change as nature's speech perception experiment. *Speech Communication* 13. 155-161.

Ohala, John J. (2003) *Phonetics and Historical Phonology*. In Joseph and Janda (2003). 667-686.

Okell, John (1969) *A reference grammar of colloquial Burmese*. London: Oxford U.P.

Okoth-Okombo, Duncan (1982) *Dholuo Morphophonemics in a Generative Framework*. Berlin: Dietrich Reimer Verlag.

Onishi, Kristine H., Kyle E. Chambers, and Cynthia Fisher (2002) Learning phonotactic constraints from brief auditory experience. *Cognition* 83. B13-B23.

Orr, Carolyn (1962) Equador Quichua Phonology. In Elson (1962)

Osumi, Midori (1995) *Tinrin Grammar*. Honolulu: University of Hawai'i Press.

Ourso, Meterwa (1989) *Lama Phonology and Morphology*. Ann Arbor: UMI.

Owens, Jonathan (1985) *A Grammar of Harar Oromo (Northeastern Ethiopia)*. Hamburg: Helmut Buske Verlag.

Palikupt, Deeyoo (1983) *Central Thai and Northeastern Thai: A Linguistic and Attitudinal Study*. Ann Arbor: UMI.

Pam, Martin David (1973) *Tigrinya Phonology*. Ann Arbor: UMI.

Pandosy, Rev. Mie. Cles. (1862) *Grammar and Dictionary of the Yakama Language*. New York: AMS Press, Inc.

Paradis, Carole (1992) Lexi*cal Phonology and Morphology: The Nominal Classes in Fula*. New York: Garland Publishing, Inc.

Paradis, Carole and Darlene LaCharité (2001) Guttural Deletion in Loanwords. *Phonology* 18.2. 225-300.

Parks, Douglas R. (1976) *A Grammar of Pawnee*. New York: Garland Publishing, Inc.

Parsons, T. and R.F. Bales (1955). *Family, socialization and interaction process*. Glencoe, IL: Free Press.

Pater, Joe (2004) Exceptionality as constraint indexation. Paper presented at 2004 MOT phonology workshop.

Patterson, Trudi Alice (1990) *Theoretical aspects of Dakota morphology and phonology*. Ann Arbor: UMI.

Payne, David L. (1981) *The Phonology and Morphology of Axininca Campa*. Arlington: The Summer Institute of Linguistics and The University of Texas at Arlington.

Peperkamp, Sharon and Emmanuel Dupoux (2004) The acquisition of abstract phoneme categories. Paper presented at LabPhon 9.

Perlmutter, David M. (1992) Sonority and syllable structure in American Sign Language. *Linguistic Inquiry* 23, 407-442.

Pestronk, Alan (2004) Neuromuscular Disease Center. http://www.neuro.wustl.edu /neuromuscular/nanatomy/median.htm

Phillips, Colin, Thomas Pellathy, and Alec Marantz (2000) Phonological Feature Representations in Auditory Cortex. University of Delaware and MIT ms.

Pia, J. Joseph (1963) *An Outline of the Structure of Somali*. Michigan State University ms.

Pierrehumbert, Janet (2001) Why phonological constraints are so coarse-grained. In J. McQueen and A. Cutler (eds.) *SWAP* special issue, Language and Cognitive Processes 16 5/6, 691-698.

Pierrehumbert, Janet (2003) Probabilistic Phonology: Discriminability and Robustness. In Bod, R., J. Hay, and S. Jannedy (eds.) *Probabilistic Linguistics*. Cambridge, Mass.: MIT Press.

Pieter, Sterk Jan (1977) *Elements of Gade Grammar*. Ann Arbor: UMI.

Pinker, Steven (1994) *The Language Instinct*. New York, NY: W. Morrow and Co.

Pinker, Steven (1999) *Words and Rules*. New York: Basic Books

Pinker, S. and A. Prince (1994) Regular and irregular morphology and the psychological status of rules of grammar. In S.D. Lima, R.L. Corrigan, and G.K. Iverson (eds.) *The reality of linguistic rules*. Philadelphia: Benjamins.

Pitt, Mark, Keith Johnson, Elizabeth Hume, Scott Keisling, and William Raymond (2004) The Buckeye Corpus of Conversational Speech: Labeling conventions and a test of transcriber reliability. OSU ms.

