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Selected Problems in Germanic Phonology: Production and Perception in Sound Change

By

George Alexander Estes

A dissertation submitted in partial satisfaction of the

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in

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in the

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of the

University of California, Berkeley

Committee in charge:

Professor Irmengard Rauch, Chair
Professor Thomas Shannon
Professor Susan Lin

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George Alexander Estes

Abstract

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George Alexander Estes

Doctor of Philosophy in German

University of California, Berkeley

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This dissertation investigates three sound changes in the early history of Germanic with an approach grounded in phonetics. Historical phonology has traditionally focused on the articulatory aspects of change (e.g., Hoenigswald 1960; King 1969). However, more recent work in phonetics on sound change has emphasized the acoustic and auditory aspects of sound change, alongside the articulatory (e.g., Beddor 2009; Blevins 2004; Ohala 1981). The present work has two goals: first, to advance the state of research on the sound changes in question; and second, to show how the findings of modern laboratory phonetics can complement the study of historical phonology.

In Chapter 2, I review past approaches to sound change, as well as more recent work in phonetics. In Chapter 3, I consider OHG *i*-umlaut, a longstanding problem in the field. Although umlaut-type changes are common in Germanic, and other types of vowel harmony are widely attested in diverse languages, I show that by attending to all the relevant phonetic factors, the change can profitably be reanalyzed, despite the vast literature surrounding it. I conclude that OHG *i*-umlaut was a type of hypo-correction, and that the phonological conditions in the late OHG period, coupled with individual variation in coarticulation, conspired to form the necessary circumstances for the change to occur. In Chapter 4, I investigate the raising of nasalized mid vowels in the early Germanic dialects. This change has been well documented in the literature, but there have been very few attempts to actually explain why nasals condition the change. By surveying the articulatory, acoustic, and perceptual properties of vowel nasalization, I show that the change is best understood as an instance of hyper-correction. This model predicts the observed changes, as well as some of the variation in the change's conditioning environment among the dialects. In Chapter 5, I evaluate two different interpretations of the orthographic sequence <gg> in Gothic. I argue that Gothic <gg> represents [ŋg] in all instances, regardless of etymology. The literature on this subject has generally rejected such a view, because it presupposes an earlier change of *[gg] > [ŋg], which many scholars have viewed as implausible. By evaluating [gg] in the light of the aerodynamic voicing constraint relative to the structure of Gothic phonology, I conclude that such a change was in fact highly plausible, thereby strengthening the argument for the single interpretation of <gg> as [ŋg].

Each of the analyses of the individual sound changes stands on its own, but also serves a larger theoretical goal: to demonstrate the value of the study of both phonetic production and

phonetic perception to historical phonology. In each of the chapters I identify how phonetics can help solve a more general type of problem, not just the specific sound change investigated in that chapter. OHG *i*-umlaut, discussed in Chapter 3, exemplifies sound changes in which the basic mechanism is already well understood. The raising of nasalized vowels, discussed in Chapter 4, is an instance of a sound change where the environment has been identified, but the conditioning is not well understood. The issue of Gothic <gg> discussed in Chapter 5 raises the question of phonetic plausibility.

In Chapter 6, I review the analyses of the preceding chapters, and outline possible avenues of further research.

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Abbreviations

C	consonant
EGmc.	East Germanic
ENHG	Early New High German
Gk.	Greek
Gmc.	Germanic
Go.	Gothic
Ingv.	Ingvaeonic
Lat.	Latin
MHG	Middle High German
N	nasal consonant
NGmc.	North Germanic
NHG	New High German
NWGmc.	Northwest Germanic
OE	Old English
OF	Old Frisian
OHG	Old High German
ON	Old Norse
OS	Old Saxon
PGmc.	Proto-Germanic
PIE	Proto-Indo-European
Pre-Go.	Pre-Gothic
Skt.	Sanskrit
Span.	Spanish
V	vowel
WGmc.	West Germanic

Acknowledgements

I have observed that many dissertators begin this section by remarking on a profound personal insight that they uncovered in the process of writing. I do not believe I have any such insight; perhaps I owe this to an underdeveloped faculty of introspection. However, I will make the following two observations. First, it has been said that linguistic history is "basically the darkest of the dark arts," because it is "the only means to conjure up the ghosts of vanished centuries." Although I deeply appreciate the sinisterness of this characterization and its evocation of the paranormal, the reason I cite it here is that it touches on a feeling that I experienced while writing part of this dissertation. In Chapter 5 I argue—decisively, I believe—for a certain pronunciation of a certain segment in Gothic. Realizing that, with careful study, a young man sitting in a library in California could establish that another man living on another continent over a millennium and a half ago must have pronounced certain words with a very specific configuration of articulatory gestures—it was here that I felt I was participating in something transcendent. I am immensely thankful to have felt this. Second, what I most appreciate from my study of historical linguistics is the richness that has been added to my life through my exposure to such a wide range of languages and texts. No matter what comes, I will carry this with me forever.

I will take the rest of this space to acknowledge and express my gratitude to some of those who, directly or indirectly, made this dissertation possible, or otherwise played a role in my becoming a historical linguist. There is much more that could be said of them here, but I would rather say less, and know it is too little, than attempt to say it all, and fall short.

I would like to first of all thank Irmengard Rauch, my dissertation chair. Thank you for your support and encouragement from the very beginning of my graduate career, and at every step of the way, and through the very end. I cannot imagine having studied under anyone else.

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Thanks to my friends in the German Department who were along for the ride. Thanks to Chris Hench for being my closest friend here. There's no one I would have rather read the original Tatian with. Thanks to Lindsay Preseau (sp?) for being a model of professionalism and stateliness, and a valuable resource when I was too lazy to figure things out for myself. Thanks to Christine Vais, the very first friend I made in the department. Thanks also to my office mates, Jon and Dagmar, and to all the other graduate students in the department. And thanks to the German Department at UC Berkeley for providing me with funding, teaching opportunities, and the necessary administrative support.

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1

Introduction

"It is surely needless here to set forth the utility, nay the necessity of a thorough knowledge of phonetics for all those, who study languages either in their historical development, or simply in order to use them as a means of communication with people of different nationalities. But how is it that the phonetic science, acknowledged as its importance seems to be by everybody, has gained so little ground, and is still very far from having penetrated the minds of all linguists so as to be not only nominally, but essentially, the basis of all linguistic work?" - Jespersen (1889:1)

1.1 Introduction

One of the tasks of historical phonology is to recover the phonological picture of a language at some fixed point in the past. The remarkable success of the comparative method has shown that this is possible even for unattested languages such as Proto-Indo-European. For attested languages, the existing historical record usually provides the most valuable information, but here too the comparative method can at times yield valuable insights.

Hand in hand with the descriptive component of historical phonology comes the study of change. Indeed, the fact of linguistic change is what makes historical study necessary. Virtually any handbook on a historical language will, when discussing a language's synchronic phonology, derive it from an earlier stage and enumerate the changes which occurred. Throughout the history of historical linguistics, scholars working in the field have adopted various ways of characterizing and codifying sound change, from the exceptionlessness of sound change asserted by the Neogrammarians to the formalisms of Generative phonology, and countless other approaches.

Phonetics has ever informed the study of sound change—since Panini in the first millennium BCE, and in western linguistics since at least the 19th century (e.g., Key 1852, Jespersen 1889)—but most approaches to sound change have tended to focus on the articulatory aspects of change. However, in recent decades there has been a substantial amount of work in phonetics on sound change, much of which emphasizes the acoustic and auditory aspects of sound change, alongside the articulatory. Such research has consisted of experimental work that models specific

sound changes, as well as theoretical discussions that draw on the laboratory findings in order to formulate general theories of sound change. From this comes the theoretical motivation for this dissertation, which is to show how the findings of modern laboratory phonetics can complement the study of historical phonology.

In this dissertation I will examine three problematic sound changes in the early history of Germanic. By taking advantage of the phonetics work mentioned above, I will propose novel analyses of these sound changes which improve upon past approaches. I will thereby aim to show that the findings of modern laboratory phonetics can help resolve difficult problems in historical phonology. I will be successful if readers are persuaded to consider applying the approach adopted here to other problems in historical phonology.

In Chapter 2, I will review the major schools of linguistics which shaped historical phonology in the twentieth century, namely the Neogrammarian, the Structuralist, and the Generative schools. The aim of Chapter 2 is to show how scholars working in these traditions tended to view sound change and its causes in a theoretical sense, and also to consider in detail some selected treatments of Germanic sound changes. Then, I consider phonetics-based approaches to sound change, such as those which emphasize the role of the listener. Finally, I contrast traditional approaches with the more recent phonetics-based approaches, and suggest in what ways the latter have advantages over the former.

In Chapter 3, I consider OHG *i*-umlaut. Specifically, I deal with the problem of secondary umlaut and the delay of its orthographic representation to centuries after primary umlaut. I argue that secondary umlaut occurred after primary umlaut, as the orthography suggests. In order to explain how secondary umlaut could have occurred alongside the disappearance of its conditioning environment, I adopt Ohala's hypo-correction model of sound change (Ohala 1981), as well as draw on other experimental work on sound change. In addition to providing a novel account of OHG *i*-umlaut, my analysis also shows how the findings of experimental phonetics can illuminate sound changes even where the basic mechanism of the change, in this case vowel harmony, is transparent.

In Chapter 4, I examine the raising of mid vowels before nasals in early Germanic. This change is well documented in the literature but has received little direct attention. I first consider the articulatory, acoustic, and perceptual aspects of nasalization and vowel height. I then argue that the change is an instance of hyper-correction. I also exploit the phonetic behavior of nasals to explain variations in the conditioning environment of the change among different Germanic dialects. My analysis in this chapter shows how a comprehensive treatment of phonetic factors can help explain a sound change whose conditioning environment has been identified, but not explained.

In Chapter 5, I investigate the phonetic interpretation of <gg> in Gothic. The orthographic sequence <gg> is typically believed to represent either [ɡɡ] or [ŋɡ], depending on etymology. The internal evidence strongly points to a single interpretation of [ŋɡ] for all instances of <gg> in Gothic, but many scholars have been reluctant to accept this because it requires an earlier change of [ɡɡ] > [ŋɡ], which they view as implausible. I argue that such a change is in fact highly

plausible, because the aerodynamic voicing constraint poses a bias against voiced geminates such as [gg], which make it likely to change. I further argue that, given the structure of Gothic phonology, [ŋg] is the most likely outcome of [gg]. My approach to this problem shows how attention to universal phonetic principles can inform concepts of phonetic plausibility in sound change.

Finally, in Chapter 6, I will offer some concluding remarks. I will review the discussions of the preceding chapters, and consider future work.

2

Historical Approaches to Sound Change

"Of all the topics of conversation and scholarly research that have seen the light of day during the last century or so, surely *sound change* ranks high among those accompanied by nonsense and obfuscation." - King (1969:105)

1.1 Introduction

The purposes of this chapter are 1) to provide a brief historical sketch of how historical phonologists working on Germanic have viewed sound change and its causes; 2) to contrast this with more recent phonetics-based approaches; and 3) to identify three areas in historical phonology in which the application of the phonetic approach can improve over traditional approaches.

I will begin with a brief overview of how sound change has traditionally been viewed in historical phonology, with an emphasis on Germanic phonology, focusing mostly on the 20th century. I will highlight the major theoretical approaches to sound change, namely those of the Neogrammarian, Structuralist, and Generative schools, which I henceforth refer to as "traditional" approaches. In addition to describing the key points of these approaches, I will also discuss selected treatments of specific sound changes in order to show them in action. This is by no means intended to be a comprehensive history of the field. By necessity, very much is left out, and it is to be understood that a label such as, say, "Structuralism" covers a vast range of methodological viewpoints which cannot possibly be thoroughly explicated in a few pages; moreover, a scholar who adopts a Structuralist approach to analyze one particular sound change may in fact employ a diverse range of approaches in the rest of his work. The goal is thus to identify some of the characteristic assumptions and principles underlying the approaches with which scholars have done historical Germanic phonology. This will allow these approaches to be contrasted with phonetics-based approaches, which will guide my analysis of the specific problems I address in the remaining chapters of the dissertation.

In this review I am chiefly concerned with two aspects of the theories in question. The first is the role of phonetic factors in sound change. By phonetic factors I mean the articulatory, acoustic, and perceptual aspects of speech. It will be seen that traditional theories, when they consider phonetic factors, tend to see articulatory processes as the most important phonetic factor in sound change. Phonetic approaches, on the other hand, not only acknowledge the role of articulation, but also tend to exploit a more sophisticated understanding of acoustic and perceptual processes based on experimental work.

The second aspect I will consider is how the theories address the cause of sound change. Although what exactly "cause" is in sound change is a difficult and enormous topic, which can mean very different things to different scholars, what I am trying to identify here is closely tied to the questions which constitute the well-known "actuation problem", as formulated by Weinreich, Herzog, and Labov (1968:102): "What factors can account for the actuation of changes? Why do changes in a structural feature take place in a particular language at a given time, but not in other languages with the same feature, or in the same language at other times?" The major distinction between traditional and phonetics-based approaches in this regard is that phonetics-based approaches see sound change as being caused entirely by phonetic factors. Traditional theories often rely on more abstract motivation for sound change, and in some cases, the cause of sound change is seen as unknowable, or simply secondary to the task of description.

In discussing sound change, my interest is not in all types of sound change, but rather what might be called "natural" sound changes. I have in mind those changes described by Ohala as being "attested in diverse, unrelated languages, i.e., those likely to have a phonetic origin. This excludes the language-specific and culture-specific sound changes such as might be precipitated by paradigm regularization, spelling pronunciations and the like" (1981:178).

2.1 The Neogrammarians

The canonical Neogrammarian statement on sound change is made in the foreword to Hermann Osthoff and Karl Brugmann's *Morphologische Untersuchungen auf dem Gebiete der indogermanischen Sprachen* (1878):

"Aller Lautwandel, so weit er mechanisch vor sich geht, vollzieht sich nach ausnahmslosen gesetzen, d. h. die richtung der lautbewegung ist bei allen angehörigen einer sprachgenossenschaft, ausser dem fall, dass dialektspaltung eintritt, stets dieselbe, und alle wörter, in denen der der lautbewegung unterworfene laut unter gleichen verhältnissen erscheint, werden ohne ausnahme von der änderung ergriffen" (xiii).

Sound changes proceed without exception, affecting every sound which occurs in the relevant environment. This can be seen as a stricter formulation of Grimm's statement regarding the First Sound Shift that, despite its regularity, "es bleiben wörter in dem verhältnisse der alten einrichtung stehn, der strom der neuerung ist an ihnen vorbeigefloßen" (1989:503). Although Grimm did recognize that some of the apparent exceptions were related to the presence of neighboring sounds, he did not see this as systematic. In the Neogrammarian view, apparent

exceptions to sound changes are either subject to other exceptionless rules which have not yet been identified, or due to analogy (see below).

A second principle of the Neogrammarian view as put forth by Osthoff and Brugmann is that the human speech mechanism consists not only of a physical or physiological component, but also a psychological one. In their view, previous scholarship had focused too much on the physiological factors governing sound and sound change. To correct this error, Osthoff and Brugmann argue that psychological factors should be taken into account. Psychological factors in sound change often manifest as analogical change, as detailed in Paul's *Principien der Sprachgeschichte* (1880). The relationship between analogy and regular sound change is expressed in Sturtevant's Paradox: "Phonetic laws are regular but produce irregularities. Analogic creation is irregular but produces regularity." (Sturtevant 1947:109). For Osthoff and Brugmann, psychological processes are also implicated in regular sound change: "selbst die gewöhnlichsten lautveränderungen, wie z.b. der übergang von *nb* in *mb*, von *bn* in *mn* oder die umstellung von *ar* zu *ra*, sind, wenn man bloss vom lautphysiologischen auspunkt ausgeht, nicht begreiflich" (iv).

2.2.1 Prokosch

To illustrate the Neogrammarian approach and its application to sound changes in Germanic, I will consider selections from *A Comparative Germanic Grammar* (Prokosch 1939). Although not one of the founding Neogrammarians, Prokosch has been described by other linguists as working in the tradition. Moulton characterizes him as a "comparative philologist[] in the German Neo-Grammarian tradition" (1999:157), and *A Comparative Germanic Grammar* is described as "essentially a product—and one of the finest—of the neogrammarian approach to language that had been developed toward the end of the 19th century" (Van Coetsem and Kufner 1972:ix). Emphasizing the importance of this work in the scholarly tradition, Lane (1939:194) calls it "the most significant contribution to Germanic linguistics to appear since Streitberg's Urgermanische Grammatik". In this work Prokosch comprehensively traces the phonological development of the oldest attested Germanic dialects from their origins in PIE. Part of the value Prokosch's study has for the present historical review is that, unlike many later historical phonologists, he does not avoid the explicit discussion of causal factors of sound change.

Prokosch affirms the Neogrammarian position that sound change is exceptionless, calling this principle "one of the chief tenets of linguistic science" (36-7). What might initially appear to be exceptions to phonetic laws are in fact instances of conditioned sound changes. In such cases an exceptionless phonetic law can still be formulated, provided it specifies the environment of the change.

Two concepts crucial to Prokosch's understanding of sound change are the "Phonetic Basis" and "Phonetic Tendency" of a language (36). A language's phonetic basis consists of its speakers' "habitual ways of producing and combining speech sounds". Taken as a whole, these patterns of articulation give a language its distinctive character, examples of which Prokosch describes rather impressionistically, comparing the "clean-cut preciseness of French" with "the contrasting ruggedness of North German".

A language's phonetic tendency is the way that its phonetic basis persists and changes through time. In other words, the synchronic features (phonetic basis) of a language determine its diachronic development (phonetic tendency). For example, in a language with more "energetic articulation" as its phonetic basis, plain stops are likely to be produced with greater force, becoming aspirated stops or fricatives. On the other hand, in a language with weaker articulation, assimilatory changes might be expected to occur. The individual sound changes which occur as part of a language's phonetic tendency are the phonetic laws which historical phonologists attempt to uncover.

2.2.2 Prokosch on the First and Second Sound Shifts

I will now consider Prokosch's discussion of the Germanic consonant shifts[1]. The First and Second Sound Shifts are generally understood to be separate sound changes, having occurred at different times and the latter only affecting the High German dialects. However, Prokosch treats them together, because they both follow from what he calls the "fundamental principle" (49) of the consonant shifts. This can be seen as the phonetic tendency of Germanic, rooted in its phonetic basis, for it dictates the types of changes which occur.

Put simply, the phonetic tendency of Germanic is a cyclical series of changes in stops and fricatives that, using a dental obstruent as an example, follows this pattern: [t] > [θ] > [ð] > [d] > [t]. This is explained as follows. For Prokosch, the two relevant factors in the production of consonants are first, the "current of air issuing from the lungs", and second, "the tension of the vocal cords and the muscles of the mouth (tongue, lips, velum, cheeks) intercepting the flow" (49). The fundamental principle of the Germanic consonant shifts dictates that for stops, the breath will be "released", and for fricatives, it will be "checked".

In other words, air passes from the lungs through the glottis and into the oral cavity. Airflow may either proceed relatively unobstructed, or there may be some type of constriction that impedes it. In the case of the glottis, for example, the adduction of the vocal folds entailed by modal voicing would constitute a constriction, whereas for a voiceless consonant, the vocal folds are abducted and air flows through relatively unobstructed. In the oral cavity, the occlusion made in the production of a stop is a complete closure, whereas for a fricative the constriction is not complete and thus, relatively, open.

Prokosch further specifies that the opening or closure will occur first in the glottis, if possible, and then in the oral cavity, if possible, which results in a fixed cyclic order according to which the changes proceed. For example, beginning with a voiceless stop [t], the fundamental principle dictates that the breath be released. This should happen in the glottis. But since the glottis is

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[1] Prokosch reconstructs a slightly different PIE obstruent inventory than the one generally accepted today (e.g. in contemporary introductions to IE linguistics such as Fortson 2009 and Clackson 2007). What most scholars reconstruct as the voiced aspirate series, Prokosch actually reconstructs as "voiceless spirants in lenis articulation" (51), e.g. [bʰ] in the traditional view is [ɸ] for Prokosch. This alternate reconstruction is necessary for his "fundamental principle" governing the Germanic consonant shifts.

already open for the production of a voiceless stop, it cannot be opened even more. Therefore the release will happen at the constriction in the oral cavity, resulting in the voiceless fricative [θ].

For fricatives, on the other hand, the fundamental principle states that a new constriction must occur. Since [θ] is voiceless, a constriction can be made at the glottis by the adduction of the vocal folds required for voicing. This results in the voiced fricative [ð]. Still a fricative, the fundamental principle requires that airflow be obstructed. Since this has already occurred at the glottis, it must now occur in the oral cavity, by making a greater oral constriction. This entails a full oral closure, and thus the voiced stop [d]. Under the fundamental principle a constriction will be released for stops. Since [d] is voiced, there is a glottal constriction. Abduction of the vocal folds leads to a voiceless stop [t], the original segment.

This illustrates the circular nature of the changes entailed by the fundamental principle: [t] > [θ] > [ð] > [d] > [t]. Indeed, this circular pattern is reflected in the First and Second Shifts. PIE voiced stops are devoiced into Germanic, and in High German dialects, which Prokosch sees as the most extreme continuation of the fundamental principle, Germanic voiced stops are devoiced. In between the different stages determined by the fundamental principle, Prokosch also allows for intermediate phonetic steps such as a lenis voiced stop between [d] and [t], or an affricate between [t] and [θ].

Despite the detail of this phonetic account of the Germanic consonant shifts, Prokosch does not consider phonetic factors to be the cause of the changes. Indeed, the fundamental principle is a description of the phonetic tendency of Germanic, not an explanation for it. Prokosch instead offers a tentative hypothesis on the basis of two historical observations. First, the consonant shifts were a unified and continuous process, one which coincided with the Germanic migrations out of present day Scandinavia. Second, the trend progressed in the dialect of each tribe for as long as that tribe had not yet settled. For this reason, High German dialects show the most extreme continuation of the shifts, whereas dialects further to the north are more conservative in this regard. Prokosch takes this to mean that the consonant shifts were intimately tied to the Germanic migrations.

Here Prokosch considers how sound change spreads through a community: "Linguistic change is largely due to imitation. Every individual departs at times or always from the average norm of speech. To an extent these personal deviations are the result of character and circumstances. Leading personalities are apt to be imitated in their manners, their dress, their speech: they set fashions" (57). That is, although variation is inherent in speech, not every variant which is produced by a speaker becomes a new linguistic norm. Only those with some amount of social status or prestige are likely to be imitated; they establish the norms. This view is certainly compatible with modern sociolinguistic approaches to the spread of sound change.

With this in mind, Prokosch proposes a cause for the consonant shifts. Leaders must have emerged among the Germanic tribes to plan the migrations, and these leaders would naturally have been the people who established linguistic norms. Since the migrations found their impetus in the difficulties of life in the Germanic homeland, such as overpopulation and infertile land, the circumstances would have favored a certain personality type for the Germanic leaders. In the

psychological makeup of these individuals, Prokosch suggests that "will and contents predominated over reflection and form" (57). This is what caused the consonant shift. For example, "the influence of a Boiorix or Ariovistus upon speech as a part of behavior differed from that of a Petronius or Marcus Aurelius" (57). Moreover, "[n]ot only the consonant shift, but also the accent shift, the vowel shift, the Germanic verb system, all reflected a predominance of elements of contents over elements of form" (57). Prokosch's psychological approach to the origins of sound change is highly suggestive, but unfortunately remains inscrutable to the present author.

2.2.3 Prokosch on Verner's Law

In his treatment of Verner's Law[2], Prokosch gives concrete phonetic reasons for the change (61-2). Briefly, Verner's Law was the voicing of voiceless fricatives in voiced environments after unstressed syllables. This is evident in alternations like the OHG strong infinitive *ziohan* 'to pull' alongside its preterite plural form *zugun*. The *h* in *ziohan* and the *g* in *zugun* both come from PIE *k*, which became the fricative [x] in early Gmc. This remained voiceless in *ziohan*, because the primary word stress fell on the root syllable. In the preterite plural, the primary stress landed on the inflectional ending, putting [x] in the environment for Verner's Law, whereby it became the voiced fricative [ɣ], eventually [g] in OHG.

Prokosch suggests that the original fricatives were likely voiceless lenes fricatives medially and finally, because they would have been weaker in such positions. Likewise, the articulation would have been stronger (i.e. fortis) following a stressed vowel than an unstressed vowel, because the fricatives would have "continued the degree of strength of the preceding syllable". In weakly articulated positions voiceless fricatives would have been most likely to assimilate to the voicing of surrounding voiced sounds. This is in line with Prokosch's earlier statement that languages with "relatively gentle articulation" have a tendency toward assimilatory changes (36). Although gentle articulation does not necessarily characterize the phonetic basis of Germanic in Prokosch's view, it does characterize the specific environment of this sound change.

In explaining Verner's Law, Prokosch describes the change as phonetically conditioned: the phonetic environment is its cause. This differs significantly from his account of the First and Second Sound Shifts. Although in those cases he details the phonetic processes involved, those processes are not the cause of the changes. They are simply a restatement of the changes in generalized phonetic terms. No phonetic motivation is given for why the articulation of obstruents should proceed according to the "fundamental principle" as opposed to any other principle. The cause is instead found in the psychological makeup of the leaders of the Germanic migrations. But Verner's Law is sufficiently accounted for by his claim that sounds in weakly articulated positions are prone to assimilate to voicing sounds. This is not the consequence of certain types of personalities; it could presumably happen in any language provided the same phonetic conditions obtained.

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[2] Prokosch treats Verner's Law separately from the First and Second Sound Shifts, and proposes a different causal explanation. However, he sees all of the changes as subject to the fundamental principle and thus part of the phonetic tendency of Germanic.

2.3 Neogrammarian Discussion

There are two main points to identify from this brief overview of the Neogrammarian view of sound change and its application to Germanic phonology. The first is that the key phonetic factor in most sound change is articulation. This is evident in Prokosch's treatment of the Germanic consonant shifts, where the phonetic tendency and fundamental principle are thoroughly described in entirely articulatory terms. Similarly, Garrett and Johnson (2013:54) identify two origins of sound change in the Neogrammarian viewpoint: "most types of sound change originate through processes of articulatory reduction, simplification, or variability; dissimilation, metathesis and a few other types comprise a residual type with other origins".

However, it is of some interest that at least one scholar associated with the Neogrammarians recognized that perception might play a role in sound change, although the possibility was not fully exploited at the time. Delbrück (1880) argued that sound change occurs when speakers imperfectly reproduce the language to which they are exposed. A speaker may do this for a number of reasons, such as ease of articulation, but it can also be "weil sein Ohr trotz aller Anstrengung nicht genau genug auffasst" (119). In such a case a new variant arises through misperception, not a change in articulation.

The second point is the view of causality. Prokosch describes the First and Second Sound Shifts in detailed phonetic terms, but for him this does not explain the change. It is perhaps correct to say that for Prokosch, the fundamental principle determines the shape of sound change in Germanic, i.e., which segments change into which other segments, but not why those segments change at a particular time. Rather, the changes were caused by the psychological make-up of certain Germanic speakers. This explains why they occurred when they did, and answer the question of causation, or actuation. In the case of Verner's Law, however, Prokosch's phonetic analysis does amount to a causal account of the change, not just a description. He identifies the phonetic environments of the change as causing the change.

3.1 Structuralism

Structuralism in linguistics is traditionally linked to Saussure's *Cours de linguistique générale* (1916); Structuralist phonology was developed in large part by Trubetzkoy and Jakobson (e.g., Trubetzkoy 1929; Jakobson 1941; Trubetzkoy 1969). Following Trask's (2000:326) definition, Salmons and Honeybone (2015:33) identify the major issues in Structuralist linguistics: "the role of the system itself, symmetry within the system[...], and the fact that the systems involved are systems of contrasts (which are formal elements)." Sound change, and indeed all types of linguistic change, is thus to be understood as inextricably related to the system of the language in which it occurs.

3.2.1 Hoenigswald

Hoenigswald's *Language Change and Linguistic Reconstruction* (1960) will serve as our starting point for examining Structuralist views of sound change. Emphasizing the primary role of the system, he writes that "individual contrasts are defined, synchronically at each stage, by the

system as a whole" (v), and that "mere alteration in the physical properties of phones does not constitute sound change in the technical sense except minimally" (72). In other words, a change in the phonetic realization of a segment, even if regular and clearly identifiable, is not properly viewed as a sound change, unless it results in a change in the structure of a language, i.e., a change in the patterning or distribution of its phonemes.

Hoenigswald identifies three potential causes of sound change: "phonetic plausibility, internal structural pressures, and areal tendencies", the last of which overlaps with language contact (82). Although language contact cannot be ruled out as a possible factor in many sound changes, it is not the type of change that I am considering here (see the end of Section 1.1).

When a phoneme undergoes sound change, the result of the change is usually phonetically similar to the stage prior to the change. For Hoenigswald, the later phonetic realization is best characterized as resulting from a "simplification in the articulatory movements" required to produce the earlier realization (73). By "simplification" Hoenigswald seems to mean at least two arguably similar, but distinct phenomena. The first is coarticulation, where articulatory gestures of neighboring segments overlap to varying degrees. This is simply a universal property of human speech production. The second is the preference for a phone which either "for some anatomical reason combine[s] more easily with surrounding phones", or, "represent[s] a less taxing combination of distinctive features" (73). It is not clear to me that Hoenigswald himself observes the distinctions I am making here, because they all fall under his description of articulatory simplification. However, it is evident that a distinction can be made between coarticulation as a universal property of human speech, and the substitution of an especially "taxing" segment in a particular linear sequence. Coarticulation can and does happen in any and every phonetic environment, whereas "taxing" segments are the product of certain combinations of neighboring segments.

According to Hoenigswald, articulatory simplification is not itself the cause of sound change, "since the particular segments which are simplified, the particular direction in which they are simplified, and the particular time and dialect in which the segment, sometimes after millennia of undisturbed existence, is altered, all remain unpredicted" (79) Rather, the cause is to be found in the structural properties of a language. The well-known concepts of phonemic merger and split are central to this view. Since merger can result in homonymy, which is detrimental to effective communication, then languages will have a tendency to resist merger. One of the predictions of this is that those phonemes whose contrasts have higher functional loads will be less likely to merge than others[3]. Another way for a language to avoid merger is through push chains. When one phoneme's "space" begins to encroach on that of another, the latter will undergo a change in order to remain distinct, thereby preserving the structural differences in the language.

3.3.1 Penzl

Herbert Penzl's *Lautsystem und Lautwandel in den althochdeutschen Dialekten* (1971) offers another Structuralist perspective on diachronic change. Because this work specifically treats

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[3] In fact, recent work (Wedel, Kaplan, and Jackson 2013) has confirmed this.

sound change in the OHG dialects, it is especially pertinent to our understanding of Structuralist approaches to sound change in Germanic phonology. Penzl states that it is his intention "die Möglichkeiten und Grenzen der verfügbaren Methoden an konkretem Material im einzelnen zu erweisen" (16).

Like Hoenigswald, Penzl observes that sound change generally proceeds along phonetically determined paths. Whereas Hoenigswald identified articulatory simplification as the main factor, Penzl recognizes it as synchronic allophonic variation (18). However, this allophonic, or phonetic, variation still remains of secondary importance to the system as a whole, where only phonemes matter (19). Very much in line with his predecessors and contemporaries, Penzl affirms that sound change tends to proceed gradually, and that the speaker is unaware of it.

In something of a relaxation of the Structuralist focus on the system, Penzl writes that "[j]edes historische Ereignis, jeder Lautwandel, wenn er zu erkennen ist, ob er zu einer Änderung des Phonemsystems führt oder nicht, ist Gegenstand der historischen Lautlehre" (23). Similarly, he also writes that "[j]eder erfaßbare Lautwandel ist ein historisches Ereignis. Seine Beschreibung ist die Aufgabe der historischen Lautlehre" (25-6). In other words, even if a change is only phonetic and does not restructure a language's phonemic system, it is still the proper study of historical phonology, so long as it has left some trace recognizable to the historical phonologist. This allows for a broader definition of sound change than Hoenigswald's view, while still maintaining the crucial theoretical distinction between phonetic and phonemic changes.

Further contrasting phonetic change with phonemic change, Penzl writes that "rein phonetisch gesehen, die Zahl der möglichen Lautwandelarten natürlich praktisch so unbegrenzt wie die Zahl der Laute und Allophone ist" (24). He lists many terms that characterize changes phonetically, such as palatalization, velarization, and assibilation. No comment is made as to whether such changes can be viewed as instances of articulatory reduction or simplification. Importantly, this traditional taxonomy labels types of sound change according to the articulatory factor at play.

In contrast to the innumerable variety of phonetic changes (*Lautwandel)* only four types of phonemic changes (*Phonemwandel*) exist, namely phoneme shift (*Phonemverschiebung*), phoneme merger (*Phonemzusammenfall*), phoneme split (*Phonemspaltung*), and phoneme loss (*Phonemschwund*), sometimes called merger with zero. These terms describe what happens to the phonemic system, without any reference to the details of the change *per se*.

Penzl outlines what is entailed by a complete description of a sound change in the Structuralist view (26). The first component is the phonetic and phonemic description of the beginning and end stages of the change, along with the identification of what type of phonemic change it is. Second is the description of possible intermediary stages. Third is the details of how the change unfolded in time and space, such as its dialectal variation and spread. Fourth is the possible connection with other sound changes in the language. Fifth is an enumeration of all factors which may have played a causal role. The first three components are descriptive, not causal. The fourth and fifth are relevant to our focus here.

The fourth component requires that the historical phonologist consider a sound change's possible connection to other sound changes in the language. If present, such a connection usually entails that a sound change is part of a push- or drag-chain. Push chains occur, in the structuralist view, in an effort to avoid the merger of phonemes, or, put another way, to preserve the structural relationships within a language. Drag chains occur if a phoneme undergoes a change which results in a structural gap in the language; such gaps will tend to be filled by another phoneme moving into that space. The preference for structural symmetry is often what motivates the filling of gaps (for an example of symmetry causing sound change, see the discussion of Moulton below).

The fifth component is the identification of all possible causal factors. Although acknowledging that "der Lautwandel als allmählicher, unbewußter Vorgang ist auch von rein phonetischen Faktoren mitbestimmt" (26-7), Penzl holds that structural pressures, including those discussed in the fourth component, are the key causal factors. In general, language systems tend to become symmetrical and have a structure that best facilitates communication. These two principles can account for why changes occur in a particular language at a particular time.

To roughly summarize Penzl's view of sound change, it can be said that while phonetic factors constrain sound change, it is structural factors that cause it. That phonemic changes tend to mirror the phonetic variation observed in synchronic speech is evident. However, this merely determines what the possible phonetic realizations of a phonemic change are. This phonetic variation in no way causes the sound change. Rather, the structural tendencies outlined above cause sound change.

3.4.1 Kretschmer

A possible concern with some Structuralist explanations of sound change is that by attributing a particular change to structural pressures, it raises the question of what causes those structural pressures in the first place. For example, in push chains, a phoneme A encroaches on the phonetic space of phoneme B, resulting in a change in phoneme B. A Structuralist account of this change might point out that phonological systems prefer to avoid merger, which results in the pressure for phoneme B to change. However, this explanation simply raises another question: what caused phoneme A to shift in the first place? There cannot simply be shifting phonemes all the way down, as it were, in a push chain.

This problem is addressed by Kretschmer (1932:274), who recognizes another possible contradiction in such explanations. If languages tend to avoid merger of phonemes, then why would phoneme A move towards phoneme B? Not only is it necessary, then, to give a reason for why a phoneme might shift in the first place, but also, if the direction of the shift is towards the phonetic space of another phoneme, one must reconcile this with the putative tendency of languages to avoid mergers.

Kretschmer explains such phenomena by noting another structural tendency inherent in language, namely that of economy—in this case, economy of number of phonemes. This accounts for why a phoneme might shift in the direction of another. Thus the various changes

seen in languages can be explained by the fact that in a given language at a given time, the principle of economy may prevail, resulting in a merger. And in another language, or in the same language at a different time, the principle of preservation of structural contrasts may prevail, which could lead to a push chain series of changes. Together, these Structuralist principles can account for the various types of sound changes that are observed by explaining them as the result of competing dynamic forces.

3.5.1 Treatment of Sound Changes

Having reviewed some of the important aspects of sound change in Structuralist phonology, I will now turn to its application to specific changes in Germanic in order to show the methodology in action. I will first review Moulton's (1961a) analysis of vowel changes in Swiss dialects, and then Penzl's (1971) treatment of the Old High German monophthongization.

3.5.2 Moulton

In parts of Switzerland and Liechtenstein, original MHG *ö* and *o*—[ø] and [o], respectively—are sometimes lowered to [œ] and [ɔ]. This is apparent in dialectal forms like [ksoffə], NHG *gesoffen*, 'drunk' without lowering vs. [trɔffə], NHG *getroffen*, 'met'; and dialectal [xrœtlɪ] with lowering vs. NHG [krøːtlɑɪn] *Krötlein* 'toad' without it. Moulton also considers the lowering of the short MHG high vowels, but here we will focus on the lowering of [o].

Moulton explicitly applies a structuralist approach in his analysis of the sound change, writing that structural phonology can help to illuminate the causes of the changes, which "scheinen ein geradezu klassisches Beispiel von Lautwandel durch innere Kausalität zu liefern: Umwandlung eines phonologischen Systems durch internen strukturellen Druck" (229). For this reason, Moulton argues that the primary focus should not be on the phonetic realizations of the phonemes in question, but rather on their place within the phonological system. A phoneme's historical development can only be understood in the context of the development of the entire system (234).

The MHG long vowel system, the immediate historical predecessor to those of the dialects in question, is one possible area from which structural pressure could have been exerted on the short vowels according to Moulton. MHG had a symmetrical long vowel system, which is represented in Figure 2.1.

iː yː uː
eː øː oː
æː ɑː

Figure 2.1 - the MHG long vowel system

In the transition from MHG into ENHG and NHG, short vowels were lengthened in certain positions. In many cases, these original short vowels merged with existing long vowels. This would have increased the number of long vowel tokens in the language, but had no effect on the

structure of the language, since the same phonemes would have remained. However, if a short vowel was lengthened and did not merge with an existing long vowel, but rather became a new long vowel, this would constitute a change in the phonological system, since it would introduce a new phoneme. Similarly, a structural change could occur if two long vowel phonemes merged, since this would mean the loss of a phoneme.

Moulton considers the lengthening of [ɑ] > [ɑː] in certain positions and its consequences for the long back vowel system of [uː oː ɑː]. For Moulton this lengthening is a "problem" for which different dialects found different "solutions" (236). In one group of dialects, lengthened [ɑ] simply merged with [ɑː]. This had no effect on the structure of the language, because both phonemes /ɑ/ and /ɑː/ existed before and after the change, and no new phonemes were introduced; the only difference was that there were now fewer tokens of /ɑ/ and more tokens of /ɑː/. In another group of dialects, lengthened [ɑ] merged with [oː]. In this case too, no structural change occurred, there was simply a redistribution of the number of tokens of already existing phonemes. In a third group of dialects, however, lengthened [ɑ] was realized as [ɑː], but the original [ɑː] shifted to [oː]. In terms of phonemes, the change consisted of (some instances) of /ɑ/ > /ɑː/, and original /ɑː/ > /ɔː/. This constituted the introduction of a new phoneme /ɔː/ to the language, which had not existed in MHG (see Figure 2.1).