Plauché, M., C. Delogu, and J. Ohala (1997) Asymmetries in consonant confusion. *Proceedings of Eurospeech '97: Fifth European Conference on Speech Communication and Technology 4*. 2187-2190.

Poppe, Nikolai Nikolaevich (1960) *Buriat grammar*. Bloomington: Indiana University.

Port, Robert F. (1996) The discreteness of phonetic elements and formal linguistics: response to A. Manaster Ramer. *Journal of Phonetics* 24. 491-511.

Poulos, George (1990) *A linguistic analysis of Venda*. Pretoria: Via Afrika.

Prasad, Bal Ram (1991) *Mising Grammar*. Mysore: Central Institute of Indian Languages.

Press, Ian (1986) *A Grammar of Modern Breton*. New York: Mouton de Gruyter.

Press, Margaret Lauritsen (1975) *A Grammar of Chemehuevi*. Ann Arbor: UMI.

Price, Thomas (1958) *The Elements of Nyanja*. Blantyre: Church of Scotland Mission.

Prince, Alan and Paul Smolensky (1993) Optimality Theory: Constraint Interaction in Generative Grammar. ms, Rutgers University, New Brunswick and University of Colorado, Boulder.

Pulleyblank, Douglas (2003) Covert Feature Effects. In Garding, Gina, and Mimu Tsujimura, (eds.) *Proceedings of WCCFL 22*. Somerville, Mass.: Cascadilla Press. 398-422.

Pullum, Geoffrey K. (1996) Learnability, hyperlearning, and the poverty of the stimulus. Jan Johnson, Matthew L. Juge, and Jeri L. Moxley (eds.) *Proceedings of the 22nd Annual Meeting: General Session and Parasession on the Role of Learnability in Grammatical Theory*. Berkeley Linguistics Society, Berkeley, California. 498-513.

Pye, C., D. Ingram, D., and H. List (1987) A comparison of initial consonant acquisition in English and Quiche. In K. E. Nelson & A. Van Kleeck (eds.) *Children's Language* 6. Hillsdale, NJ: Lawrence Erlbaum. pp. 175-190.

Pyles, Thomas, and John Algeo (1993) *The Origins and Development of the English Language*, 4th edition. Fort Worth: Harcourt Brace Jovanovich College Publishers.

Quesada, J. Diego (2000) *A Grammar of Teribe*. Muenchen: Lincom Europa.

Ramos, Teresita V. (1971) *Tagalog Structures*. Honolulu: University of Hawaii Press.

Randoja, Tiina (1990) *The Phonology and Morphology of Halfway River Beaver*. Ann Arbor: UMI.

Rangan, K. (1979) *Purki Grammar*. Mysore: Central Institute of Indian Languages.

Ray, Punya Sloka (1966) *Bengali Language Handbook*. Washington, D.C.: Center for Applied Linguistics.

Raymond, William, Robin Dautricourt, and Elizabeth Hume (to appear) Medial t/d deletion in spontaneous speech: The effects of extra-linguistic, lexical and phonological factors. To appear in *Language Variation and Change*.

Raz, Shlomo (1983) *Tigre Grammar and Texts*. Malibu, CA: Undena Publications.

Reesink, Ger P. (1999) *A grammar of Hatam, Bird's Head Peninsula, Irian Jaya*. Canberra: Pacific Linguistics.

Reh, Mchthild (1996) *Anywa Language*. Köln: Rüdiger Köppe Verlag.

Rehg, K.L., and D.G. Sohl (1981) *Ponapean reference grammar*. Honolulu: University Press of Hawaii.

Reichard, Gladys A. (1925) *Wiyot Grammar and Texts*. Berkeley: University of California Press.

Reichard, Gladys A. (1974) *Navaho Grammar*. New York: J.J. Augustin Publisher.

Reiss, Charles (2003) Quantification in Structural Descriptions: Attested and Unattested Patterns. Concordia University ms.

Rennison, John R. (1997) *Koromfe*. New York: Routledge.

Rhodes, Richard Alan (1976) *Morphosyntax of the Central Ojibwa Verb*. Ann Arbor: UMI.

Rice, Keren (1989) *A Grammar of Slave*. New York: Mouton de Gruyter.

Rice, Keren (1992) On deriving sonority: A structural account of sonority relationships. *Phonology* 9: 61-99.