The new phoneme /ɔː/ resulted in a structural asymmetry between the long and short back vowel systems of the relevant Swiss dialects. This asymmetry is seen in Figure 2.2, where the "gap" in the short vowel system is represented by empty parentheses.

uː u
oː o
ɔː ( )
ɑː ɑ

Figure 2.2 - the long and short back vowel systems

Moulton identifies this asymmetry as exerting the structural pressure which caused the introduction of the /ɔ/ phoneme to the language. He notes that although such asymmetries are not unusual in languages, there is nonetheless always "eine deutliche Neigung, eine solche Lücke, ein solches leeres Fach zu füllen" (237). It follows, then, that "die Schaffung eines vierstufigen Systems der Langvokale auch die Schaffung eines entsprechenden Systems der Kurzvokale hätte hervorrufen können [...] und damit wäre die ostschweizerische Vokalspaltung erklärt" (237-8). Moulton then considers other details of the change, such as what other structural factors may have helped cause it in different dialect areas, as well as similarly motivated vowel changes.

For our purposes, his explanation for the emergence of /ɔ/ serves as an illuminating example of the application of Structuralist principles to phonology. The variation among dialects is explained by different changes leading to different structural conditions. The different structural conditions in turn exerted different pressures on the phonological systems. Moulton's analysis is especially effective as an example of the Structuralist approach to sound change because he

shows precisely where asymmetries exist by visualizing the phonological structure of the different dialects and stages.

3.5.3 Penzl

In *Lautsystem und Lautwandel in den althochdeutschen Dialekten*, Penzl (1971) not only discusses structuralist methodology in the abstract (see above), but also examines several sound changes in OHG in order to demonstrate the application of this methodology. Here we will consider his analysis of the OHG monophthongization.

The OHG monophthongization affected the PGmc. diphthongs *ai and *au. They monophthongized to the corresponding long mid vowels *ē* and *ō* in the OHG period; perhaps first as the lax vowels [ɛː] and [ɔː] and then later becoming the tense vowels [eː] and [oː]. Part of what has drawn attention to the change is that it only occurred in certain environments, the motivation for which has been unclear to most scholars. Another reason is that the front and back vowels do not monophthongize in identical environments; there is only some overlap. *ai monophthongized before the consonants *h* (only Gmc. *h*, not OHG *hh* from Gmc *k*), *r*, and *w*. *au monophthongized before dental consonants (*d t s z n r l*) and *h*. *h* and *r*, then, conditioned both changes, but otherwise *w* only conditioned the monophthongization of *ai and the dentals only conditioned the monophthongization of *au.

Penzl assumes that at the earliest stages of the change, the first element of the diphthongs must have partially assimilated to the second element, resulting in something like the diphthongs [ei] and [ou]. The actual monophthongization was conditioned by the consonantal environment. He attempts to explain the phonetic rationale for the change (125), writing that *au did not diphthongize before labial and velar consonants because these environments preserved the labiovelar offglide of the diphthong. In the dental environments, then, there was nothing to block the monophthongization. As to why *r*, but none of the other dentals, would condition monophthongization of *ai, Penzl suggests that the rhotic may have sometimes been uvular [ʀ], which would presumably have a backing effect on the second element of the diphthong. As to why Gmc. *h* would condition the monophthongization of both diphthongs, he writes that the velar fricative must have contributed to reduction of the second diphthong component.

Ultimately Penzl is unable to identify any internal structural factors that contributed to the change (130). He suggests that it is simply a case of allophonic variation, which became phonemic when certain other structural changes, such as the merger of PGmc. *h* and *k* in OHG, made the diphthongs and monophthongs no longer stand in complementary distribution, as in the pair *zōh* 'went' : *ouh* 'also'. Once the change became phonemic, it became observable to the historical phonologist. Had it remained allophonic, it most likely would not have been identifiable.

3.6.1 Structuralist Discussion

Although Moulton does not consider in detail the phonetic factors of the changes he studies, in Penzl's discussion of the OHG monophthongization the focus on articulatory factors—as far as

phonetics is concerned—is clear. He explains the conditioning of the changes as resulting from assimilation with the various segments, much as Hoenigswald explains how phonemes tend to change.

Far more important to the Structuralist view of sound change, as evident in the discussions of Hoenigswald, Penzl, and Kretschmer above, is the emphasis on internal, structural factors. For Moulton, the phonetic details of the Swiss vocalic changes are already known, but an account of why the change actually occurred must look elsewhere. What caused the change to happen when it did was the pressure exerted by an asymmetrical phonological system. In Moulton's analysis, this is especially significant because it is the dialects with the structural asymmetry which underwent the change—neighboring dialects that were otherwise extremely similar but did not have the same structural gap did not undergo the change. The phonetic conditions may explain the environments of a change, or what segment a phoneme will change into, but not *why* there was a change in the first place. For this, structural factors must be brought to bear.

In this connection is is of interest that Penzl does not attribute the OHG monophthongization to structural factors. However, he points out that this itself is significant. That is, the historical phonologist should expect to be able to find such factors connected to a change, and their absence in the OHG monophthongization is anomalous in the Structuralist view.

4.1 Generative Historical Phonology

The beginning of the Generative school of linguistics is of course most closely associated with Chomsky's *Syntactic Structures* (1957); *The Sound Pattern of English* (Chomsky & Halle 1968) established the field of Generative phonology. Although *The Sound Pattern of English* does include phonological treatments which could be considered historical in a sense, such as that of the Great Vowel Shift, it is generally viewed as a work on synchronic phonology.

One of the defining characteristics of Generative linguistics, and by extension, Generative phonology, is the positing of underlying forms, which by the successive application of rules, undergo transformations which yield the surface forms which are actually attested in language use. Crucial to this is the distinction between *competence* and *performance*. Competence is the knowledge, either explicit or implicit, which a speaker has of his native language. This competence is what allows him to generate utterances in his language. His performance is the actual production of utterances in his language.

In principle, the Generative linguist is interested only in the competence of the speaker, not in his performance. Nonetheless, it is only through observation of a speaker's performance that the linguist can uncover the structure of his competence or attempt to model it. The goal of the linguist is to construct a *grammar*, which is an account of a speaker's competence. This grammar consists of rules which apply to underlying forms to yield the forms observed in performance. In Generative phonology these rules are formalized with reference to distinctive features that identify specific segments, and the environments in which they undergo some change, and what that change is. Crucially, a Generative grammar constructed by a linguist is not assumed to be equivalent to a speaker's competence; it is a *model* of his competence.

4.2.1 King on Types of Change

Historical Linguistics and Generative Grammar (King 1969) presents a Generative approach to historical phonology. In addition to explaining the approach in a theoretical sense, King also uses many examples from Germanic languages, so we can also see the application of the method to Germanic phonology in his work as well.

If the goal of the Generative linguist is to construct a grammar that accounts for a speaker's competence, then the goal of the historical Generative linguist is to account for how the competence of speakers changes through time, which means accounting for how grammars change. For King there are two major types of change which a grammar can undergo (39). So-called "primary change" is a change in the rules of the grammar, which can manifest itself in four ways: rule addition, rule loss, rule reordering, and simplification. The other category of change is "restructuring", which is when the underlying representations in a grammar change.

Rule addition, the first type of primary change, is simply when a language adds a rule to its grammar. King uses the example of Germanic umlaut (40), a type of vowel harmony common to all of the oldest attested Germanic dialects except Gothic. The simplest way to account for this in historical Generative phonology is to say that the non-Gothic dialects added a rule of umlaut to their grammars. Similarly, the changes which together form the First Sound Shift would be interpreted as rules which were added to the grammar of Proto-Germanic, but not, say, Proto-Italic or Proto-Greek, thus accounting for (some) of their differences despite their common origin in Proto-Indo-European.

Rule loss, the second type of primary change, occurs when a language removes a rule from its grammar. For example, King argues that rule loss explains the reflexes of Verner's Law in Gothic. The original rule would have voiced an underlying voiceless fricative in the relevant environments, as seen in the related Gothic words *frawairþan* 'to perish', with <þ> for voiceless [θ], and *frawardjan* 'to ruin', with <d> for voiced [d]. However, Verner's Law is not evident within the paradigms of Gothic strong verbs. The verb *kiusan* 'to choose' has the participle *gikosan*—both with voiceless [s]—instead of expected **gikozan* with [z]. According to King, the absence of the expected voiced fricative in the strong verbs is because speakers of Gothic lost the Verner's Law rule from their grammars. The voiced fricatives remained in words like *frawardjan* which speakers did not see as being derived from *frawairþan*. In such words, the voicing alternation was not a result of a Verner's Law anymore, but rather a part of their underlying representations.

Rule reordering, the third type of primary change, can differentiate languages when two or more rules are identical in the grammars, but are applied in a different order. King's example is from NHG, where the rules of vowel lengthening before voiced obstruents and final obstruent devoicing are well established. The effects of these rules are visible in certain noun forms like the nominative and genitive *Lob* : *Lobes* 'praise', phonetically [loːp] : [loːbəs]. The underlying forms are assumed to be /lob/ and /lobəs/, crucially with a voiced final segment in the singular. First, vowel lengthening before voiced obstruents applies, which lengthens the vowels in both

forms, yielding [loːb] and [loːbəs]. Then final devoicing applies, devoicing the [b] in the nominative form but not in the genitive form because it is not word-final, resulting in the surface forms, [loːp] and [loːbəs]. This is straightforward enough, but there is evidence that these rules actually entered the language in the reverse order. Historically, a rule of final devoicing is attested before a rule of lengthening before voiced obstruents, and this ordering of rules is preserved in some NHG dialects. If devoicing applies first, then the vowel lengthening cannot apply to the nominative form, because it will not end in a voiced obstruent. Such dialects have the forms [lop] : [loːbəs], the key difference being the short vowel in the nominative.

The fourth and last type of primary change is rule simplification. In Generative Grammar a rule is considered simpler than another if its formulation requires fewer feature specifications. Fewer feature specifications mean that a rule is more general. For example, early Old English shows devoicing of final fricatives, but later Old English shows devoicing of all final obstruents. This development is a clear instance of simplification. A rule for final fricative devoicing would require the specifications [+ obstruent] and [+ continuant], whereas one for final obstruents only requires [+ obstruent].

Restructuring is the other major type of change in Generative grammar, contrasted with the four types of primary change described above. Restructuring is defined as a change in underlying representations. King takes the *hw* > *w*—phonetically [ʍ] > [w]—change characteristic of many modern English dialects, as in words like *what*. For adult speakers of these dialects, King proposes that their grammar has a rule changing [ʍ] > [w]. For children, however, there is no need to posit such a rule. Because children are exposed to the output of the grammar which has the [ʍ] > [w] rule, they will encounter few, if any, instances of [ʍ]. There is thus no need to posit [ʍ] in any of their underlying forms, and therefore no need for a rule to change it to [w]. Instead, the segment [ʍ] does not exist in their grammar; only [w] does. Such a change is different from primary change because there is no change to any rules.

4.2.2 King on the Causes of Sound Change

For King, most major changes in grammars occur when a child is learning his native language. Although adults can and do implement changes, they generally change rules which are "late" in the grammar—rules that are ordered after most of the other rules, and thus do not substantially alter the grammar. Children in the process of first language acquisition, however, are not making minor modifications to an already existing grammar. They are constructing an entirely new grammar. Although a child's grammar will likely resemble the grammars of previous generations of speakers of their native language, a much wider range of changes is possible.

In this view, a motivating factor for many innovations in a child's construction of his grammar is ease of articulation. This manifests itself in assimilatory rules. Indeed, this is a universal tendency and it "accounts for the widespread occurrence of certain rules in approximately the same form in different languages" (79). King also suggests that other sound changes, such as final devoicing, which are not obviously assimilation in the usual sense, may still have something in common with assimilatory changes. Most importantly, however, King writes that

"child innovations probably are often (if not always) assimilatory in nature" (79). In other words, ease of articulation is the major cause of sound change initiated in L1 acquisition.

Nonetheless, King stresses that questions about the cause of sound change are not central to the task of a Generative historical phonologist, which is to account for changes in grammars by means of the types of changes (rule loss, rule reordering, restructuring, etc.) outlined above. For example, referring again to the change of *hw > w*, King writes that "[w]e can, if we like, speculate on *why* this rule was added. Perhaps the speaker thought *w* sounded better than *hw*, perhaps *hw* was harder to pronounce than *w*. Such speculation is interesting but outside our immediate major concern, which is to give an account in our grammar of a change in speech habits" (80).

However, King maintains that a Generative phonologist needs an understanding of what types of change are likely to happen. Although the general guiding principle for the formulation of rules is that they should be as simple as possible (i.e. use as few features as possible), this does not take into consideration the intrinsic phonetic or phonological content represented by distinctive features, which is subject to certain other constraints. In other words, features cannot be manipulated without regard for how their real world correlates function. King writes that in order to ensure this, "our theory must have some way of stating what formally possible simplifications [...] are in fact excluded because they violate principles governing natural languages"[4] (90). Ultimately the goal would be to determine "why one simplification instead of another took place in the development of a language" (90), but that is not yet possible. However, "[o]ne of the best proofs of the naturalness of a rule is to show that such a rule occurred as an innovation in a language" (103).

Views on the gradual nature of sound change are closely related to the cause of sound change. King rejects the common view that sound change is gradual, because such a view entails that sound change is caused by changes in performance, i.e. normal articulatory variation over time eventually leading to a new pronunciation norm. For a Generative linguist, this is impossible. Linguistic change is a change in competence, which is not influenced by performance. When a change has occurred, performance factors "neither caused it, contributed to it, abetted it, nor slowed it down. The performance factors simply cause the random fluctuations that always take place in articulating sounds" (108). Even though one can hypothesize intermediate phonetic steps in the different stages of a sound change, King claims that it is rarely, if ever, the case that such intermediate steps are actually observed. Moreover, for changes like metathesis or epenthesis it is difficult, if not impossible, to propose intermediate steps.

The Generative view of the relationship between phonetic variation and the sound change is important to consider here because it is of supreme importance in the phonetics-based approaches to be discussed in Section 6. King takes the stance that "[m]inor variation in the performance or realization of sounds is simply an aspect of language; there is nothing which requires us to regard such variation as *causing* sound change" (111). It is not sounds that change, it is the grammars of speakers which change. This reflects a change in competence and is

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[4] King views most assimilatory changes as instances of simplification.

manifested in a change in performance. King suggests that the principles governing phonetic variation are universal, and are not properly included in a grammar, but rather should be "accounted for in the theory of performance associated with the grammar" (114). He concludes that instead of "sound change" we should speak of "phonological change".

4.3 Vennemann

Vennemann's 1972 article *Phonetic Detail in Assimilation: Problems in Germanic Phonology* treats a group of related changes in Germanic phonology in the framework of Generative phonology. The primary purpose of the article is to account for the OHG monophthongization[5] by means of a new theory of assimilation, which he also applies to similar changes in Germanic where consonants condition vocalic changes, but the exact nature of the conditioning has remained obscure to other scholars.

A major motivation for Vennemann's study is the shortcomings of past approaches. Regarding the OHG monophthongization, he writes that it "has been described in numerous handbooks and articles, but has, to the best of my knowledge, never been formulated in an explanatory way within a theory of phonology based on distinctive features" (863). Furthermore, the fact that there are different conditioning environments for the monophthongization of PGmc. *au* and *ai* in OHG "seems to have baffled the authors of all the descriptions of this change known to me. None of them have attempted an explanatory statement about these environments. They all content themselves with a listing of the individual cases", and they fail to even ask "why this change occurs in the first place, and why it occurs in the differential environments where it does", adding that this is true even for scholars working in the Generative tradition (866).

Vennemann states that the "causal factor is sought (if anywhere) in the phonetic nature of the conditioning consonant itself, in an absolute sense. Speaking in terms of transformational-Generative phonology, the causal factor is sought in the feature composition of the conditioning segments" (867). What separates the changes Vennemann investigates is that the relationship between the conditioner and the resultant change is not self-evident in terms of traditional features. For example, in a change like [np] > [mp] it is clear enough that the nasal has assimilated to the following stop with respect to the place feature [+labial]; the underlying articulatory process is transparent. But it is not obvious, to many historical phonologists at least, why, say, dental consonants should condition a change of [au] > [oː].

Vennemann's argument relies on his proposal that the features involved in assimilation should be understood relative to one another, not in absolute terms (876). Since the OHG monophthongization can largely be viewed as a lowering of the second element of the original diphthongs, then the relevant feature in the conditioning environments is [+low]. And since not all of the consonants which condition the monophthongization are [+low], and the two diphthongs have different environments, then the feature [+low] must be relative to the segment

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[5] Penzl's approach to the OHG monophthongization (1971) was discussed in the Structuralism section. To briefly resummarize the change: PGmc. *ai* and *au* monophthongized to OHG *ē* and *ō* in certain environments; *ai* before *h*, *r*, and *w*; *au* before dentals (*d t s z n r l*) and *h*. *h* and *r* conditioned both changes, whereas *w* only conditioned *ai* > *ē* and only the dental consonants other than *r* conditioned *au* > *ō*.

which is undergoing assimilation. In other words, they are not [+low] in absolute terms, but relative to the preceding vowel.

OHG *w*, for example, which conditions **ai > ē*, is usually assigned the feature [+high] as a labiovelar glide. Vennemann argues that "*w* is high only in its own area, the *u* area or back area; but it is low in relation to the area where front vowels are produced", and that "the tongue-position for the production of a *w* is relatively much lower in the area where front vowels are formed than in the area where back vowels are formed" (876). For dentals, which condition **au > ō*, Vennemann explains that "the tongue is extended diagonally through the oral cavity, sloping from its upper front part to its lower back part. The body of the tongue is, therefore, relatively much lower in the back vowel area than in the front vowel area during the production of dentals" (876).

4.4 Generative Discussion

Articulatory factors are the most important phonetic aspect of sound change according to the Generative approach to historical phonology. King suggests that all phonological innovations may result from assimilation. Vennemann seeks to find the relevant phonetic factors in the changes in his study that explain why assimilation occurs in cases where it cannot be transparently derived from the feature composition of the segments involved.

King and Vennemann differ on the importance of causality in the work of the historical phonologist. For King, there is no reason in principle to consider the cause of a sound change when constructing grammars and accounting for the addition and loss of rules; the task is purely descriptive. King writes that "historical linguists do what they are supposed to do: describe change" (139). The only reason one might need to think about the causes of sound change is in evaluating whether a proposed rule is plausible, and the best way of determining if a change is plausible is by knowing that it occurred in another language.

A potential problem with this view is that the linguist's understanding of plausibility will be limited to whatever sound changes he happens to know from whatever languages he has happened to study. As Ohala (1993:237) writes, in this approach "plausibility is determined inductively, that is, by what the linguist has previously encountered in other human languages". The linguist would be better served by a deductively determined plausibility, grounded in universal properties of language which manifest themselves in the various changes and patterns found among the world's languages.

King even goes so far as to say that the Generative approach leads to the best analysis of difficult changes *because* it ignores the question of causality entirely. For example, the change of Latin [kt] > Rumanian [pt], as in Latin *octo* > Rumanian *opt* 'eight', presents a problem for non-Generative approaches to sound change. King argues that in a theory which views sound change as the gradual accumulation of articulatory change, a saltatory change like [kt] > [pt] is inexplicable, because this would require an intermediate step of [tt], which did not occur. The Generativist, however, can easily account for this change by simply positing the addition of a rule which states the change in terms of distinctive features.

That this should be touted as an advantage of the Generative approach to sound change is somewhat puzzling. The formulation of a Generative rule to account for [kt] > [pt] can be said to succeed in that it describes the change, but the change's description is not what is problematic about it. The change is difficult precisely *because* it is at odds with theories about the cause of sound change. Ignoring the cause of sound change simply ignores the problem; it does not solve it. If it is granted to King that, say, the gradualist view of sound change is incorrect, then a Generative account of the Rumanian change could be viewed as an improvement only insofar as it does not make an incorrect assumption about the cause of sound change. But ideally, a proper account of the change would not only describe it, but also have a theory of the cause of sound change which is compatible with that particular change.

Vennemann, unlike King, is motivated almost entirely by the question of causality, which shows the room for different views within the Generative tradition—although, it should be noted, he is critical of other Generative scholars who have avoided addressing the cause of the change. In his treatment of certain changes in Germanic, the formulation of rules which state the environments of the changes is insufficient if such rules do not indicate why the changes occurred. Based on his assumption that sound change is the result of articulatory assimilation, his goal is to show how certain articulatory aspects of the segments in question would result in assimilation. Given this approach, Vennemann would quite likely disagree with King's assessment that the Latin to Rumanian changes have sufficiently been accounted for.