Rice, Keren (1999) Featural markedness in phonology: variation. University of Toronto ms.

Rice, Keren and Peter Avery (1989). On the Interaction between sonorancy and voicing. In B. Brunson, S. Burton & T. Wilson (eds.) *Toronto Working Papers in Linguistics* 10: 65-82.

Rice, Keren, and Peter Avery (1995) Variability in a Deterministic Model of Language Acquisition: A Theory of Segmental Elaboration. In Archibald, John (ed.) *Phonological Acquisition and Phonological Theory*. Hillsdale, NJ: Lawrence Erlbaum Associates. pp. 23-42.

Roberts, John R. (1987) *Amele*. New York: Croom Helm.

Robins, R. H. (1958) *The Yurok Language: Grammar, Texts, Lexicon. Berkeley*: University of California Press.

Rood, David S. (1976) *Wichita Grammar*. New York: Garland Publishing, Inc.

Rosenhouse, Judith (1984) *Bedouin Arabic Dialects*. Wiesbaden: Otto Harrassowitz.

Rossing, Melvin Olaf (1978) *Mafa-Mada*. Ann Arbor: UMI.

Rubach, Jerzy (1993) *The Lexical Phonology of Slovak*. Oxford: Clarendon Press.

Rubino, Carl Ralph Galvez (2000) *Ilocano Dictionary and Grammar*. University of Hawai'i Press.

Rubongoya, L. T. (1999) *A Modern Runyoro-Rutooro Grammar*. Köln: Rüdinger Köppe Verlag.

Rumelhart, D.E., and J.L. McClelland (1986) On learning the past tenses of English verbs. In J.L. McClelland, D.E. Rumelhart, and the PDP Research Group (eds.) *Parallel distributed processing: Explorations in the microstructure of cognition. Vol. 2. Psychological and biological models*. Cambridge, MA.: MIT Press.

Rupp, James E. (1989) *Lealao Chinantec Syntax. Studies in Chinantec Languages* Volume 2. Arlington, TX: Summer Institute of Linguistics and the University of Texas at Arlington.

Ruskin, E. A., and L. Ruskin (1934) *A grammar of the Lomongo language*. Bongandanga: C.B.M. Press.

Saeed, John Ibrahim (1987) *Somali Reference Grammar*. Wheaton, MD: Dunwoody Press.

Sagey, Elizabeth C. (1986) *The representation of features and relations in non-linear phonology.* MIT PhD dissertation.

Saint, Rachel, and Kenneth L. Pike (1962) Auca Phonemics. In Elson (1962)

Saltarelli, Mario, Miren Azkarate, David Farwell, Jon Ortiz de Urbina, Lourdes Oñederra (1988) *Basque*. New York: Croom Helm.

Samarin, William J. (1967) *A Grammar of Sango*. The Hague: Mouton & Co.

Samely, Ursula (1991) Kedang (Eastern Indonesia) Some Aspects of its Grammar. *Forum Phoneticum* 46. Hamburg: Helmut Buske Verlag.

Sandler, Wendy (1989) *Phonological representation of the sign: Linearity and nonlinearity in American Sign Language.* Dordrecht: Foris.

Sapir, J. David (1965) *A Grammar of Diola-Fogny*. Cambridge: Cambridge University Press.

Sastry, G. Devi Prasada (1984) *Mishmi Grammar*. Mysore: Central Institute of Indian Languages.

Saxton, Dean (1979) Papago. In Langacker (1979).

Scatton, Ernest A. (1984) *A Reference Grammar of Modern Bulgarian*. Columbus, OH: Slavica Publishers, Inc.

Schadeberg, Thilo C. (1990) *A sketch of Umbundu*. Köln: R. Köppe Verlag.

Scherer, Wilhelm (1868) *Zur Geschichte der deutschen Sprache*. Berlin: Duncker.

Schiffman, Harold F. (1999) *A Reference Grammar of Spoken Tamil*. New York: Cambridge University Press.

Schmidt, Bodil Kappel, David Odden, and Anders Holmberg (eds.) (2002) *Some Aspects of the Grammar of Zina Kotoko*. Muenchen: Lincom Europa.

Schulze, Wolfgang (1997) *Tsakhur*. Muenchen: Lincom Europa.

Schulze, Wolfgang (2000) *Northern Talysh*. Muenchen: Lincom Europa.

Schütz, Albert J. (1969) *Nguna Grammar*. Honolulu: Oceanic Linguistics Special Publication.

Schütze, Hinrich (1997) *Ambiguity Resolution in Language Learning: Computational and Cofnitive Models*. CSLI Lecture Notes 71. Stanford, CA: CSLI Publications.

Sebeok (1961) *An Eastern Cheremis Manual*. Bloomington/The Hague: Mouton & Co./Indiana University.

Seiler, Hansjakob (1977) *Cahuilla Grammar*. Banning, CA: Malki Museum Press.

Selkirk, Elisabeth (1988) Dependency, Place and the Notion 'Tier'. UMass ms.

Selkirk, Elisabeth (1991) Major Place in the Vowel Space: Vowel Height Features. UMass ms.

Selkirk, Elisabeth (1993) [Labial] Relations. UMass ms.

Sengova, Matthew Joko (1984) *Tense, Aspect, and Time Specification in the Verb System of Mende*. Ann Arbor: UMI.

Seo, Misun (2001) A Perception-based Study of Sonorant Assimilation in Korean. in Hume and Johnson (2001b). 43-69.

Shalizi, Cosma Rohilla (2001) Emergent Properties. http://www.santafe.edu/~shalizi/notebooks/emergent-properties.html

Shannon, C.E., and W. Weaver (1949) *The mathematical theory of communication.* Urbana: University of Illinois Press.

Sharma, D. D. (1988) *A Descriptive Grammar of Kinnauri*. Delhi: Mittal Publications.

Shaterian, Alan William (1983) *Phonology and Dictionary of Yavapai*. Ann Arbor: UMI.

Shattuck-Hufnagel, S., and Dennis H. Klatt (1975) An analysis of 1500 phonetic errors in spontaneous speech. *Journal of the Acoustical Society of America* 58 (supplement 1): 66 (A).

Shattuck-Hufnagel, Stefanie, & Dennis H. Klatt (1979) The Limited Use of Distinctive Features and Markedness in Speech Production: Evidence from Speech Error Data. *Journal of Verbal Learning and Verbal Behavior* 18: 41-55.

Sherzer, Joel (1975) A Problem in Cuna Phonology. *The Journal of the Linguistic Association of the* Southwest, Vol. I, No. 2.

Shetler, Joanne (1976) *Notes on Balangao Grammar*. Huntington Beach, CA: Summer Institute of Linguistics

Shibatani, Masayoshi (1990) *The Languages of Japan*. Cambridge University Press.

Shimizu, Kiyoshi (1980a) *Comparative Jukunoid. Vol 1*. Wien: Beiträge zur Afrikanistik.

Shimizu, Kiyoshi (1983) *Zing Dialect of Mumuye: A Descriptive Grammar*. Hamburg: Helmut Buske Verlag.

Shukla, Shaligram (2000) *Hindi Phonology*. Muenchen: Lincom Europa.

Siegel, Jeff (2000) Substrate influence in Hawai'i Creole English. *Language in Society* 29. 197-236

Simpson, John (2004) *The Oxford English Dictionary, 3rd Edition*. Oxford: Oxford University Press.

Singh, Sadanand, and John Black (1966) Study of Twenty-Six Intervocalic Consonants as Spoken and Recognized by Four Language Groups. *Journal of the Acoustical Society of America* 39. 372-387.

Sischo, William R. (1979) Michoacán Nahauatl. In Langacker (1979).

Skinner, Margaret Gardner (1979) *Aspects of Pac'anci Grammar*. Ann Arbor: UMI.

Smalley, William A. (1961) *Outline of Khmu$^{?}$ Structure*. New Haven: American Oriental Society.

Smith, Ian Russell (1978) *Sri Lanka Creole Portuguese phonology*. Vanchiyoor, Trivandrum, India: Dravidian Linguistics Association.

Smith, Ian Russell (1981) *Sri Lanka Portuguese Creole Phonology*. Ann Arbor: UMI.

Snapp, Allen, John Anderson, and Joy Anderson (1979) Northern Paiute. In Langacker (1979).

Snyder, M., B.H. Campbell, and E. Preston (1982) Testing hypotheses about human nature: assessing the accuracy of social stereotypes. *Social Cognition, 1*, 256-272.