5.1 Summary of Traditional Approaches

In this section I will highlight the similarities among the Neogrammarian, Structuralist, and Generative approaches to sound change. Despite their differences, they have much in common. Indeed, viewed from a larger historical perspective these schools are perhaps best seen as logical continuations of their respective predecessors, not the results of schisms in the field (see Steinberg 2003). The shared principles and assumptions in their views will then be contrasted with phonetics-based approaches in the next sections.

As has been repeatedly emphasized, all three approaches see articulatory processes as the primary phonetic factor in sound change. Although scholars in these traditions recognize that certain sound changes cannot easily be explained by articulatory factors, most sound changes, in particular those that are "natural", are seen as closely tied to articulatory processes. These processes are generally grouped together as "ease of articulation", "articulatory simplification", or something similar. We will simply refer to them as coarticulation, even though finer distinctions could perhaps be made.

However, coarticulation is not necessarily seen as causal in these approaches. The exact relation between coarticulation and the cause of sound change varies among the theories. For example, the articulatory component of the diphthong [ɑu] explains why it monophthongizes to [o] as opposed to, say, [i], but for many scholars this is not a causal explanation, in the sense of Weinreich, Herzog, and Labov's formulation of the actuation problem (see Section 1.1). Even if a theory recognizes that coarticulation is necessary for sound change to occur, it is difficult to

answer the questions posed by the actuation problem on this basis alone. Why, for example, did monophthongization occur in the OHG period specifically, if the diphthongs already existed in PGmc.?

Depending on the particular theory, other considerations may be called upon to explain sound change. For a Neogrammarian like Prokosch sound change can follow from the psychological makeup of certain individuals in the speech community, whereas for a linguist working in the Structuralist tradition the cause could be systemic pressure towards symmetry. Some have the same view as Bloomfield, a Structuralist, who wrote that "the causes of sound change are unknown" (1933:385). A Generativist like King may recognize that coarticulation provides the fodder for sound change, but claim that its actual cause is irrelevant.

These views of the cause of sound change are related to the common emphasis, either explicit or implicit, on description being the primary work of a historical phonologist. King, for example, writes that "historical linguists do what they are supposed to do: describe change" (1969:139). In Penzl (1971) it is clear that description is the main task of the study. Similarly, the handbooks of historical Germanic phonology meticulously catalogue sound changes, but in many cases there is little explanation for changes. The lack of explanation is particularly conspicuous when a sound change is not obviously an instance of coarticulation. A good example of this is the raising of mid vowels before nasals in Gmc., a problem which is the focus of Chapter 4. It thus becomes evident that for the 20th century and earlier, many historical phonologists have seen the description of sound change—not its explanation—as their main task.

In Structuralist phonology the object of description is the system, and in Generative phonology it is the grammar. There exists a taxonomy of changes (merger, split, and the like for the Structuralists; rule addition, rule loss, e.g., for the Generativists), but these concepts merely state that a change has occurred, expressed in the conceptual framework of that particular theory. In principle these terms are purely descriptive and do not address causality.

I suggest that, although detailed and accurate description of linguistic phenomena is of critical importance, historical phonologists should also concern themselves with trying to understand the cause of sound change. Descriptive work is the first, necessary step on the path to answering the *why* of sound change, but it seems self-evident that if a scientist studies some phenomenon that occurs repeatedly and in diverse contexts, he should at least be interested in why it happens. It should perhaps be—and in my view, it is—the most important question for him to answer.

In the next section I will consider phonetics-based approaches to sound change, which differ significantly from the traditional approaches discussed so far. In the following section, I will argue that phonetics-based approaches offer certain advantages to the traditional approaches to sound change discussed so far.

6.1 Phonetics-based Approaches

The traditional approaches outlined in the previous sections tend to focus on the articulatory aspects of sound change, and could in this way be described as speaker-based approaches.

Indeed, these traditional approaches can be contrasted with more recent approaches to sound change which focus on the role of the listener, a comparison which current scholars have made (Garrett and Johnson 2013:54). The most well known work in the listener-based view of sound change is perhaps that of Ohala (e.g., Ohala 1981; Ohala 1993), but many other scholars have also examined the place of the listener in sound change (e.g., Lindblom 1990; Blevins 2004; Blevins 2006; Beddor 2009). In this section I will focus chiefly on the work of Ohala, as his model of sound change will serve as the basis for my analyses of changes in the rest of this dissertation. However, it is important to make clear at the outset that I am using his model only as a starting point for viewing sound change; where necessary I will modify it or consider other perspectives as well.

I will refer to the viewpoints I cover in this section as phonetics-based approaches, or simply phonetic approaches, not merely listener-based approaches. The reason I prefer these terms is that various phonetic aspects are taken into account in these models, not just the perceptual role of the listener. This includes articulatory variation on the part of the speaker—such as coarticulation, articulatory strengthening, and articulatory weakening—which often provides the necessary input serving as the basis for change. In many cases a sophisticated understanding of the acoustics of certain segments, which does not always necessarily follow intuitively from the articulatory component, is also important to the analysis of a change.

Another important note on my use of this term to describe these approaches is that many of them also recognize social factors as playing a role in sound change. The conditions in which sound change can occur in an individual are determined by phonetic factors, but its spread through a speech community is largely shaped by social factors (Michael 2015). These approaches are therefore not necessarily *entirely* phonetics-based. However, my discussion will focus on the phonetic component of sound change, which for historical changes is often the only recoverable part.

6.2.1 Ohala

Yu (2015:413) describes the key observation underlying approaches like Ohala's as being "the ambiguous nature of the speech signal. Such ambiguities, or 'noise', stem from articulatory, acoustic, auditory, and perceptual constraints inherent to the vocal tract and the auditory and perceptual apparatus." In most cases, the ambiguity resulting from these constraints is successfully resolved by the listener. But occasionally it is not, and this is when sound change can occur.

Universal articulatory constraints and biases are central to Ohala's view of sound change. To take coarticulation as an example, we may consider a hypothetical word in which a high vowel is followed by a low vowel, e.g., [utɑ]. As a result of anticipatory coarticulation for the following low vowel, a speaker may produce the high vowel [u] with a lower tongue body in running speech than he would in careful or citation speech, in some cases approaching a mid vowel [o], resulting in [otɑ]. Such coarticulatory phenomena are universal, although they vary in direction and degree, but they do not inevitably result in sound change. If they did, virtually every word in every language would evince phonologized vowel harmony.

There is substantial experimental work which shows that listeners compensate for the presence of coarticulation, and that this is determined in part by native language and dialect (e.g., Beddor & Krakow 1999; Kang, Johnson & Finley 2016; Kawasaki 1986; Mann & Repp 1980; Tamminga & Zellou 2015). This compensation for coarticulation can be understood as a result of a listener's linguistic knowledge. That speakers of different languages differ in their coarticulatory patterns, and that listeners are able to appropriately compensate for coarticulation means that they must have some implicit knowledge of the subphonemic coarticulatory patterns of their native language. This knowledge allows them to reconstruct the target, or intended pronunciation of their interlocutor, by "undoing" the coarticulation. The listener's ability to compensate for coarticulation is why coarticulation does not always lead to sound change. In the example of [utɑ] / [otɑ], the listener is able to compensate for the presence of [o], because his linguistic knowledge allows him to attribute the vowel's height to the following low vowel [ɑ], and thereby reconstruct the speaker's target pronunciation of [utɑ].

The following figure represents an exchange between speaker and listener with compensated coarticulation:

speaker's pronunciation target	/utɑ/
speaker's actual pronunciation	[otɑ]
listener hears	[otɑ]
listener reconstructs	/utɑ/

Figure 2.3 - "successful" exchange between speaker and listener

Although the actual pronunciation, and what the listener hears, are both different from the speaker's target pronunciation, the listener is able to reconstruct the target pronunciation by compensating for coarticulation. This ensures that, despite ubiquitous variation in actual speech production, the speech norm will stay as /utɑ/. This compensation is what happens in most speech interactions between native speakers of the same language, and it prevents sound change from occurring despite variation in the speech signal (Ohala 1993:245).

There are two aspects of Ohala's model that I will focus on. The first is his listener-based typology of sound changes, and the second is his view that sound change is ultimately a phonetic process, i.e. its causes are found in universal phonetic principles.

Ohala (1993) identifies three types of sound change. The first is what he calls "hypo-correction", which is when a listener fails to compensate for coarticulation—the listener "under-corrects" the speech signal. In such cases, coarticulation occurs just as in the /utɑ/ example, and the listener accurately perceives the speech signal. The crucial difference is that the listener does not compensate for the coarticulation, and therefore does not reconstruct the intended form. This is modeled in Figure 2.4:

speaker's pronunciation target	/utɑ/
speaker's actual pronunciation	[otɑ]
listener hears	[otɑ]
listener reconstructs	/otɑ/

Figure 2.4 - listener fails to compensate for coarticulation

Hypo-correction can lead to a sound change if the listener adopts /otɑ/ as his pronunciation norm, and this is then adopted by other members of the speech community. Although the subsequent spread of a hypo-correction is a sociolinguistic issue, its instantiation in a single person is what Ohala calls a "mini-sound change" (1981:184), and this is the phenomenon that we are interested in here.

Perhaps the most common reason why hypo-correction occurs is that the segment causing the coarticulation is weakly articulated or difficult to detect due to ambient noise (Ohala 1981:183-4). If the listener does not perceive the part of the acoustic signal which is responsible for the coarticulation, then he will not be able to compensate for it. Continuing with the same example, the speaker-listener interaction would look like this:

speaker's pronunciation target	/utɑ/
speaker's actual pronunciation	[ot(ɑ)]
listener hears	[ot]
listener reconstructs	/ot/

Figure 2.5 - failure to compensate for coarticulation with weak conditioning segment

Since the listener did not detect the /ɑ/ in the intended pronunciation responsible for the coarticulation, he could not compensate for it. The listener will perceive /ot/ as the intended pronunciation, and may subsequently adopt it as his normal pronunciation of the word.

Significant here is that the change occurs alongside the loss of the conditioning environment. Ohala points out that very many hypo-correction type changes appear to occur simultaneously with the loss of the conditioning environment. Although this may seem paradoxical, it is explained by the fact that the coarticulation which provided the phonetic input to the change was always present. By the time the conditioning environment was lost, the coarticulation and the conditioning segment were no longer linked in the mind of the listener (1981:185).

Of course, not all hypo-correction type sound changes occur with the loss of the conditioning environment. The listener might fail to compensate for coarticulation if the coarticulation is especially extreme (Baker, Archangeli & Mielke 2011). In many instances, perhaps most, coarticulation between [u] and [ɑ] will not necessarily result in a mid vowel [o], but rather a vowel somewhere in the space between [u] and [o]. If listeners are accustomed to compensating for this degree of coarticulation, then they may not sufficiently correct a more heavily coarticulated utterance such as [otɑ].

The occurrence of hypo-correction can also be understood as a function of probability. Coarticulation results in a speech signal that would be perceptually ambiguous but for the listener's linguistic knowledge which generally allows him to correctly parse the coarticulated acoustic input. Nonetheless, because the speech signal is potentially ambiguous, the listener will not necessary reconstruct the speaker's target pronunciation in *all* instances, even if he does so in most; otherwise the speech signal would, by definition, not be ambiguous. Moreover, not all listeners may have the exact same level of linguistic knowledge which allows them to compensate for coarticulation. This is of course especially true for children learning their native language. Therefore, even in the absence of such factors as a weakly articulated conditioning environment or unexpectedly strong coarticulation, hypo-correction could be expected to occur at some, presumably small but non-zero rate.

Changes which fall into the hypo-correction model are extremely common; they broadly overlap with traditional assimilatory changes, in which a segment changes to become more similar to a nearby segment. For example, umlaut in Old English (e.g., PGmc. *manniz* > OE *menn* 'men'), velarization of nasals before velars in Ancient Greek (e.g., ἐν + κρατής > ἐγκρατής 'in power'), and intervocalic voicing in Spanish (e.g., Lat. *lupus* > Span. *lobo* 'wolf') could all be viewed as assimilation or hypo-correction. The key difference is that by viewing such changes as hypo-correction, the listener is viewed as the "bottleneck", as it were, for sound change. Coarticulation, or assimilation, is still a necessary condition for the sound change, but not sufficient.

Hyper-correction is the second category in Ohala's typology of sound change. Hyper-correction occurs when a listener compensates for a phonetic process not applied by the speaker. Because there is no actual distortion in the speech signal for which the listener needs to compensate in order to arrive at the speaker's intended pronunciation, he is thereby hyper-correcting the phonetic input. This can occur, for example, if a speaker produces a form which does not actually have a substantial amount of coarticulation. If the listener incorrectly[6] assumes that his percept has been influenced by coarticulation and compensates for it, resulting in a different phonological representation of the form than the speaker's. To continue with the example used in hypo-correction, an analogous instance of hyper-correction is shown in Figure 2.6:

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[6] The use of "correct" or "incorrect" in this context is somewhat imprecise. In hyper-correction, a listener compensates for a phonetic process that was not applied by the speaker. However, for the sake of economy, I will say that this is "incorrect" compensation for coarticulation, and that the listener is not arriving at the "correct" pronunciation.

speaker's pronunciation target	/otɑ/
speaker's actual pronunciation	[otɑ]
listener hears	[otɑ]
listener reconstructs	/utɑ/

Figure 2.6 - listener hypercorrects for nonexistent coarticulation

Here the speaker's actual pronunciation was faithful to the intended pronunciation. And just as in hypo-correction, the listener correctly perceived the speech signal. The change occurred because the listener compensated for coarticulation that was not actually present. He assumed that the height of the mid vowel [o] was the result of coarticulation with the following low vowel [ɑ], and erroneously corrected for this, thereby reconstructing a high vowel even though it was not intended.

Some dissimilatory changes may be instances of hyper-correction. A famous example is Grassmann's Law, a sound change in which a PIE voiced aspirated stop was devoiced when followed by another voiced aspirated stop in Sanskrit and Greek, e.g., PIE *bʰendʰ- 'bind' > Skt. *bandʰ-. Ohala explains this change as an instance of hyper-correction in which listeners interpreted the breathiness of the first stop as being due to the second stop. They therefore incorrectly compensated for it, and reconstructed a representation in which the first stop was unaspirated (Ohala 1984:221-2).

The third type of change in Ohala's framework is called "confusion", because it is the confusion of acoustically similar sounds. Whereas in both hypo-correction and hyper-correction the listener correctly hears the form, but either fails to compensate for coarticulation or compensates for nonexistent coarticulation, it is also possible for the listener to simply mishear the sound. This can happen if the acoustic signal of a certain utterance is easily confusable with another form. Ohala notes that confusion and hypo-correction could potentially be collapsed into one category of sound change, since both are caused by perceptual ambiguity of the speech signal. The difference is that the ambiguity in hypo-correction it is caused by coarticulation, and in confusion it is caused by chance acoustic similarity between two different sounds. An example of confusion would be the change of PIE labiovelars to labials in Ancient Greek, e.g., PIE *ekwōs > Gk. *hippos* 'horse' (Ohala 1993:242). Laboratory evidence (Winitz et al. 1972) demonstrates that the two sounds are perceptually similar.

6.2.2 - Sound Change Follows from Universal Phonetic Principles

In addition to his typology of changes, an important aspect of Ohala's theory of sound change is that the causes of sound change are to be found in phonetic processes. It is universal phonetic processes, such as articulatory, acoustic, and perceptual mechanisms, which form the basis for all sound change. Although all languages differ and can certainly be affected by non-phonetic

factors, Ohala notes that "[p]hysics and human physiology, however, represent a universal substrate on which all speech is built" (1983:189).

Crucially in Ohala's theory, the cause of sound change is not unknowable. Although explanation in phonology cannot reach the level of predicting what changes will occur in a given language at a given time, Ohala argues that no scientific discipline can make such predictions of its object of study. Rather, "deductive probabilistic" explanations are possible in phonology, which "include appropriate statements as to the limited degree to which they hold" (1984:218).

Another important part of phonetics-based approaches such as Ohala's is that by taking the listener into account, they suggest an answer to the actuation problem. For traditional theories that do not directly address causation, it is difficult to explain why sound change is not constantly changing every segment in every word, because coarticulation, or the impulse to articulatory simplification, is always present. Although coarticulation provides the necessary phonetic material for sound change in Ohala's view, change occurs as a result of occasional perceptual failure. This constrains sound change to those limited instances of misperception, rather than the countless instances of coarticulation in speech.

6.3 Other Phonetic Approaches

Although Ohala's three-way typology of sound change will form the basis for my analysis of sound changes in this work, there are numerous scholars who have taken the findings of phonetics to explain linguistic variation and change. For example, Blevins' Evolutionary Phonology (Blevins 2004; Blevins 2006) seeks to find explanations of sound change in factors external to phonology. This includes factors such as perception, as opposed to internal factors like analogy and frequency. Like Ohala, the types of changes which occur fall into three categories: change, chance, and choice. "Change" is when the phonetic signal is misperceived by the listener; "chance" is when the phonetic signal is accurately perceived, but the listener constructs a phonological form which differs from that of the speaker; "choice" is when multiple phonetic variants are accurately perceived, but the listener chooses a different phonological form than the speaker.

Lindblom (1990) accounts for the variation inherent in speech by proposing the concepts of hyper- and hypospeech (H&H Theory). In this view, speakers vary their speech along a continuum from hyperspeech to hypospeech. Hyperspeech is carefully articulated speech, in which the acoustic signal carries a high degree of information which allows the signal to be successfully contrasted with other, similar, acoustic signals, so that the correct lexical items can be more easily identified by the listener. Hyperspeech is not perceptually ambiguous. Hypospeech, on the other hand, is characterized by containing less information in the acoustic signal, which makes discrimination among candidate lexical items more difficult for the listener. However, speech perception is aided by "signal-complementary processes" (404), such as the listener's knowledge of the language, which allow the listener to correctly parse the acoustic signal even when it is ambiguous, as in hypospeech. Speakers vary their speech along this continuum based on a number of factors, but important among them is the "cost" of a given articulation—more extreme gestures that approach an idealized articulatory target constitute a

greater articulatory cost. Speakers generally want to minimize the cost of their speech, but they must also ensure that they produce a signal with sufficient contrast such that the listener, along with signal-complementary processes, can determine the meaning. This leads to variation in the acoustic signal in different contexts, and sound change could presumably occur when there is a mismatch between the listener's needs and the utterance's place on the hyper/hypospeech continuum.

Beddor (2009) considers a coarticulatory path to sound change that is based on listeners correctly perceiving the acoustic signal, but nonetheless constructing a different phonological representation than the speaker's. Beddor's study examines the case of anticipatory vowel nasalization, as in a change from VN to Ṽ, a prototypical hypo-correction type change. In VNC sequences, it is often the case that the velum lowering gesture required for the production of the nasal is stable, but its timing relative to the preceding vowel is variable. Some utterances may have a highly nasalized vowel followed by a very short nasal consonant, whereas others will have a weakly nasalized vowel followed by a longer nasal consonant. Beddor argues on the basis of experimental evidence that listeners tend to correctly perceive the acoustic signal, but that change can occur when they differ in the phonological representation they construct of it. For example, when distinguishing between /bɛt/ and /bɛnt/, some listeners may focus on the presence of nasalization throughout the syllable rhyme of /bɛnt/ as the distinctive property, as opposed to the nasal consonant specifically. In other words, they will treat [bɛ̃t], [bɛnt], and the range of possible variants in between, as perceptually equivalent, since the variable, non-contrastive, timing of the velum lowering gesture may result from any such production. In certain contexts which are conducive to earlier lowering of the velum, listeners may attach greater perceptual weight to Ṽ as the contrastive feature, as opposed to N. In this case the listener still correctly perceives the acoustic signal, and his phonological representation of it is compatible with the articulatory variation, but may differ from the speaker's phonological representation. Although Beddor's account of this type of change differs from that entailed by the hypo-correction model, it serves as a valuable example of a phonetic approach, in that it unites both the articulatory and perceptual aspects of sound change.