Sohn, Ho-Min (1975) *Woleaian Reference Grammar*. Honolulu: The University Press of Hawaii.

Solnit, David B. (1997) *Eastern Kayah Li: Grammar, Texts, Glossary*. University of Hawai'i Press.

Soukka, Maria (2000) *A Descriptive Grammar of Noon*. Muenchen: Lincom Europa.

Spear, Norman E., and David C. Riccio (1987) *Memory: Phenomena and Principles*. Boston: Allyn and Bacon.

Spears, Richard Alan (1965) *The Structure of Faranah-Maninka*. Ann Arbor: UMI.

Spitz, Walter L. (2001) *Hiligaynon / Ilonggo*. Muenchen: Lincom Europa

Sreedhar, M. V. (1980) *A Sema Grammar*. Mysore: Central Institute of Indian Languages.

Sridhar, S. N. (1990) *Kannada*. New York: Routledge.

St. Clair, Robert N. (1974) *Theoretical Aspects of Eskimo Phonology*. Ann Arbor: UMI.

Stallcup, Kenneth Lyell (1978) *A Comparative Perspective on the Phonology and Noun Classification of Three Cameroon Grassfields Bantu Languages: Moghamo, Ngie, and Oshie*. Ann Arbor: UMI.

Stanford, Ronald and Lyn (1970) *Collected Field Reports on the Phonology and Grammar of Chakosi. Collected Language Notes No. 11*. University of Ghana: Institute of African Studies.

Stanhope, John M. (1980) *The Language of the Rao People, Grengabu, Madang Province, Papua New Guinea*. Canberra: Pacific Linguistics.

Steels, Luc (1997) The synthetic modelling of language origins. *Evolution of Communication* 1: 1-34.

Steriade, Donca (1997) Similarity and lexical conservatism in surface analogy. UCLA ms.

Steriade, Donca (2001). Directional asymmetries in place assimilation: a perceptual account. In Hume and Johnson (2001a)

Steriade, Donca (2004). The Phonology of Perceptibility Effects: the P-map and its consequences for constraint organization. In Kristin Hanson and Sharon Inkelas (eds.) *The nature of the word*. Cambridge, Mass.: MIT Press.

Stevens, Kenneth (1972) The quantal nature of speech: Evidence from articulatory-acoustic data. In David, E.E., and P.B. Denes (eds.) Human Communication: A Unified View (pp. 51-66). New York: McGraw Hill.

Stevens, Kenneth (1989) On the quantal nature of speech. *Journal of Phonetics* 17: 3-45.

Stokoe, William 1960. Sign language structure: An outline of the visual communication of the American Deaf. *Studies in Linguistics, Occasional Papers* 8.

Stonham, John (1999) *Aspects of Tsishaath Nootka Phonetics & Phonology*. Muenchen: Lincom Europa.

Straight, H. Stephen (1976) *Acquisition of Maya Phonology*. New York: Garland Publishing, Inc.

Stringer, Mary and Joyce Hotz (1973) *Waffa Phonemes*. In McKaughan (1973)

Stroomer, Harry (1987) *A Comparative Study of Three Southern Oromo Dialects in Kenya*. Hamburg: Helmut Buske Verlag.

Studdert-Kennedy, M., & D. Shankweiler (1970) Hemispheric specialization for speech perception. *Journal of the Acoustical Society of America* 48. 579-594.

Studdert-Kennedy, M., D. Shankweiler, & D. Pisoni (1972) Auditory and phonetic processes in speech perception: Evidence from a dichotic study. *Cognitive Psychology* 3: 455-466.

Subrahmanyam, P. S. (1968) *A Descriptive Grammar of Gondi*. Annamalainagar: Annamalai University.

Sudlow, David (2001) *The Tamasheq of North-East Burkina Faso*. Köln: Rüdiger Köppe Verlag.

Suharno, Ignatius (1982) *A Descriptive Study of Javanese*. Canberra: Pacific Linguistics.

Sulkala, Helena, and Merja Karjalainen (1992) *Finnish*. New York: Routledge.

Swan, Oscar E. (1983) *A Concise Grammar of Polish*. Lanham, MD: University Press of America.

Takizala, Alexis (1974) *Studies in the Grammar of Kihungan*. Ann Arbor: UMI.

Tamura, Suzuko (2000) *The Ainu language*. Tokyo: Sanseido.