6.4 Phonetics and Historical Phonology

Unfortunately, historical languages by their very nature do not leave behind native speakers for linguists to study. For this reason, work in experimental phonetics generally focuses on modern languages. However, many scholars have designed experiments to test the putative conditions of historical sound changes, as well as applied the insights of modern phonetics to problems in historical phonology. In much of the work already cited by Ohala, historical phenomena are often cited to illustrate the types of changes which can occur, but other scholars have also taken a phonetic approach to historical phonology. Sampson (1999) treats the development of nasal vowels in the Romance languages. His study begins with Latin and traces the various changes into the modern Romance dialects. Important to Sampson's treatment is a detailed explanation of the phonetics of nasality, which includes its articulatory component, the acoustic effects of nasalization, and how these function perceptually, backed by a review of the relevant experimental phonetic literature. Stuart-Smith (2004) adopts Ohala's approach to examine the development of the PIE voiced aspirate stops in Italic. Her approach is to "consider

systematically [the PIE voiced aspirates'] phonetic characteristics and the likely constraints on their articulation, acoustic output and perception, and from there, to predict the potential variation which could become misparsed and result in sound change" (161). Relevant to Germanic phonology is Ritchie (2000), which studies the OHG monophthongization. In this dissertation, Ritchie considers the phonetic factors of the consonants which conditioned the change, and carries out an experiment in order to demonstrate the role of listener misperception in the change.

7.1 Differences and Advantages of the Phonetics-based Approach

Phonetics-based approaches to historical phonology differ from traditional approaches in at least two ways. First, whereas traditional historical phonology has mostly emphasized the role of articulation and, by extension, the speaker in sound change, phonetics-based approaches such as Ohala's place greater weight on perception and, by extension, the listener. Second, whereas traditional historical phonology has appealed to a wide range of causes, or not explicitly outlined a theory of causation, or claimed it to be undiscoverable, phonetics-based approaches make explicit claims about causation and place it squarely in the phonetic domain.

In this dissertation I will attempt to demonstrate that a phonetics-based approach to historical phonology offers certain advantages to traditional approaches. I will show this by examining specific problems in historical Germanic phonology, because the successful application of the phonetics-based approach to such problems will be its best justification. There are at least three ways in which this approach improves over the traditional theories discussed in this chapter.

First, by considering the role of the listener in sound change, the phonetics-based approach more accurately identifies and describes the different stages in a change, from its preconditions to its actuation, even in changes where the fundamental phonetic process is largely understood by historical phonologists. In Chapter 3, I will consider the problem of OHG *i*-umlaut in this context, and attempt to resolve some of the disputes over its origin which persist in the literature. What is significant about OHG *i*-umlaut is that, as a type of vowel harmony, the underlying articulatory process is relatively transparent. However, by considering the perceptual aspects of the change, certain problems of its implementation can be resolved.

Second, the phonetics-based approach can explain sound changes where the conditioning phonetic processes are obscure and have otherwise eluded historical phonologists. It is unfortunately not uncommon that sound changes and their environments are described and not explained, despite their motivation being unclear in a traditional articulatory-based approach, as we saw in Vennemann (1972). In examining these types of changes, the listener's role is important, but also necessary is a more sophisticated understanding of the articulation and acoustics of certain segments and how they inform perception. The motivation for certain sound changes may be clear to a phonetician who has studied the universal principles governing speech production and perception, but perhaps not to a historical phonologist whose expertise is the phonology of a particular language or group of languages. In this connection I will examine in Chapter 4 the effect of nasals on vowel height in early Germanic, a phenomenon which is well documented but for which there is a conspicuous absence of explanations.

Third, the phonetics-based approach can assist historical phonologists in determining what types of changes are natural and plausible. There are a number of ways in which the naturalness of a change is important to historical phonology. For example, if there exist two competing explanations for a change, the one which proceeds along more natural lines should be preferred. But in order to determine this, a well-grounded theory of phonetic naturalness is required, and clearly knowledge of phonetics is invaluable for such a theory. Another example is in instances, which are perhaps rare, where it is unclear whether a sound change has actually occurred at all, and part of the reason for accepting or rejecting that it occurred is its phonetic naturalness. I will explore this in Chapter 5 with an investigation of the circumstances surrounding Gothic <gg>, whose phonetic interpretation is disputed.

By examining these three problems, I aim to demonstrate not only the advantages of the phonetics-based approach over traditional approaches, but also that phonetics is useful, and in fact necessary, for doing good historical phonology. In addition to improving the analysis of the specific problems in Germanic that I analyze, I will also consider my project successful if it encourages other historical linguists to adopt phonetics-based approaches in their work.

3

OHG *i*-Umlaut

"But one cannot reasonably expect instrumental phonetics to contribute very much to such problems of historical phonemics as the origin of umlaut phonemes" - Penzl (1949:235)

1.1 Background

OHG *i*-umlaut is a sound change which affected back vowels in OHG, causing them to become front vowels. The change occurred when one of the back vowels was followed by any of the high front segments [i, iː, j], which we will henceforth refer to as *i*-sounds. The canonical example of OHG umlaut is the alternation between the singular noun form *gast* 'guest', and its plural form *gesti*. Phonetically, the two forms were [gɑst] and [gesti], respectively, with umlaut causing the change from [ɑ] > [e] in the plural form. The cognate Gothic forms *gasts*, *gasteis*, in which umlaut did not occur, show that the root vowel in both forms descends from PGmc. **a*.

Umlaut also affected the other OHG back vowels. For example, the typical form *hūsir* 'houses', phonetically [huːsir], appears in late OHG and MHG as *hiuser*, phonetically [hyːsər]. Examples of umlaut of all OHG monophthongs are shown in Figure 3.1. The forms without umlaut are all from OHG, whereas with the exception of *gasti*, the forms with umlaut are from MHG.

OHG - no umlaut	MHG - with umlaut	vowel change
gast 'guest'	*gesti* 'guests' (OHG)	[ɑ] > [e]
swāri 'heavy'	*swære*	[ɑː] > [æː]
oli 'oil'	*öl*	[o] > [ø]
scōni 'beautiful'	*schœne*	[oː] > [øː]
ubil 'bad'	*übel*	[u] > [y]

| *hūsir* 'houses' | *hiuser* | [u] > [yː] |

Figure 3.1 - OHG forms without umlaut and their reflexes/alternations with umlaut.

Although umlaut of [ɑ] and [ɑː] resulting in [e] and [æː], respectively, can be seen as a simple front:back alternation, umlaut of the non-low vowels does not result in merely the front vowel of corresponding height, but rather a front rounded vowel.

1.2 Primary and Secondary Umlaut

In the literature on OHG *i*-umlaut, scholars have traditionally made a distinction between umlaut of [ɑ] resulting in [e], so-called "primary umlaut", and umlaut of all other vowels, referred to as "secondary umlaut" (Penzl 1949; Voyles 1991; Iverson and Salmons 1996b). Primary umlaut refers only to umlaut of [ɑ] by unstressed [i, iː, j] in the immediately following syllable. In this environment, the vowel was realized as [e]. Primary umlaut was blocked under some conditions, such as when certain consonant clusters intervened, for example *ht* in *mahti* 'powers', and *lt* in the Upper German dialects in forms like *haltis* 'you hold'. Secondary umlaut refers to the umlaut of the other OHG back vowels, as well as umlaut of [ɑ] in the environments which blocked primary umlaut. Secondary umlaut of [ɑ] resulted in [æ].

Primary and secondary umlaut differ in three ways. First, whereas primary umlaut only applies to [ɑ] and in a restricted environment, secondary umlaut applies to all back vowels and in a less restricted environment. Second, whereas primary umlaut is consistently represented orthographically in the OHG record beginning in the 8th century, secondary umlaut is not attested orthographically until OHG *ū* appears as *iu* in Notker in the 10th century at the end of the OHG period; umlaut of the other back vowels does not appear orthographically until the MHG period. Third, whereas primary umlaut of [ɑ] resulted in [e], secondary umlaut of [ɑ] resulted in [æ], as in OHG *mahti* > MHG *mähte*.

Although both primary and secondary umlaut involve the fronting of back vowels before *i*-sounds, the differences enumerated above have led to disagreement over the exact nature of the relationship between the changes. Some scholars view primary and secondary umlaut as similar changes which nonetheless occurred at two different times. In this view, primary umlaut preceded secondary umlaut, since this is what the orthographic representation of the changes suggests. Others claim that the distinction is spurious, and that OHG *i*-umlaut was a single change affecting all back vowels at the same time, without separate primary and secondary phases. Supporters of this view hold that the orthographic representation of secondary umlaut did not occur until long after the change had actually occurred, for reasons we will discuss below (see section 2.1).

The timing of the orthographic representation of secondary umlaut is a serious problem. Secondary umlaut does not appear in the orthography until centuries after primary umlaut. In fact, secondary umlaut is not represented in the manuscripts until after the *i*-sounds which conditioned the change had already disappeared. In the transition from OHG into MHG, end

syllables were reduced to schwa or disappeared entirely. This change had wide-reaching implications for the development of the German language, but for umlaut the important consequence was that the conditioning environment disappeared. The *i*-sounds which conditioned umlaut only appeared in syllables without primary stress, and were thus subject to the process of syllable attrition. This is evident in Figure 1, where the pre-umlaut forms still have [i] as the final syllable, but have [ə] by the time umlaut has occurred. The exception, of course, is *gesti*, which is an instance of primary umlaut.

The problem behind making sense of these facts is well stated by Twaddell (1938:177): "[w]e are faced with two alternative interpretations: either the [secondary] umlaut occurred after the disappearance of the condition which caused it -- a patent absurdity -- or the [secondary] umlaut occurred in OHG. times but for some reason was not recorded orthographically until centuries later". This problem lies at the heart of the scholarly disagreement over OHG *i*-umlaut. For scholars who hold that primary and secondary umlaut occurred at the same time, an explanation must be found for the lag in the orthographic representation of secondary umlaut. For scholars who do distinguish between the two, an explanation must be found for why secondary umlaut would not emerge until the disappearance of its putative conditioning environment.

1.3 Chapter Outline

Marchand (1990:11) observed that "writing on umlaut is tantamount to writing on the very foundations of descriptive and historical linguistics, since it involves so many different parts of our discipline". In order to avoid such an unwieldy discussion, the focus of this chapter will be on the issue Twaddell points out. I will argue that primary umlaut and secondary umlaut occurred at two different time periods: primary umlaut preceded secondary umlaut and the two changes do not constitute a single historical event. Accordingly, the question I must answer is how secondary umlaut could have developed alongside the loss of its conditioning environment. Specifically, I will argue that the disappearance of the conditioning environment played a causal role in secondary umlaut, which explains why it was not represented orthographically until the conditioning environment had disappeared.

As discussed in Chapter 2, one of the goals of this dissertation is to show how the application of phonetics to historical phonology can benefit the study of sound change. My analysis of OHG *i*-umlaut in this chapter will show the value of phonetics to historical phonology in cases where the basic mechanism of a sound change is already well understood. As a type of vowel harmony resulting from vowel-to-vowel coarticulation, *i*-umlaut is a relatively transparent change. However, the difficult details surrounding its implementation in OHG suggest that a more sophisticated approach is necessary to account for all of the facts. In my account of this change, I will draw on work in experimental phonetics that examines the articulatory and perceptual aspects of sound change.

Section 2 will consist of a review of selected previous approaches to OHG *i*-umlaut. In Section 3 I will present my own analysis of the problem grounded in work from phonetics. Section 4 will conclude the chapter.

2.1 Literature Review

The literature on OHG umlaut is voluminous (e.g., Antonsen 1969; Braune and Reiffenstein 2004; Dal 1967; Penzl 1949; Penzl 1994; Sonderegger 1974; Twaddell 1938; Voyles 1991; these works also contain many other references). Rather than attempt to convey the entire breadth of previous work on this subject, I will focus on three different approaches to the problem. The first is that advanced in Twaddell (1938), which represents the standard view in the field, namely that primary and secondary umlaut occurred at the same time. In this connection I will also discuss Penzl (1949), who addresses some of the other issues surrounding OHG umlaut within the same general framework. The second approach is the view argued in Voyles (1991), which is that primary and secondary umlaut were separate changes, and that secondary umlaut was in large part morphosyntactically conditioned. Finally, I will consider Schulze (2010), who defends Twaddell's view by incorporating the findings of phonetics to examine the articulatory and perceptual factors of umlaut.

2.2 Twaddell and the Standard View

Twaddell's article (1938) likely reflects the majority view among today's scholars. The problem, as detailed in Section 1.2, is that only primary umlaut—umlaut of [ɑ] in certain positions—is reflected orthographically in OHG, but secondary umlaut—umlaut of [ɑ] in all positions and of the other back vowels—does not appear until much later. However, since the transition from OHG to MHG involved the attrition of unstressed syllables, which entailed the loss of the *i*-sounds which caused *i*-umlaut, the historical record gives the puzzling impression that secondary umlaut somehow occurred after its conditioning environment had disappeared.

Twaddell argues that primary and secondary umlaut in fact occurred at the same time, despite the delay in the orthographic representation of secondary umlaut. He argues that *phonetically*, umlaut of all back vowels had occurred already in OHG in all of the umlaut conditioning environments. The key difference between primary and secondary umlaut is that only primary umlaut resulted in a new phonemic contrast in OHG, whereas secondary umlaut introduced allophones that were predictable from their environment.

OHG already had an existing contrast between /ɑ/ and /e/. However, [æ] and the front rounded vowels that resulted from secondary umlaut were not OHG phonemes, and did not contrast with their corresponding unumlauted vowels. Although, according to Twaddell, these vowels existed on the phonetic level in OHG, they were restricted to the umlaut-conditioning environments. For example, the adjective *scōni* 'beautiful', was phonetically [skøːni], with a front rounded vowel. But the related adverb *scōno* was phonetically [skoːno], with a back vowel. Despite the phonetic difference, the root vowels of both forms were allophones of the same phoneme /oː/, since they were in complementary distribution, with [øː] occurring only before *i*-sounds, and [oː] in all other environments.

However, when the *i*-sounds which conditioned umlaut disappeared or became schwa in MHG, the phonetic contrast became phonemic. The OHG forms *scōni* and *scōno* would have been realized phonetically in MHG as [ʃøːnə] and [ʃoːnə], respectively. At this stage, the words

differed only in the quality of the root vowel; therefore [øː] and [oː] were no longer in complementary distribution. This would have constituted a phonemic split, thereby introducing a new phoneme /øː/, alongside /oː/.

A crucial premise of Twaddell's argument is that phonetic distinctions are not normally represented in orthography, whereas phonemic distinctions are. He writes that "[t]o have represented them would have been an act of supererogation, of orthographical pedantry, parallel to an attempt at representing orthographically the various phonetic forms of the sound-type K in modern English and German" (180). If this is true, then it neatly explains why the OHG scribes wrote <e> for primary umlaut, but did not represent secondary umlaut. In OHG, only primary umlaut resulted in a phonemic contrast. But once the conditioning environment disappeared, the phonetic output of secondary umlaut also became phonemically contrastive, at which point it was represented in the orthography.

Penzl, like Twaddell, holds that "the phonemization of umlaut allophones was a single historical event" (1949:240). He accepts Twaddell's argument for the delayed orthographic representation of secondary umlaut, and also considers some of the other problems related to umlaut that Twaddell does not address in detail. One such problem is the existence of myriad OHG forms in which umlaut occurs irregularly or infrequently, despite the conditions for umlaut being met. For example, in the paradigm of the masculine *n*-class noun *hano* 'cock', both *hanin* without umlaut and *henin* with umlaut occur as the genitive/dative forms, with *hanin* being the more common form. The existence of *henin* shows that umlaut did in fact occur in this form, but Penzl argues that *hanin* is the result of analogical influence from the nominative *hano*. Similarly, forms without umlaut like *manlich* 'manly' are explicable on the basis of the nouns from which they are derived, in this case *mann* 'man', which does not have umlaut. "In short", writes Penzl, "morphological and derivational analogy reintroduced the original vowels in positions where the umlaut phonemes had developed" (228). Similarly, Penzl argues that umlaut spread throughout the MHG period to certain forms on the basis of analogy. Since at this stage umlaut was the only indicator of certain plural forms, it was sometimes transferred to words which never met the phonological conditions for umlaut, e.g. *gedänke* from *gedanc* 'thought'.

2.3 Voyles

Voyles (1991) argues, against Twaddell, that secondary umlaut had not occurred, even at the phonetic level, before the end of OHG. He identifies five problems with Twaddell's theory and others who have argued along similar lines (161-8), which will be summarized here. The first three are empirical problems with the theory, and the remaining two are formal problems. Following Voyles, we shall refer to Twaddell's theory and its related variants as the T-theory.

The first empirical problem with the T-theory is what Voyles calls the orthographic dilemma. According to exponents of the T-theory, OHG orthography is phonemic, i.e. it does not reflect subphonemic phonetic variation[7]. However, Voyles cites numerous examples which directly

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[7] In connection with OHG *i*-umlaut it has been argued that this is true for most orthographic traditions. For example, Voyles cites Moulton (1961b): "In einer normalen Orthographie (d. h. abgesehen von gelehrten phonetischen

contradict this, such as Otfrid's use of <g> to reflect unaspirated [k] in *fisg* 'fish', as opposed to <k> for word-initial aspirated [kʰ] in *kuning* 'king'; both [k] and [kʰ] are allophones of the OHG phoneme /k/. The existence of such forms undermines a central premise of the T-theory. Voyles contends that the instances of subphonemic writing occur with such frequency that if a certain subphonemic variant actually existed in OHG, then it is "certain to be represented somewhere at least sporadically" (162). That there is no orthographic record of *i*-umlaut of vowels other than *a* before 1000 AD in any OHG text, then, suggests that it was not present phonetically before that time either. Another aspect of the orthographic dilemma is that Notker, whose orthography indicates umlaut of both [ɑ] and [uː], does not record it for [oː]. If umlaut had already affected all of these vowels, as the T-theory holds, why would Notker only record it for some of them? The T-theory explains why only umlaut of [ɑ] was recorded, but does not explain why there would be a stage where only umlaut of [ɑ] and [uː] would be recorded.

The second empirical problem facing the T-theory is what Voyles calls the synchronic dilemma, namely that "a rule accurately describing the occurrence of i-umlaut in any attested OHG corpus has yet to be formulated" (164). Voyles argues that the standard explanations which describe umlaut as being entirely phonologically conditioned are insufficient. First, many such phonological-based accounts (in the generative tradition) postulate a rule of *j*-deletion to account for certain forms, but this leads to an ordering paradox. For example, *festes* 'firm', a *j*-class adjective, has a posited underlying form /fɑstjes/, to which umlaut must first apply, and then *j*-deletion. This adjective is the genitive singular masculine form of a *j*-class adjective. However, the nominative singular form is *fasto*, but the underlying form must be /fɑstjo/. However, since the surface form is *fasto*, without umlaut, not **festo*, with umlaut, this would require first *j*-deletion, and then umlaut to apply, which is the reverse order required for *festes*. The second feature of the synchronic dilemma is that there are certain OHG forms that satisfy the putative phonological conditions but do not actually undergo umlaut, such as in the past subjunctive form *santi* 'sent' from the verb *senden* 'send'. Given these two observations, Voyles concludes that umlaut must have been in part morphosyntactically conditioned, as opposed to other scholars who have attempted to explain it entirely in phonological terms.

The third empirical problem is the so-called diachronic dilemma (166-7). Voyles argues that later developments in the history of German contradict certain claims of the T-theory. For instance, the T-theory predicts that the class I weak verbs, which historically had a *j*-suffix, all undergo umlaut. This is the case for the reflexes of verbs like verbs like PGmc. **sandjan*, which is *senden* in both OHG and NHG. However, certain other verbs show no evidence of umlaut in their NHG reflexes. For example, PGmc. **sōkjan* 'seek' has the OHG reflex *suohhan*. If this form had undergone umlaut, as the T-theory would predict, then its phonetic form would have been [syøxɑn]. Undergoing the normal German developments, this form should then have the phonetic form [zyːçən] in NHG, with the front rounded vowel the product of umlaut. However, the actual NHG reflex *suchen* has the phonetic form [zuːxən], without umlaut. Proponents of the T-theory would have to either concede that umlaut simply did not occur in all forms where the phonological conditions were met, or that umlaut did occur in those forms, but was somehow reversed by the time of NHG.