Tarpent, Marie-Lucie (1987) *A Grammar of The Nisgha Language*. Ann Arbor: UMI.

Tauberschmidt, Gerhard (1999) *A Grammar of Sinaugoro*. Canberra: Pacific Linguistics.

Taylor, Charles (1985) *Nkore-Kiga*. Dover, NH: Croom Helm.

Teoh, Boon Seng (1988) *Aspects of Malay Phonology Revisited – A Non-linear Approach*. Ann Arbor: UMI.

Terravecchia, Gian Paolo (2002) Free On Line Dictionary Of Philosophy. http://www.swif.uniba.it/lei/foldop/

Terrill, Angela (1998) *Biri*. München: Lincom Europa.

Thomas, David D. (1971) *Chrau Grammar*. University of Hawaii Press.

Thomason, Sarah G. and Terrence Kaufman (1988) Language Contact, Creolization, and Genetic Linguistics. Berkeley: University of California Press.

Thompson, Laurence C., and M. Terry Thompson (1992) The Thompson Language. *University of Montana Occasional Papers in Linguistics* No. 8.

Thorne, David A. (1993) *A Comprehensive Welsh Grammar*. Cambridge, Mass.: Blackwell.

Thornley, David H. (1997) The Philosophical Glossary. http://www.visi.com/~thornley/david/philosophy/definitions.html.

Thráinsson, H. (1978) On the phonology of Icelandic preaspiration. *Nordic Journal of Linguistics* X. 3-54.

Tosco, Mauro (1991) *A grammatical sketch of Dahalo: including texts and a glossary*. Hamburg: Helmut Buske Verlag.

Tosco, Mauro (1997) *Af Tunni: Grammar, Texts, And Glossary Of A Southern Somali Dialect*. Köln: Rüdiger Köppe Verlag.

Tosco, Mauro (2001) *The Dhaasanac language: grammar, text, vocabulary of a Cushitic language of Ethiopia*. Köln: Rüdiger Köppe Verlag.

Toweett, Taaitta (1979) *A Study of Kalenjin Linguistics*. Nairobi: Kenya Literature Bureau.

Traill, Anthony (1985) *Phonetic and Phonological Studies of !XÓÕ Bushman*. Hamburg: Helmut Buske Verlag.

Trubetzkoy N.S. (1939) Grundzüge der Phonologie. Travaux de Cercle Linguistique de Prague 7. English Translation 1969: Principles of Phonology. Berkeley: University of California Press.

Trudgill, Peter (2002) Linguistic and Social Typology. In Chambers, J.K., Peter Trudgill, and Natalie Schilling-Estes (eds.) *The Handbook of Language Variation and Change*. Malden, Mass.: Blackwell Publishers.

Tserdanelis, Georgios (2001) A Perceptual Account of Manner Dissimilation in Greek. in Hume and Johnson (2001b). 172-199.

Tuggy, David H. (1979) Tetelcingo Nahauatl. In Langacker (1979).

Tuite, Kevin (1997) *Svan*. Muenchen: Lincom Europa.

Unbegaun, B. O. (1957) *Russian Grammar*. Oxford: Clarendon Press

Uyechi, Linda Ann N. (1996). *The geometry of visual phonology*. Stanford, CA: CSLI Publications.

Valdman, Albert (1976) *Introduction to French Phonology and Morphology*. Rowley, Mass.: Newbury House Publishers, Inc.

Vamarasi, Marit (2002) *Rotuman*. Muenchen: Lincom Europa.

van Enk, Gerrit J., and Lourens de Vries (1997) *The Korowai of Irian Jaya*. New York: Oxford University Press.

van Klinken, Catharina Lumien (1999) *A grammar of the Fehan dialect of Tetun: An Austronesian Language of West Timor*. Canberra: Pacific Linguistics.

Van Knippenberg, A. and A. Dijksterhuis (1996) A posteriori stereotype activation: the preservation of stereotypes through memory distortion. *Social Cognition, 14*, 21-53.

van Sambeek, W.F. (1966) *A Bemba Grammar*. Cape Town: Galvin & Sales (Pty.) Ltd.

Vance, Timothy J. (1987) *An introduction to Japanese phonology*. Albany, N.Y.: State University of New York Press.

Vanoverbergh, Morice (1937) *Some undescribed Languages of Luzon*. Nijmegen: Dekker & van de Vegt N.V.

Vargha-Khadem, F., K. Watkins, K. Alcock, P. Fletcher, and R. Passingham (1994). Praxic and nonverbal cognitive deficits in a large family with a genetically transmitted speech and language disorder. *Proceedings of the National Academy of Science* 92: 930-933.

Vaux, Bert (1998) *The Phonology of Armenian*. Oxford: Clarendon Press.

Vaux, Bert (2002) Consonant epenthesis and the problem of unnatural phonology. Paper presented at Yale University Linguistics Colloquium.

Vennemann, Theo (1972) Phonetic analogy and conceptual analogy. In Vennemann and Wilbur (eds.) *Schuchardt, the Neogrammarians, and the transformational theory of phonological change: Four Essays* (= *Linguistische Forschungen* 26). Frankfurt/M.: Athenäum. 181-204.

Vennemann, Theo (1974) Topics, subjects, and word order: from SXV to SVX via TVX. In Anderson, John M., and Charles Jones (eds.) *Historical linguistics*, 2 vols. Proceedings of the first international conference on historical linguistic. Amsterdam: North-Holland. 339-76.

Vihman, Marilyn May (1993). Variable paths to early word production. *Journal of Phonetics* 21: 61-82.

Vihman, Marilyn May (1996) *Phonological Development: The Origins of Language in the Child*. Cambridge, Mass.: Blackwell.

Vogt, Hans (1940) *The Kalispel Language, An Outline of the Grammar with Texts, Translations, and Dictionary*. Oslo: I Kommisjon Hos Jacob Dybwad.

Volker, Craig (1998) *The Nalik Language of New Ireland, Papua New Guinea*. New York: Peter Lang Publishing.

Volker, Craig Alan (1982) *Introduction to Rabaul Creole German (Unserdeutsch)*. University of Queensland PhD dissertation.

Voorhis, Paul H. (1974) *Introduction to the Kickapoo Language*. Bloomington: Indiana University.

Voorhoeve, C. L. (1965) *The Flamingo Bay Dialect of the Asmat Language*. S-Gravenhage – Martinus Nijhoff.

Wali, Kashi, and Omkar N. Koul (1997) *Kashmiri*. New York: Routledge.

Walker (1975) Cherokee. In Crawford (1975)

Wallon, H. (1945) *Les origines de la pensée chez l'enfant*. I. Paris.

Wang, Marilyn D., and Robert C. Bilger (1973) Consonant confusions in noise: a study of perceptual features. *Journal of the Acoustical Society of America* 54. 1248-1266.

Wang, Yingxu, Dong Liu, and Ying Wang (2003) Discovering the Capacity of Human Memory. *Brain and Mind* 4. 189-198.

Ward, Ida C. (1933) *The Phonetic and Tonal Structure of Efik*. Cambridge: W. Heffer & Sons Ltd.

Waters, Bruce E. (1989) *Djinang and Djinba – A Grammatical and Historical Perspective*. Canberra: Pacific linguistics

Watkins, Laurel J. (1984) *A Grammar of Kiowa*. Lincoln: University of Nebraska Press.

Watters, John Robert (1981) *A Phonology and Morphology of Ejagham—with Notes on Dialect Variation*. Ann Arbor: UMI.

Weber, David John (1983) *A Grammar of Huallaga (Huanaco) Quechua*. Ann Arbor: UMI.

Wedel, Andrew (2004) Self-organization and Categorical Behavior in Phonology. UC Santa Cruz PhD dissertation.

Weidert, A., and B. Subba (1985) *Concise Limbu Grammar and Dictionary*. Amsterdam: Lobster Publications.

Werker, Janet F., and Richard C. Tees (1984) Phonemic and phonetic factors in adult cross-language speech perception. JASA vol. 75 no. 6, pp. 1866-1878.

Westbury, John, and Patricia Keating (1986) On the naturalness of stop consonant voicing. *Journal of Linguistics* 22: 145-166.

Westerman, D., and H. J. Melzian (1974) *The Kpelle Language in Liberia*. Berlin: Dietrich Reimer/Ernst Vohsen.

Westley, David O. (1991) *Tepetotutla Chinantec Syntax. Studies in Chinantec Languages* Volume 5. Arlington, TX: Summer Institute of Linguistics and the University of Texas at Arlington.