Transkriptionen usw.) werden die Allophone ein und desselben Phonems nie und nimmer schriftlich unterschieden" (161).

Voyles identifies two problems with the T-theory that are "of a logical and formal nature" (161). The first he calls the *reductio* dilemma, which is that "the methodological premisses of the standard theory, if pursued consistently, lead to patently false conclusions" (167). If one assumes that secondary umlaut was phonetically present in OHG forms despite the absence of direct evidence, then it is entirely consistent to propose that umlaut of any type was phonetically present at even earlier stages, for which there is also no direct evidence. Indeed, some scholars have argued for *i*-umlaut already in PGmc., such as Penzl (1972) and Antonsen (1972). But, argues Voyles, since modern Dutch shows very little trace of umlaut, then anyone holding this view would have to somehow argue that Dutch lost the umlauted forms while the other Germanic languages did not. He also points out that this same logic could even be extended to PIE, where one could on the same grounds claim that *i*-umlaut was already subphonemic in PIE, but was simply lost in languages other than the dialects of Germanic for which there is evidence. Although Voyles acknowledges that probably no scholar would seriously argue that there was subphonemic umlaut in PIE, his point is that it is logically equivalent to the claims made by the T-theory. If the T-theory entails absurd conclusions, then we should reject it.

The final problem with the T-theory according to Voyles is the nonfalsifiability dilemma (167-8). Simply put, since the T-theory takes the absence of (graphemic) data as support for its conclusions, then it is nonfalsifiable. A nonfalsifiable theory is a nonscientific theory.

Voyles then proposes his own theory to explain the origin of *i*-umlaut in OHG. Put simply, he argues that *i*-umlaut in OHG, although certainly subject to phonological conditioning, was from its outset also morphosyntactically conditioned (on morphosyntactic conditioning of OHG *i*-umlaut see also Dal 1967). The OHG *i*-umlaut rule was then generalized by OHG speakers over time and in different dialects to include more phonological and morphosyntactic domains. Voyles formulates detailed *i*-umlaut rules for the Isidor, Otfrid, and Notker corpora which account for the attested forms (172-183). The rules also continued to expand, often with dialectal differences, throughout the MHG period, and in some cases even in the NHG period.

2.4 Schulze

Schulze (2010) presents a comprehensive treatment of *i*-umlaut in OHG. Schulze not only defends the T-theory, but also provides a typological framework for umlaut in general, including other types of Germanic umlaut. Schulze's work is pertinent to the analysis I will propose, because his discussion of the phonemicization of umlaut centers on the phenomenon of compensation for coarticulation. In this way, his is very much a phonetic approach. However, as shall be seen, our analyses differ in some fundamental ways.

Schulze holds that there was only one period of *i*-umlaut in the history of German, and that it is restricted entirely to the OHG stage. Addressing Voyles' criticism that the T-Theory is nonscientific because it is unfalsifiable, Schulze argues that the criterion of falsifiability is unrealistic for historical phonology. In contrast to the natural sciences, "[i]n der historischen Phonologie gibt es bekanntermaßen keine experimentelle Basis," and thus reconstruction is "stets eine Interpretationsaufgabe" (43). Although Schulze touches on many aspects of OHG umlaut

and its various interpretations, I will focus on his discussion of the role of phonetics in its phonemicization.

Like Twaddell, Schulze proposes that there was an allophonic stage of umlaut in Pre- and Early Old High German (71). Primary umlaut of [ɑ] is evident already in OHG, but there must have been coarticulation between the other back vowels and the umlaut-triggering *i*-sounds. This subphonemic coarticulation formed the phonetic basis for the later umlaut of these vowels. An important point noted by Schulze is that coarticulation, although treated as a universal process, still varies in its extent according to language, dialect, and speaker. Schulze suggests that even at its earliest stages, there were dialectal differences in the realization of allophonic umlaut in OHG.

Regarding primary umlaut of [ɑ], Schulze identifies two factors that would make this vowel more likely to undergo umlaut before the other vowels (76). The first is its length. Consider a sequence V1-C-V2. The shorter V1 is, the earlier in its production it will be subject to coarticulation with V2, assuming that V-to-V coarticulation has a constant duration of effect that is fixed to the onset of V2. In other words, if the duration of coarticulation is constant, then a larger relative portion of the production of a shorter segment will be coarticulated than that of a longer segment. The second factor is articulatory distance from the trigger. The greater the articulatory distance between V1 and V2, the more extreme the coarticulation in V1. Since [ɑ] is a short low vowel, and it is maximally distant from the high front *i*-sounds, then [ɑ] will be more affected by coarticulation than the other OHG vowels. These two factors make it more likely to change in the umlaut environment than other vowels.

Schulze attributes the phonemicization of umlaut in OHG to the failure of listeners to compensate for coarticulation (84-92). Beginning as subphonemic variation, he argues that the coarticulation intensified over time such that by the beginning of the OHG period, the umlauted and non-umlauted allophones were too contrastive for new generations of speakers to link together as allophones of the same phoneme, at which point umlaut was phonemicized. After the phonemicization of umlaut, coarticulation of the umlauted vowels with their following *i*-sounds continued, and the umlauted vowels were drawn to ever further front places of articulation until they became fully fronted vowels.

Importantly, the failure of listeners to connect umlauted vowels to their phonological trigger is what allowed for the umlauted variants to persist after the reduction of the *i*-sounds in late OHG. The loss of the umlaut triggers effected no change in the phonetic realization of the umlauted vowels, since speakers no longer perceived a connection between them.

Schulze also considers why [e] from primary umlaut of [ɑ] was represented orthographically before the vowels resulting from secondary umlaut. If phonemicization occurred at the same time for all of them, as Schulze holds, then why was this not represented orthographically at the same time as well? Schulze argues that the OHG scribes would not have invented new graphemes or combinations of graphemes to represent new sounds (41). They would have adhered to traditional orthographic practices as much as possible, in order to preserve the readability of their texts for later readers, as well as for readers from other geographic regions.

But scribes would have readily used existing graphemes if these graphemes were well-suited for the task. Since the grapheme <e> already existed to represent OHG [ɛ], then it would be a natural choice to use <e> to represent [e] as well when it entered the language. But since there were no graphemes already in use that represented front rounded vowels or anything like them, umlaut of the other back vowels remained unmarked at first. Schulze also notes that the orthographic representation of umlaut was not a centralized and coordinated process; it was carried out by separate individuals over a span of generations, so it is to be expected that it proceeded gradually.

To summarize, Schulze identifies four phases of the phonemicization of OHG umlaut (92). In Phase 1, there is coarticulation on the part of the speakers in the relevant environments, but listeners successfully compensate for it. Although the umlauted variants exist allophonically at this stage, they are not phonemic. In Phase 2, listeners fail to compensate for coarticulation of back vowels with *i*-sounds. The result is that the fronted variants are now perceived as distinct from the back variants. In Phase 3, coarticulation persists and the range of pronunciations for the fronted variants becomes even further front, resulting in greater contrast with the original back vowels. In Phase 4, end syllables are reduced throughout OHG, with the result that umlauted vowels are no longer in complementary distribution with their corresponding back vowels. Although this is similar to the T-theory, which Schulze explicitly supports, the stage at which phonemicization occurs appears to be different for Twaddell and Schulze. For Twaddell, phonemicization occurs at Phase 4, when the conditioning environments are lost. For Schulze, it occurs at Phase 2, because this is where the umlauted variants are no longer connected in the mind of the listener to the original back vowels.

2.5 Problems

This overview of some of the important lines of argument in the umlaut literature helps focus the approach to OHG umlaut I will take in this chapter. Although Twaddell rather elegantly explains the late orthographic appearance of secondary umlaut, I believe that Voyles' criticisms are legitimate and must be given due consideration in an account of OHG umlaut. The *reductio* dilemma represents, in my opinion, a serious challenge to the T-theory. If one accepts that secondary umlaut was phonetically complete in OHG solely on the basis of its later orthographic representation, then there is no way in principle to restrict this phonetic state of affairs to the OHG period, for by the same logic it could be projected back to Proto-Germanic or even Proto-Indo-European. If at any point in the (pre)history of the German language a back vowel occurred before an *i*-sound, it can be assumed to have been phonetically umlauted, because there is nothing whatsoever in the T-theory that ties this fronting exclusively to the OHG period. Umlaut is connected to the OHG period only in that it becomes phonemic at this time, due to the loss of the *i*-sounds, which had no effect on the phonetic value of the vowels.

Voyles' view of OHG umlaut relies heavily on morphosyntactic conditioning. The variation and inconsistency found in the umlaut data (see Penzl 1949) certainly show that morphosyntactic factors played some role in umlaut and its spread, especially throughout the MHG period and later. However, I believe Voyles' account could be improved by grounding the change more

firmly in its phonetic conditioning environment. Additionally, by focusing on morphosyntactic factors, Voyles' account fails to explain certain aspects of the conditioning environment, such as that the *i*-sounds which trigger umlaut must occur in a syllable without primary stress.

Although Schulze's application of phonetic principles to umlaut is valuable, certain problems remain with his account. The main issues are in Phases 2 and 3 of his description of the change. In Phase 2, listeners fail to compensate for coarticulation, and the umlauted allophones become distinct from their back vowel counterparts. At this stage, the umlauted allophones are not yet fully fronted. In Phase 3, coarticulation continues, and the umlauted vowels become fully fronted. The concern is that neither of these phases is connected to the specific phonetic and/or phonological conditions of OHG at the time. Schulze does not explain why, in Phase 2, listeners would have failed to compensate for coarticulation. Likewise, in Phase 3, Schulze does not justify why coarticulation would have persisted such that it increased the degree of fronting of the umlauted vowels. In both cases, it seems that Schulze simply assumes these things must have happened.

In the next section I will propose my own analysis of OHG *i*-umlaut that attempts to avoid the problems I have pointed out by making use of phonetic principles as well as grounding the changes in terms of the relevant phonological properties of OHG. To reiterate, my overarching claim is that primary umlaut of [ɑ] occurred first, and was followed by the changes known as secondary umlaut; this is in line with the chronology of their orthographic representation. My main task then is to explain how secondary umlaut occurred alongside the loss of its conditioning environment. I will argue that the loss of the secondary umlaut conditioning environment actually played a major causal role in the change. In this way I will connect the sound change to the OHG-specific phonological conditions.

3.1 A Phonetic Approach to Umlaut

Following the orthographic evidence, I hold that secondary umlaut occurred after primary umlaut, at the end of the OHG period. The difficulty this view encounters is in explaining the emergence of secondary umlaut alongside the disappearance of its conditioning environment. By viewing this change with the phonetics-based approach to sound change discussed in Chapter 2, as well as drawing on relevant work in experimental phonetics, I will propose an analysis that explains how the sound change occurred in such a way that the the loss of the conditioning environment itself played a role in the change.

3.2 Phonetics-based Models of Sound Change

Traditional speaker-based approaches to phonology, such as those discussed in Chapter 2 and earlier in this chapter, would label OHG umlaut as a type of assimilation. This term is accurate insofar as it identifies coarticulation as playing a role in the sound change, but it is inaccurate from the perspective of listener-based theories. In a phonetics-based model of sound change which also considers perceptual factors, coarticulation is a necessary, but not sufficient condition for assimilatory type changes. Because coarticulation occurs in virtually every linguistic utterance, yet not every utterance evinces sound change, then coarticulation cannot be the causal

factor. Rather, sound change occurs when a listener either misperceives the speech signal, or otherwise constructs a different phonological representation than the speaker's.

Let us first construct a model of a successful exchange between a speaker and listener in OHG under the model of Ohala, analogous to the example in Chapter 2. In this model, a speaker has a pronunciation target, which will be enclosed in slashes. This target may represent the pronunciation norm of the word, or how the speaker might pronounce it in careful speech. In addition to the speaker's pronunciation target we also show the speaker's actual pronunciation, which in any given utterance may deviate from the target pronunciation due to coarticulation, simple gestural error, or normal variance. The speaker's actual pronunciation will be enclosed in square brackets.

What the listener hears is also enclosed in square brackets. This should match the speaker's actual pronunciation. Below this is what the listener "reconstructs" as the speaker's pronunciation target, enclosed in slashes. This form is what the listener perceives after having compensated for coarticulation or accounted for other disturbances in the speech signal. A crucial assumption for this model of sound change is that listeners generally try to reproduce what they reconstruct as their interlocutor's intended pronunciation. It follows that the speaker's actual pronunciation can vary from his target, but as long as the listener correctly reconstructs the pronunciation target, there will be no sound change. A "mini sound change" (Ohala 1981:184) occurs if the listener reconstructs something different from the speaker's target. This listener may then alter their own pronunciation when they subsequently speak, and if this propagates throughout the speech community, a sound change in the true sense will occur.

We will use the OHG word *mūsi* 'mice', phonetically [muːsi] as the illustrative word in the following hypothetical exchanges. In the exchange shown in Figure 3.2, the speaker's production is acoustically faithful to his target, and it is accurately heard and perceived as such by the listener.

speaker's pronunciation target	/muːsi/
speaker's actual pronunciation	[muːsi]
listener hears	[muːsi]
listener reconstructs	/muːsi/

Figure 3.2 - "successful" exchange between OHG speaker and listener

There is no coarticulation or misperception at any point in the interaction. The listener therefore continues to adhere to the pronunciation norm, and no sound change spreads through the speech community.

However, coarticulation is always present in speech. A more realistic model of a possible exchange between OHG speakers would show this coarticulation, and also show that the listener correctly compensated for it. This is seen in Figure 3.3.

speaker's pronunciation target	/muːsi/
speaker's actual pronunciation	[myːsi]
listener hears	[myːsi]
listener reconstructs	/muːsi/

Figure 3.3 - "successful" exchange between OHG speaker and listener, with coarticulation

In this exchange, the vowel [uː] is pronounced as [yː][8], due to coarticulation with the following [i]. The listener hears [y:], but due to his linguistic knowledge, is able to compensate for the coarticulation of the following [i], and reconstruct [uː] as the intended pronunciation. The listener then continues to adhere to the pronunciation norm, and no sound changes spreads through the speech community. This is what happens in most exchanges among speakers.

Now let us consider what happens when a sound change occurs. For the type of sound change in question here, the crucial step is the listener's reconstruction of the intended pronunciation. The exchange shown below in Figure 3.4 is the same as in the successful exchange in Figure 3.3, except that the listener fails to compensate for the coarticulation, resulting in a different representation of the sound for the listener, and thus a new pronunciation norm for him. This is an instance of hypo-correction in Ohala's model, where a listener under-corrects for coarticulation.

speaker's pronunciation target	/muːsi/
speaker's actual pronunciation	[myːsi]
listener hears	[myːsi]
listener reconstructs	/myːsi/

Figure 3.4 - "unsuccessful" exchange resulting in sound change

This model of OHG umlaut as hypo-correction is compatible with the traditional views held by Twaddell and Schulze, according to which secondary umlaut occurred already in the OHG period, when the conditioning environment was present. The subsequent disappearance of the umlaut triggers had no effect on the phonetic realization of the umlauted vowels, but it did

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[8] Fronting to this degree would be extreme and unlikely to occur in all utterances; I use it only for the purposes of illustration. Below I will discuss more realistic intermediate steps.

phonemicize the change and lead to its being represented in the orthography, resulting in the appearance that the change had coincided with the loss of its conditioning environment. Ohala argues that in such changes, there is in fact only one change at the phonetic level at the time the change appears to take place, namely the loss of the conditioning environment (1981:184).

3.3 Four Stages of Secondary Umlaut

I will argue that the vowels involved in secondary umlaut had not yet changed to their MHG forms at the time that the umlaut conditioning environments disappeared in late OHG. My claim is that, although the seeds for secondary umlaut—partially fronted allophones of back vowels caused by coarticulation—were already present in OHG, the disappearance of the conditioning environment played a major role in their becoming front rounded vowels as they are attested in MHG and NHG. In other words, I am arguing that in changes like OHG *mūsi* > MHG *miuse*—phonetically [muːsi] > [myːsə]—there was not only a reduction, or complete disappearance, of the final syllable, but also a change in the quality of the stem vowel itself. This differs from the T-theory, which holds that the only change at this time was in the final syllable.

There is good reason to allow for the possibility that secondary umlaut vowels were not yet fully fronted in the OHG period. First of all, Ohala himself writes that in many changes of the hypo-correction type, "[s]ome exaggeration and other qualitative changes in phonetic character of what was previously a distortion may also take place" (1981:185). Garrett and Johnson, noting this same tendency for the final stage of a sound change to differ in degree from the early variants caused by coarticulation, call it "enhancement" (2013:78). Second, Schulze's own explanation of OHG umlaut has as its third stage the strengthening of coarticulation resulting in greater phonetic contrast between front and back vowels (see Section 2.4), although he does not offer an explanation for why this must have happened. Regardless, it shows that in his own view, the coarticulation which formed the basis for umlaut must have somehow undergone "enhancement". Third, if we accept that the pronunciation norm in OHG was full fronting of the secondary umlaut vowels, as the T-theory holds, then we are vulnerable to the *reductio* dilemma pointed out by Voyles (see Section 2.3). For this reason we should look to see if we can locate the fronting of the secondary umlaut vowels exclusively to late OHG.

I propose that the first stage of secondary umlaut was phonetic fronting of back vowels in the relevant environments. Since coarticulation is a universal property of speech, it can be said with relative certainty that there must have been some coarticulation in the secondary umlaut environments in OHG, such that back vowels before *i*-sounds were further front than back vowels in other environments. Crucially, at this stage, these variants were not identical to their later MHG forms. Using *mūsi* as our example, I suggest that coarticulation at this stage frequently resulted in pronunciations like [muˌːsi], with a partially fronted vowel—this would have likely been the speech norm. In contrast, forms with fully fronted vowels such as [myːsi] would have been much rarer, although still occurring from time to time. These fully fronted variants were *not* the pronunciation norm, contra Twaddell and Schulze. OHG at this point evinced coarticulation of a type which can safely be assumed to occur in any language, even Proto-Germanic or Proto-Indo-European.

The second stage of secondary umlaut was the weakening of unstressed syllables, which caused the loss of the *i*-sounds which conditioned umlaut. Crucially, the development of the final vowel from [i] in OHG *mūsi* to [ə] in MHG *miuse* must have been gradual, precipitated by synchronic variation in the speech community, and variation even within individuals. At this stage the umlaut triggering *i*-sounds would have been variously realized as segments spanning the range from [i] to [ə], such as the high central vowel [ɨ] and the upper-mid central vowel [ɵ]. There must have therefore been pronunciations with coarticulation of the umlauted vowels in which the triggering element, although present, was not pronounced as the corner vowel [i]—for example [muˌːsɨ] or [muˌːsɵ].

A possible objection to the description of this posited second stage is that the reduction of the *i*-sounds which caused coarticulation should have resulted in a reduction of this coarticulation. In other words, the weakened *i*-sound would be more likely to yield utterances like [muːsɨ] or [muːsɵ], without fronting of the back vowel. Although this may indeed have been the general trend for many OHG speakers, there is no reason to assume that coarticulation and the robustness of its conditioning segment will be perfectly correlated for all speakers in all instances. It is entirely plausible that speakers would have produced utterances with moderately—or, occasionally, even substantially—fronted vowels in less robust umlaut conditioning environments even if, in general, most speakers tended to show less coarticulation in these environments at this time. What I claim is that at this stage, such forms must have existed, not that they were the most common variants.