Wheeler, Alva, and Margaret Wheeler (1962) Siona Phonemics (Western Tucanoan). In Elson (1962)

Wheeler, Max (1979) *Phonology of Catalan*. Oxford: Basil Blackwell.

Whisler, Ronald (1992) Phonology of Sawai. In Burquest and Laidig (1992).

White, Lydia (1998) Universal Grammar in Second Language Acquisition: The Nature of Interlanguage Representation. paper presented at GASLA.

White, Robin Barbara Davis (1973) Klamath Phonology. *University of Washington Studies in Linguistics and Language Learning volume XII*.

Whitney, William Dwight (1867) *Language and the study of language; twelve lectures on the principles of linguistic science*.

Whitney, William Dwight (1875) *The life and growth of language; an outline of linguistic science*. New York: Appleton.

Wichmann, Søren (1995) The Relationship Among the Mixe-Zoquean Languages of Mexico. Salt Lake City: University of Utah Press.

Wickelgren, W. A. (1965) Distinctive features and errors in short-term memory for English vowels. *Journal of the Acoustical Society of America* 38: 583-588.

Wickelgren, W. A. (1966) Distinctive features and errors in short-term memory for English vowels. *Journal of the Acoustical Society of America* 39 (2): 388-398.

Wiering, Elisabeth (1994) Tone Patterns of Nominals in Doyayo. In Wiering and Wiering (1994a)

Wiering, Elisabeth, and Marinus Wiering (eds.) (1994a) *The Doyayo Language: Selected Studies*. Arlington: The Summer Institute of Linguistics.

Wiering, Elisabeth, and Marinus Wiering (1994b) Phonological Description of Doyayo (Poli dialect). In Wiering and Wiering (1994a)

Willett, Thomas Leslie (1988) *A reference grammar of Southeastern Tepehuan*. Ann Arbor: UMI.

Williamson, Kay (1965) *A Grammar of the Kolokuma Dialect of Ijo*. Cambridge: Cambridge University Press.

Wilson, Colin (2003) Experimental Investigation of Phonological Naturalness. Proceedings, In G. Garding and M. Tsujimura (eds.) *WCCFL 22*. Somerville, MA: Cascadilla Press. pp. 533-546.

Wilson, W. A. A. (1961) *An Outline of the Temne Language*. SOAS: London

Winer, Lise (1993) *Trinidad and Tobago*. Philadelphia: John Benjamins Publishing Company.

Winfield, Rev. W. W. (1928) *A Grammar of the Kui Language*. Calcutta: Baptist Mission Press.

Winford, Donald (2000) Tense and Aspect in Sranan and the Creole Prototype. Language Change and Language Contact in Pidgins and Creoles. Amsterdam: John Benjamins. pp. 383-442.

Woollams, Geoff (1996) *A Grammar of Karo Batak, Sumatra*. Canberra: Pacific Linguistics.

Worden, Robert (1995) A speed limit for evolution. *Journal of Theoretical Biology* 176: 137-152.

Xu, Shixuan (2001) *The Bisu Language*, Cecilia Brassett (transl.). München: Lincom Europa.

Yadav, Ramawatar (1996) *A Reference Grammar of Maithili*. New York: Mouton de Gruyter.

Yallop, Colin (1977) *Alyawarra*. Canberra: Advocate Press Pty Ltd.

Yi, Hyon-bok (1989) *Korean grammar*. New York: Oxford University Press.

Yip, Moira (2004a) Lateral survival: an OT account. To appear in Boersma, Paul, and Juan Antonio Cutillas (eds.) Advances in Optimality Theory, special issue of *International Journal of English Studies*.

Yip, Moira (2004b) Variability in feature affiliations through violable constraints: The case of [lateral]. To appear… Leiden.

Ziervogel, D. (1952) *A Grammar of Swazi*. Johannesburg: Witwatersrand University Press.

Ziervogel, D. (1959) *A Grammar of Northern Transvaal Ndebele*. Pretoria: J. L. van Schaik, Ltd.

Zimmermann, J. (1858) *A Grammatical Sketch and Vocabulary of the Akra- or Gã-Language*. Stuttgart: Gregg International Publishers Limited.

Zvelebil, Kamil V. (1973) *The Irula Language*. Weisbaden: Otto Harrassowitz.