This second stage, characterized by normal coarticulation and weakening of unstressed syllables, would have created optimal conditions for changes of the hypo-correction type. Hypo-correction happens when listeners fail to compensate for coarticulation. Although this can, in principle, happen at any time, it is more likely to happen when the conditioning environment is weakened and thus not as easily identifiable to a listener. If the listener cannot identify the cause of coarticulation, he cannot compensate for it. For example, in a study on the perception of nasalized vowels, Kawasaki (1986) found that nasalized vowels were perceived as more nasalized when a neighboring nasal consonant was attenuated, and acoustically identical vowels were perceived as less nasalized in the presence of unattenuated nasal consonants. This phenomenon helps explain what was occurring in the late OHG period. Instead of nasalization caused by a following nasal consonant, the effect on umlauted vowels was fronting, and perhaps raising, caused by the high front vowels and glide. Weakening of the unstressed syllables which contained these *i*-sounds would have resulted in their centralization and a decrease in their amplitude. In utterances where these *i*-sounds still caused coarticulation, which I claim must have occurred at times, then the fronting would have been more perceptually salient. In such cases, a listener would be even more likely to fail to compensate for coarticulation, and in turn reconstruct the fronted vowel as the target pronunciation. Figure 3.5 shows such an exchange.

speaker's pronunciation target	/muːsi/
speaker's actual pronunciation	[muˌːsɨ]
listener hears	[muˌːsɨ]

listener reconstructs	/muˑ̠ːsɨ/

Figure 3.5 - exchange resulting in change of [uː] > [u̠ː]

This stage is where a true shift in the pronunciation norm—as opposed to normal synchronic variation due to coarticulation—could take place. Importantly, the hypo-correction model shows how the loss of a conditioning environment can actually be a causal factor in a sound change. However, as evident in Figure 3.5, if the change occurred at this stage in OHG, this would result in a change of [uː] > [u̠ː], not the observed change of [uː] > [yː].

The third stage is when secondary umlaut occurred, i.e. when the partially fronted back vowels in umlaut environments became fully fronted. The conditions described in the second stage played an important role in the change in that they satisfied the ideal conditions for hypo-correction. However, they do not explain the full fronting of the original back vowels.

The additional necessary condition for OHG secondary umlaut is variation among individuals in degree of coarticulation. Experimental work on *s*-retraction in American English (Baker, Archangeli, and Mielke 2011) has shown that even in a group of speakers who all exhibit the same coarticulatory patterns, some individuals show this coarticulation to a more extreme degree. This supports my characterization of the second stage of the change, where I claimed that at least some speakers would have had fronted vowels despite the reduction of *i*-sounds. Although sound change can be seen as the phonologization of coarticulation, it is not the phonologization of the general pattern of coarticulation in a speech community. Rather, it is the phonologization of the extreme coarticulation of certain individuals.

Baker et al. argue that sound change occurs when "inter-speaker differences in the *degree* of a phonetic effect facilitate identification of new targets" (350). If a speaker has a sufficiently extreme articulatory target, then a listener may interpret it as new phonetic target. In Ohala's model, the new target can be a common pattern of coarticulation that exists for many speakers of the language. For Baker et al., new targets are only identified when a listener encounters a speaker whose speech shows extreme coarticulation. Despite these important differences, the two models of sound change are consistent in that the basic mechanism of the change is a listener's failure to adequately account for coarticulation.

Computational work on population dynamics in sound change also suggests that instances of extreme coarticulation are necessary for sound change. Kirby & Sonderegger (2013) attempt to model the rise of primary umlaut in OHG, and find that it is best explained by a model which assumes that learners are exposed to some variants which show more coarticulation than expected. Their model accounts for a stable population in pre-OHG with minimal coarticulation, a stable population in OHG with full coarticulation, and the transition from the former to the latter.

I therefore propose that the shift from [uː] > [yː] at this stage—and the shifts in the other back vowels affected by secondary umlaut—followed from the convergence of two factors: 1) the

weakening of unstressed syllables, which made listeners more likely to fail to compensate for coarticulation; and 2) the existence of individuals with more extreme coarticulatory patterns than the general population. Although in principle a sound change could occur due to either one of these factors, both are required for a satisfactory account of OHG secondary umlaut. The weakening of unstressed syllables explains why the change occurred when it did—at the end of the OHG period. Individuals with more extreme coarticulatory patterns being the source of the change explains why the output was [yː], instead of only a partially fronted vowel. As unstressed syllables weakened, the probability of the misperception necessary for sound change increased. Misperception would have been most likely to occur for utterances which evinced extreme coarticulation, namely, full fronting of back vowels, such as [uː] > [yː]. Figure 3.6 shows a hypothetical exchange between a speaker with extreme coarticulation and a listener.

speaker's pronunciation target	/muːsi/
speaker's actual pronunciation	[myːsɨ]
listener hears	[myːsɨ]
listener reconstructs	/myːsɨ/

Figure 3.6 - exchange with extreme coarticulation resulting in change of [uː] > [yː]

Just as in Stage 2 of the change, forms like [myːsɨ] with a fully fronted vowel were not the pronunciation norm prior to the change. This view of sound change requires that the coarticulatory patterns which lead to sound change be more extreme than the normal coarticulatory patterns of the speech community.

In the fourth stage of the change, secondary umlaut has occurred, and back vowels are fully fronted in the umlaut environments. Unstressed syllables have been reduced to [ə]. Secondary umlaut is complete, and is now represented in the orthography.

To recapitulate, using a change of [uː] > [yː] as representative of secondary umlaut, the four stages in my account of the change are the following:

1. Coarticulation of back vowels before *i*-sounds resulting in partially fronted vowels, such as [u̟ː]. This stage is concurrent with primary umlaut.
2. Weakening of unstressed syllables that contain the *i*-sounds which condition secondary umlaut. This creates conditions favorable for hypo-correction type changes. This stage is in late OHG.
3. Individuals with extreme coarticulation, coupled with favorable hypo-correction conditions from Stage 2, lead to listener misperception resulting in [yː]. This is when the sound change occurs. This stage is in late OHG.
4. All umlaut conditioning *i*-sounds become [ə] or disappear entirely. Secondary umlaut is gradually represented in the orthography. This stage is in MHG.

3.4 Advantages over Past Approaches

I believe the account of secondary umlaut presented here has several advantages over the approaches discussed in Section 2. First, it avoids the criticisms Voyles raises against the T-theory. Since I claim that [yː] was not a regularly occurring allophone of /uː/ in OHG, my account is not vulnerable to the orthographic dilemma, which states that fully fronted vowels ought to have been reflected in OHG orthography. Similarly, since I assume that the vowel-to-vowel coarticulation in secondary umlaut environments in OHG was of the same type that could occur in any language at any time, my theory is not vulnerable to the *reductio* dilemma. The coarticulation I propose for OHG could have indeed existed in Proto-Germanic, or even Proto-Indo-European, because these languages must have evinced *some* coarticulation, just as all languages do.

Second, it explains how the sound change could have occurred alongside the loss of its conditioning environment. This apparent paradox motivated the commonly accepted view that the change had already occurred on the phonetic level in the OHG period, despite the lack of orthographic evidence for it. In my account, the loss of the conditioning environment plays an important role in causing the change, and the paradox is avoided.

Third, this account explains the phonetic enhancement evident in secondary umlaut. If [u̞ː] was the normal result of coarticulation, then the shift to [yː] requires further explanation. Although Schulze attempts to explain *i*-umlaut as listeners failing to compensate for coarticulation, he simply assumes that coarticulation gradually increased throughout the OHG period. There is no reason to believe that this was the case, other than the fact that the sound change happened. By drawing on the model of sound change outlined by Baker et al., my account explains the enhancement of the general pattern of coarticulation as resulting from individual variation in coarticulation. In this way an explicit path is drawn from the stage of moderate coarticulation of back vowels with *i*-sounds to the subsequent stage of fully fronted vowels.

Fourth, my account can explain certain aspects of the umlaut conditioning environment. Specifically, my description of the change suggests why the triggering element must be in an unstressed syllable. Since I argue that misperception occurred when extreme coarticulation was coupled with a weakened conditioning environment, triggers in unstressed syllables would have been more likely to cause the change. If extreme coarticulation were the only factor, then stress of the conditioning element would be irrelevant. Or, since unstressed syllables tend to be more heavily coarticulated than stressed syllables (Kirchhoff and Bilmes 1999), one might predict the opposite of what is observed, namely that umlaut should occur in unstressed syllables.

4.1 Conclusion

In this chapter I have argued that primary umlaut preceded secondary umlaut. Although this is supported by the OHG orthographic data, a problem arises in accounting for the emergence of secondary umlaut alongside the disappearance of the conditioning environment. My main goal in this chapter has been to provide a phonetically plausible account for how secondary umlaut must have occurred. Specifically, I argued that two factors were critical: the weakening of the

conditioning environment set the stage for hypo-correction, and individuals with extreme coarticulatory patterns provided the variants that fed the change.

My account has at least four advantages over past approaches to OHG *i*-umlaut. First, it is not susceptible to the same criticisms as theories which hold that secondary umlaut had already occurred on the phonetic level at the same time as primary umlaut. Second, it implicates the loss of the conditioning environment in the change itself, thereby removing the seeming paradox of the change having occurred after the conditioning environment's disappearance. Third, it accounts for the necessary enhancement of normal coarticulation in the OHG period to the fully fronted vowels resulting from secondary umlaut. Fourth, it explains why the conditioning *i*-sounds occurred in unstressed syllables.

In addition to providing a novel account of OHG *i*-umlaut, a secondary goal of this chapter was to demonstrate how phonetics can improve the analysis of problems in historical phonology. Viewed simply as an instance of vowel-to-vowel coarticulation, there is nothing puzzling about umlaut as a sound change. However, in order to understand how it developed in OHG, it was shown that a listener-based approach, coupled with an understanding of coarticulatory variation among speakers, was necessary. If the analysis here is correct, we have been able to resolve a long-standing problem of historical phonology.

At this juncture there are four further points I should like to make. First, it is clear that further research in this area will benefit from experimental work that attempts to recreate the circumstances surrounding OHG umlaut. Some of the key areas to investigate would be F2 changes as a result of vowel-to-vowel coarticulation in environments that replicate the umlaut environments, variation among speakers in degree of this coarticulation, and the perceptual consequences of attenuation of the conditioning *i*-sounds.

Second, as a complement to the laboratory work which must be done on umlaut, the problem could also benefit from being subjected to other phonetics-based approaches. In this chapter I have mostly followed Ohala's model of sound change, but other analyses may provide valuable insights. For example, the view of sound change outlined in Beddor (2009) would suggest that the cause of secondary umlaut was not hypo-correction, but rather listeners arriving at a different phonological interpretation of the acoustic signal. Crucially in this view, listeners would have correctly perceived the input as, say, [muˌˑsɨ]. But their phonological representation of it might amount to a form that is marked by, say, 'front' as the salient property, such that it accounts for a range of encountered variants, from those with more extreme coarticulation like [myˑsə], to those with less coarticulation like [muˑsi].

Third, there remains the question of why primary umlaut occurred before secondary umlaut. The account here shows that the picture suggested by the orthographic data is plausible. However, it is still an interesting question as to why umlaut would affect [ɑ] before the other vowels. One possibility is that the change of [ɑ] > [e] would have been more likely to occur in OHG because of the already existing /e/ phoneme. OHG speakers may have been more likely to interpret a fronted [ɑ] as belonging to the native /e/ phoneme, than to interpret a fronted [u] as belonging to the /y/ phoneme, which did not yet exist (for a similar argument in Gothic, see the discussion in

Section 4.1 of Chapter 5). This would explain why secondary umlaut did not occur until the optimal conditions obtained.

Finally, the problem of German, and Germanic, umlaut is a difficult one, littered with conflicting, sparse, and simply difficult data, especially when the dialectal diversity of MHG, ENHG, and NHG are taken into account. Given that it is a historical problem and our knowledge is largely incomplete, there will always be details that escape us. In light of this I have approached the problem from a narrow perspective, focusing on constructing a plausible phonetic account of secondary umlaut. However, work such as Penzl (1949), Dal (1967), and Voyles (1991) discussed above has shown that morphosyntactic factors played a role in conditioning the change. Although umlaut was, at its inception, a phonologically conditioned change, a full description of primary and secondary umlaut throughout the history of the German language certainly requires attention to factors outside of phonetics.

4

Nasal Vowel Raising in Early Germanic

1.1 Background

PGmc. *e* is raised to *i* in the early Germanic languages under different conditions. Voyles (1992:48 ff.) treats this as a change that spread throughout EGmc. and NWGmc, with slightly different environments in each, although the changes could perhaps be viewed as independent. In Gothic, for example, *e* always appears as *i* unless followed by *r*, *h*, or *h̨*, in which case it remains *e*, orthographically <aí>: Go. *wigs* vs. OHG *weg* 'way'; Go. *haírto* vs. OS *herta* 'heart'. In OHG, *e* > *i* when *i*, *ī*, or *j* occur in the following syllable. This is evident in the reflexes of PIE *bher-* 'to bear' in OHG: the infinitive *beran* shows no raising since it is followed by a non-high vowel; the third person singular form *birit* from PIE *bhéreti* shows that the original final *i* raised the preceding *e*, which in turn raised the root vowel.

This raising also occurs in OHG when *e* with primary stress is followed by a nasal and a consonant, for example in *wint* 'wind', cf. Lat. *ventus*. This change, as conditioned by nasals, is common to NWGmc., as seen in the infinitives of certain class III strong verbs, which come from an original PIE *e*-grade ablaut followed by a nasal and a consonant: OHG *bindan*, OE *bindan*, ON *binda*, 'bind'. Although *e* occurs as *i* in this same environment in Gothic, as in the cognate *bindan*, the Gothic change is better viewed as a general raising, which is only blocked by certain consonants, as described above—not as a raising necessarily conditioned by nasals.

The raising of PIE *e* to dialectal Germanic *i* before high vowels occurs alongside the lowering of *u* to *o* before the low vowel *a*. Here, another set of class III strong verbs illustrates the changes. In the participle of verbs of this class, the PIE form had a zero-grade ablaut. For example, the past participial form of the PIE root *kelb-*, 'help', had the form *kl̥b-*, with the PGmc. reflex of *hulpanaz*. The NWGmc. dialects unanimously reflect the lowering of the root vowel to *o*: ON *holpinn*, OHG *giholfan*, OE *holpen*; Gothic shows no such lowering. However, in the set of class III strong verbs mentioned above, where the root vowel is followed by NC, this lowering does not occur. Instead the PGmc. *u* is maintained, as seen in ON *bundenn*, OE *bunden*, and OHG *gibuntan*. NC therefore not only raises preceding mid vowels, but also inhibits the lowering of a preceding high vowel when it would otherwise be lowered. For the sake of economy of language, I will henceforth refer to both changes as "raising" where appropriate, although the latter is not an instance of vowel raising, strictly construed.

A variation of these phenomena is found in the Ingvaeonic languages, namely Old English, Old Saxon, and Old Frisian. Whereas in all of the NWGmc. languages, including Ingv., NC clusters raise *e to i and block the lowering of *u to o, in the Ingv. languages these changes also occur when conditioned by a single nasal, without a following consonant. Both changes can be observed in the reflexes of the principal parts of the PGmc. class IV strong verb *nemana 'take'. The infinitive appears with an unchanged root vowel in ON *nema* and OHG *neman*, but has undergone raising in OE/OS *niman*. The participle is reconstructed as *numanaz in PGmc., and its reflexes show lowering of the root vowel in NGmc. and OHG, but preservation of *u* in Ingvaeonic: ON *nomenn*, OHG *ginoman* vs. OE *numen*, OS *ginuman*.

The data presented here show that NC clusters had some sort of raising effect on mid vowels in early Germanic. In the case of PGmc. *e, this vowel was raised to i when followed by NC. In the case of PGmc. *u, this vowel was normally lowered to o when followed by a low vowel, unless NC intervened, or just a nasal in the Ingvaeonic languages.

2.1 Literature Review

Although Germanic phonologists are well aware that nasals condition the changes shown in Section 1, it is difficult to find a discussion of *why* they condition these changes. The handbooks list the changes and their environments, but few scholars address the phenomena in substantial detail.

2.2 Prokosch

Prokosch (1939) addresses the raising of PGmc. *e. His view differs, as ever, from the traditional account. Rather than treating the raising of *e as a change conditioned by nasals and high vowels, he instead views the raising as part of the 'drift' characteristic of the Gmc. languages. The raising was unconditioned, but it was blocked when followed by a non-high vowel. Although this is simply an alternative formulation of the same change and its environments, the difference is that under Prokosch's analysis, a following NC cluster did not cause raising, but rather "merely formed a syllable barrier that prevented the influence of the following [low] vowel" (1939:113). This same reasoning could presumably be extended to why *u does not lower to o before NC.

On nasals, Prokosch writes that "a nasal group forms a more effective syllable barrier than other consonants or consonant groups" (1939:100). Importantly, this statement does not implicate any specific properties, articulatory or otherwise, of nasals in the changes. However, observing that nasals appear to lower vowels in ON, as evident in *rekkr* 'man' vs. OE *rinc*, Prokosch suggests that this is likely the more common consequence of nasal clusters, writing that "[n]asals before certain consonants nasalize the preceding vowel, lowering both its acoustic effect and its actual articulation, and then disappear" (1939:113). It is not clear what exactly Prokosch means by "lowering [...] its acoustic effect"—perhaps he means lowering of vowel height, which in acoustic terms is the raising of F1.

2.3 Lass and Anderson

Lass and Anderson (1975) provide a Generative account of pre-nasal raising in Old English. According to their rule, any [- low] vowel is specified as [+ high] before a nasal. Observing that this rule cannot be construed as a type of assimilation, Lass and Anderson explain that the rule functions to reduce the number of vowel contrasts in pre-nasal environments. By eliminating [e] and [o] in this environment, "the exceedingly common and perhaps 'optimal' (or at least certainly minimal) three-vowel system /i u a/" obtains (70). They go on to demonstrate that this pre-nasal raising rule can be collapsed with a separate pre-nasal retraction rule into a single markedness rule, whereby non-low vowels become high vowels, and low vowels become back vowels, before nasals.

Lass and Anderson's account is typical of the Generative approach to sound change as discussed in Chapter 2. They construct rules which elegantly describe a language's phonological patterns in terms of features, but these rules do not, in principle, explain *why* the patterns occur in the first place. Lass and Anderson do, however, address this important question in a footnote, noting that "[i]t may be of some interest to inquire why this convention should operate at all. What reason is there for reducing the size of a vowel system in this environment?" (73). They consider the possibility that certain phonological environments are not conducive to many perceptual contrasts. They suggest, for example, that perhaps the reason fewer vowel types are found in syllables with low stress is because "the speed of articulation and relative lack of sonority function effectively as channel noise" (73). The extra formants caused by nasalization may introduce analogous "channel noise", which makes vowel contrasts more difficult to perceive in nasal environments.

2.4 Overview

It is evident that a more comprehensive treatment of the role of nasals in these changes is necessary. The question of why nasals raise vowels is, in my view, not merely "of some interest", as Lass and Anderson put it, but rather of primary interest to the historical phonologist. If we are to understand these changes, then we must understand why nasals condition vowels the way they do, and not in some other arbitrary way.

This group of changes is deeply tied to the larger issue of the application of phonetics to historical phonology. Although the changes are well known, the mechanisms behind them have received less direct analysis in the literature than seemingly similar Gmc. changes in which consonants condition changes in vowel quality (e.g., Howell 1991; Rauch 1967; Rauch 1973; Vennemann 1972). It is likely the case that changes in which the conditioner is an oral obstruent are more amenable to an analysis based on articulatory features. Featural descriptions of the segments involved make the assimilatory aspect of the changes transparent. However, nasals have complex articulatory and acoustic properties that cannot necessarily be represented in terms of traditional phonological features; indeed, nasalization is referred to as "the most complicated configuration of the vocal tract found in speech" (Johnson 2003:163). This suggests that a different approach is necessary to understand the changes. The discussion in this chapter will not

only shed light on a relatively unexamined set of changes, but also demonstrate the value of taking other phonetic aspects into account when articulatory approaches are clearly insufficient.

From the overview of the data in Section 1.1, two questions emerge which will guide the analysis. First, why would a nasal have the sort of raising effect on vowels that is observed in the NWGmc. languages? Second, why are the changes conditioned in all NWGmc. languages by NC clusters, but only in the Ingv. languages by just N?

In order to better understand these changes I will first survey the relevant articulatory, acoustic, and perceptual aspects of vowels and nasals. I will then argue that these changes are instances of hyper-correction in Ohala's model of sound change (see Chapter 2.6.1.1).

3.1 Vowel Raising in Phonetic Terms

Before discussing possible mechanisms for how nasals might have a raising effect on vowels, we must be clear about what it means for a vowel to be raised. Although the labels for distinctive features of vowels (e.g., [+/- front], [+/- back]) are derived from tongue position, these articulatory configurations also correspond to certain acoustic features of the vowel, which are what determine the listener's perception of vowel quality. Research has shown that there is a strong relationship, although not perfect correlation, between tongue position and formant frequencies (Ladefoged et al. 1978; Lee, Shaiman, and Weismer 2016; Wang et al. 2013).

The relative vertical position of the tongue in the mouth corresponds to the phonological property of vowel height, and acoustically it is correlated with the vowel's first formant, or F1. A high F1 value, generally caused by a low tongue position, corresponds to the perception of a low vowel, and a low F1 value, generally caused by a high tongue position, corresponds to the perception of a high vowel. Similarly, the phonological property of frontness/backness corresponds to the relative horizontal position of the tongue in the mouth. The acoustic correlate is the vowel's second formant, or F2. A high F2 value, caused by a front tongue position, corresponds to the perception of a front vowel, and a low F2 value, caused by a back tongue position, corresponds to the perception of a back vowel.

3.2 Nasal Vowel Raising as Hypo-correction or Hyper-correction

The sound changes under discussion are, in phonological terms, instances of vowel raising, but acoustically they are a lowering of F1. By viewing the sound change in terms of its acoustic properties, rather than solely its articulatory properties, we can model the change with Ohala's listener-based theory of sound change. As discussed in Chapter 2, for Ohala most regular sound changes belong to one of three categories: hypo-correction, hyper-correction, or confusion—with confusion and hypo-correction potentially viewed as one category. I will first describe how the nasal-conditioned changes would have occurred as either hypo-correction or hyper-correction, without any assumptions as to the actual phonetic behavior of nasals. This will illustrate how each category makes a different demand, so to speak, on the phonetic effects of nasalization. We will then examine the results of relevant experimental work in the phonetics literature to determine which category matches the data.

In a hypothetical hypo-corrective change from [en] to [in], the fundamental assumption is that the acoustic consequences of coarticulation between the vowel and the nasal are such that [en] is perceptually similar to [in], so that [en] may be confused for [in] by a listener. In other words, the articulatory gestures required to produce a nasal, when coarticulated with a preceding [e], have the acoustic consequences of lowering the vowel's F1, or otherwise creating the perception of a lower F1. In this case, when a speaker attempts to produce an utterance with the sequence [en], it will be perceptually similar to [in], because [i] has a lower F1 value than [e]. In most cases, listeners correctly attribute the *perception* of a lowered F1 to the following nasal, and reconstruct [e] as the intended vowel, in which case no sound change occurs. But in some instances, such as if the conditioning nasal is weakly articulated, a listener may fail to attribute his perception of the vowel's height to the presence of the following nasal, in which case he will not sufficiently compensate for the influence of the nasal. In such instances the listener will assume that a high vowel, [i] was in fact the articulatory target, resulting in sound change.

Alternatively, in a hypothetical hyper-corrective change from [en] to [in], the fundamental assumption is that nasal coarticulation results in [in] being perceptually similar to [en]. In this case, the articulatory gestures required to produce a nasal must have the acoustic consequences of raising F1, or otherwise creating the perception of a raised F1, of a preceding vowel. In a language where this type of phonetic nasalization is common, listeners will compensate for this coarticulation, and successfully reconstruct [in] as the phonological target. In other words, when a speaker of this language attempts to produce a sequence with [in], although it is perceptually similar to [en], listeners will attribute their perception of a mid vowel to the influence of the nasal, and reconstruct [in], with a high vowel. Sound change can occur under these circumstances if a speaker produces a sequence where the phonological target is, however, [en], but without substantial coarticulatory nasalization of the vowel. In this case the listener's perception of F1 matches the speaker's target and is relatively unaffected by the following nasal. But because of the listener's expectation that his perception of a mid vowel before a nasal is due to the nasal, he may hyper-correct, and reconstruct a high vowel as the target, even though it was not.

The acoustic and perceptual effects of nasals in a hypo-correction model of this change are very different from those in a hyper-correction model. Before turning to the literature that has specifically addressed these properties of nasals, we will discuss the articulatory aspects of nasal consonants and their coarticulation with vowels.

3.3 The Articulation and Acoustics of Nasals and Nasalized Vowels

Nasal stops, like oral stops, are articulated with a constriction in the oral cavity. The constriction can occur at virtually all of the same places of articulation as oral stops. Thus there exist bilabial [m], alveolar [n], and velar [ŋ] nasals, among others, alongside bilabial [p, b], alveolar [t, d], and velar [k, g] oral stops. During the occlusion of an oral stop, the air flowing from the lungs through the glottis accumulates in the oral cavity behind the constriction, until the constriction is released. What distinguishes nasal stops from oral stops is the lowering of the velum, or soft palate. A lowered velum allows for the nasal cavity to connect to the oral cavity, which in turn

allows for the nasal cavity to function as a resonator. This connection of the nasal and oral cavities is called "nasal coupling".

Like nasal stops, nasalized vowels are characterized by the lowering of the velum, resulting in nasal coupling. Although many languages have phonemic nasalized vowels, allophonic nasalization of vowels commonly occurs in other languages when a vowel is adjacent to a nasal consonant. So-called contextual nasalization (i.e., vowel nasalization caused by an adjacent nasal consonant, as opposed to a phonemic nasalized vowel) is a straightforward consequence of coarticulation: if the velum is lowered in anticipation of the following nasal before the stop closure is made in the mouth, then a portion of the preceding vowel will be nasalized; or, if the velum remains lowered following a nasal, then a portion of the following vowel will be nasalized. We can now turn to the acoustic and perceptual effects of nasalization.

Much work has been done on identifying the acoustic correlates of nasalization (e.g., Chen 1997; Fujimura 1962; Hattori, Yamamoto, and Fujimura 1958) as well as its effect on perceived vowel height (Beddor 1983; Beddor, Krakow, and Goldstein 1986; Carignan 2017; Wright 1986). For the present discussion, the most important acoustic consequences of nasalization are the introduction of nasal formants to the vowel spectrum, and the raising of the oral formants (Fujimura & Lindqvist 1971:552). Increase of the oral formants would suggest that nasal vowels will be perceived as lower than their oral counterparts, because a raised F1 corresponds to a lower vowel. However, Beddor, Krakow, and Goldstein (1986) point out that this is not necessarily the case, because the perception of height will depend on the lowest peak in the vowel spectrum, which, depending on the vowel, will be either the lowest nasal formant (FN), or the shifted F1. Low oral vowels have a high F1, but the lowest, and therefore first formant of the corresponding nasal vowel will derive from FN, and may result in the perception that it is higher vowel than its oral counterpart, despite the increase in the oral F1. On the other hand, high oral vowels already have a low F1, and in corresponding nasal vowels FN will be higher than F1. In this case the shift in F1 will affect the perceived vowel height, and high nasalized vowels will be perceived as lower than their oral counterparts. The result is that vowel nasalization—when it causes a shift in vowel height—tends to have a centralizing effect: high vowels are lowered, and low vowels are raised. This conforms with many of the observed typological patterns of contextual nasal vowel height (Beddor 1983).

Such changes are easily understood in the context of the hypo-correction model outlined above. When a listener hears a nasalized vowel which is perceptually similar to a centralized oral vowel, he will in most cases attribute his perception of the vowel's height to the presence of the nasal. But under certain circumstances, such as if the nasal consonant is weakly articulated and not perceived by the listener, then he may fail to attribute the difference in perceived vowel quality to the nasal consonant, and instead attribute it to a different tongue height, and reproduce the vowel accordingly. In such cases, the nasal consonant will also disappear as a result of the sound change.

4.1 Nasal Vowel Raising in Germanic as Hyper-correction

The Germanic changes under investigation are in the opposite direction of some of the typological patterns mentioned in Section 3.2. Mid vowels in Germanic are raised before a nasal consonant, not lowered. These changes must therefore fit into the hyper-correction model, which, given the acoustics of nasalization, predicts the Germanic changes.

If a listener is accustomed to hearing phonetically nasalized vowels in nasal contexts, then in most cases he will successfully compensate for the nasal consonant's effects on the vowel's spectral properties; this follows from the fact that listeners are able to compensate for coarticulation (see Chapter 2). When this listener hears a nasalized high vowel, although it may be perceptually similar to an oral mid vowel, his expectation of nasalization before nasal consonants allows him to correct for this perception and attribute it to the nasal consonant, not to a lower tongue height.

But hyper-correction can occur if this expectation is not met because the listener encounters a weakly nasalized mid vowel in a nasal context[9]. In cases where there is relatively weak nasalization, the listener hears a mid vowel, but his expectation of nasalization in the presence of the nasal can lead him to attribute his perception of a mid vowel to the nasal, and instead reconstruct a high vowel, thereby hyper-correcting for the nasal. This explanation for changes in nasal vowel height is supported by experimental work showing that speakers of American English overcompensate for unexpectedly weak nasalization (Beddor, Krakow, and Goldstein 1986).

Another important consideration is that hyper-correction will be more likely to occur in this situation if the nasalized mid vowel is also perceptually different from the oral mid vowel. That is, continuing with the example of hyper-corrective change from [en] > [in], it should be the case that nasalization not only perceptually lowers [i], but also has some effect on the perception of [e]. Beddor (1983) found that not only is nasalized [i] perceptually lowered to listeners, but so is nasalized [e]. If this were not the case, listeners would not necessarily hyper-correct [en] to [in], because it could also be interpreted, and in fact "correctly" so, as an instance of [en].

The hyper-correction model also accounts for the preservation of the conditioning environment in the Gmc. changes, where the conditioning nasal remains in all instances. The conditioning environment is often lost in hypo-corrective changes, because the weak articulation of the conditioning environment is precisely what makes the sound in question perceptually ambiguous. But in hyper-corrective changes, the conditioning environment must remain, because its presence is the very thing for which the listener is overcompensating.

This section has shown how the articulatory, acoustic, and perceptual properties of nasalization can, when understood through the hyper-correction model, explain the Gmc. changes. In the next

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[9] As emphasized in Chapter 2, the variability of speech production plays a key role in sound change. In hypo-corrective changes where the conditioning environment is lost, variability in speech production leads to weak articulation of the conditioning environment; in hyper-corrective changes of the type investigated here, variability in speech production leads to weaker than expected coarticulation. For variability of nasalization, see the references in Beddor (1986:212).

section we will consider the variation in conditioning environments found among the Gmc. languages.

5.1 Nasals in Syllable-final and Syllable-initial Position

As discussed in Section 1.1, the exact conditioning environments for vowel raising before nasals differ in the Gmc. dialects. In all Gmc. dialects, NC raises *e to *i*, and blocks the lowering of *u to *o* by a following *a*, *e*, or *o*. In Ingvaeonic (OE, OS, and OF), however, these changes are also conditioned by a single intervocalic nasal. The phonetic aspects of nasalization can provide more insight into the Ingv. phenomena.

Prokosch offers an explanation for the difference, writing that "[i]n Anglo-Frisian, single nasals formed a sufficiently effective syllable barrier to prevent a following vowel from influencing *i* or *u*" (1939: 113). This observation offers a useful starting point by suggesting that the syllable played a role in the sound change. It may otherwise be difficult to explain why—given that the nasal has been identified as the segment conditioning the sound change—NC would condition the change in all of these related languages, but N in only some of them, especially since there is no apparent restriction on, nor further specification of, C in the cluster. But if VN and VNC sequences behaved differently with respect to syllable structure, then this may point to how they could have affected vowels differently in the different dialects.

Consider the OE forms *niman* 'take', *limpan* 'to happen', and *wind* 'wind'. All three forms show raising of the root vowel from original PGmc. *e. These words are syllabified as /ni.man/, /lim.pan/, /wind/, respectively. Compare these with their OHG cognates *neman* (without raising), *limpfan* (with raising), and *wint* (with raising), which would have been syllabified as /ne.man/, /lim.p͡fan/, and /wint/.

Two distinct syllabifications are identifiable in the cited forms. Words like OE *niman* and OHG *neman* have a V.NV structure; that is, a syllable boundary intervenes between the vowel and the following nasal. In words like OE *limpan* and *wind* and OHG *limpfan* and *wint*, we find VN.CV and VNC#, which can be treated the same in terms of syllable structure: in both cases the vowel and the following nasal occur in the same syllable. Thus in words with a V.NV structure, the relevant vowel and the nasal are heterosyllabic, because the nasal is syllabified into the onset of the following syllable. In contrast, words of the type VN.CV and VNC# have the same syllable structure in that the vowel and nasal are tautosyllabic.

The conditioning environment can be formulated in a number of different ways. For instance, it is accurate to say that in all the NWGmc. languages, stressed mid vowels are raised, or prevented from lowering, by a following tautosyllabic nasal. In the Ingv. languages, these changes are also conditioned by a following heterosyllabic nasal. In this case, the phonetic question is how VN coarticulation differs when the nasal is tautosyllabic vs. heterosyllabic. Alternatively, the tautosyllabic nasal environment can be viewed as a vowel followed by a coda or syllable-final nasal, and the heterosyllabic nasal environment can be viewed as a vowel followed by an onset or syllable-initial nasal. In this case, the phonetic question is how VN coarticulation differs when the nasal is syllable-final as opposed to syllable-initial.

Research on the phonetics of the syllable has addressed these questions. Krakow (1999) provides a review of the relevant literature demonstrating that the syllable is a physiological unit, which has implications for how segments are produced when in different parts of the syllable. Even if there is no identifiable syllable boundary in the speech stream, Krakow (1989) suggests that the syllable can be detected on the physiological level in that segments have different articulatory patterns when in syllable onsets vs. syllable codas.

With respect to nasals, Krakow reports that work on various languages has repeatedly confirmed that syllable-final nasals are produced with a lower velum position than syllable-initial nasals (1999:25-6, with references). The lower velum position of syllable-final nasals relative to syllable-initial nasals means that an adjacent vowel will likely have a greater degree of coarticulation with a syllable-final nasal than a syllable-initial nasal, because the more extreme articulatory gesture is more likely to overlap with adjacent segments. Listeners may consequently be accustomed to vowels being more heavily nasalized before coda nasals than onset nasals. Since the expectation of nasalization will be greater before coda nasals than onset nasals, the potential for hyper-corrective change will also be greater before coda nasals than onset nasals.

Krakow (1989) investigated the articulatory differences between syllable-final and syllable-initial nasals while also controlling for position of the nasal relative to the vowel. The study found that for nasals immediately following vowels, syllable-final nasals reach a lower velum position, have a longer low plateau, a greater displacement amplitude of velum lowering, as well as a greater subsequent raising, all of which accord with syllable-final nasals having a greater coarticulatory effect on a preceding vowel. Stress was also a variable in this study, and it was found that velum lowering gestures had longer plateaus in syllables with primary stress than in syllables without primary stress. The role of stress is also relevant to the situation in Germanic, because nasals only raise vowels under primary stress. A following coda nasal will, by definition, be tautosyllabic with such vowels and therefore have a longer velum lowering plateau than nasals separated from the primary stressed syllable by a syllable boundary. This again points to the likelihood of greater vowel coarticulation with coda nasals than onset nasals in Germanic.

The syllable-initial nasals in the Krakow study were separated from the preceding vowel by a word boundary, whereas in Germanic the syllable-initial nasals which condition the change are, although heterosyllabic, still in the same word. Fujimura (1990) investigated the differences in velum position for word-internal syllable-final and syllable-initial nasals in Japanese, and the results are similar to Krakow's: syllable-final nasals are produced with a lower velum position not only on the margin of words, but also word internally. This study is important because the word-internal environments more closely match those of the Germanic changes.

Clumeck (1976) looked at differences in the duration of vowel nasalization when followed by syllable-initial nasals and syllable-final vowels in Brazilian Portuguese. He found that a greater proportion of a vowel is nasalized when followed by a syllable-final nasal than a syllable-initial nasal. This study is the most significant for our argument because it shows that nasals in different

syllable positions actually result in a different degree of nasalization in a preceding vowel. The other cited studies showed that syllable-final nasals have more extreme velum lowering gestures, which implies the possibility of greater coarticulation with, and thus greater nasalization of, a preceding vowel, but these studies did not measure this directly. Ultimately it is nasalization in the relevant environments, caused by coarticulation, that is the crucial expectation listeners must have in order for hyper-correction to cause the changes seen in Germanic.

Returning to our example Gmc. forms, the findings in the phonetics literature support the following claim. In PGmc. *lempan* and *neman*, resulting in OE *limpan* and OHG *limpfan*, and OE *niman* and OHG *neman*, respectively, there was a greater degree of coarticulation between the root vowel [e] and the following syllable-final nasal in *lempan* than between the root vowel [e] and the following syllable-initial nasal in *neman*, such that the [e] in *lempan* was more nasalized than that of *neman*.

For hyper-correction to occur, the listener must expect vowel nasalization in nasal contexts, since it is when this expectation is not met, as in the case of a weakly nasalized vowel, that the listener may overcompensate for the expected acoustic effects of the nasal, and reconstruct a mid vowel as a high vowel. Because this change depends on the expectation of nasalization in certain contexts, it follows that the greater the degree of nasalization a listener expects in a given context, the more likely that context is to yield a hyper-corrective change if the other necessary conditions are met. Since vowels tend to have greater coarticulation with syllable-final consonants than syllable-initial consonants, it stands to reason that listeners will expect more nasalization before syllable-final nasals than before syllable-initial nasals. Therefore, this type of change is more likely to occur before a syllable-final nasal than before a syllable-initial nasal. In other words, the interplay of coarticulatory, acoustic, and perceptual factors suggests that a mid vowel followed by a syllable-final nasal is a more favorable environment for raising due to hyper-correction than is a mid vowel followed by a syllable-initial nasal; but, importantly, such a change is possible in both contexts.

The phonetic factors discussed allow us to make certain predictions about how the changes may develop in different languages. Given that hyper-correction is possible in both environments, but that the position before syllable-final nasals is more conducive to the change, then we should expect that if a language shows raising of mid vowels in only one of the two contexts, it will be before syllable-final nasals. Likewise, we should not expect to find languages in which there is raising of mid vowels before syllable-initial nasals but not before syllable-final nasals.

And indeed, this is what is found in the Gmc. languages. In all the NWGmc. languages, including Ingv., there is raising before syllable-final nasals, which is the environment more favorable to the change. It is only in Ingv. that we also find raising before syllable-initial nasals, the less favorable environment. But crucially, in Ingv. it occurs in both environments, so these languages are in line with the predictions. The difference in the behavior of the Ingv. languages as compared to the rest of the NWGmc. languages can thus be explained as a function of the different probabilities of the change occurring in different environments. A vowel before a syllable-final nasal is in a position more conducive to the change, and the change should be found to occur in this environment in more languages; the change is less likely to occur before a

syllable-initial nasal, and this is evident in the more limited distribution of this change. The predicted distributions of the changes are matched by the Germanic languages.

6.1 Conclusion

The analysis presented in this chapter has shown that the raising of mid vowels before nasals in Germanic can be explained by careful examination of the phonetic properties of vowel nasalization. Coarticulation of a nasal with a preceding high vowel has acoustic effects which make the vowel perceptually similar to a mid vowel. Listeners generally compensate for the effect of such coarticulation, but in nasal contexts where there is little or no coarticulation, they may hyper-correct, resulting in the perception of a high vowel when the production target was in fact a mid vowel. In addition, it was seen that studies on nasal coarticulation help explain why environments with syllable-final nasals are more favorable to the change than environments with syllable-initial nasals, thereby explaining the broader range of environments for the change in the Ingv. languages.

A major impetus for this investigation was that, despite this change and its conditioning environments having been identified in the literature on Germanic, there was little satisfactory analysis of exactly how nasals conditioned the change. As was discussed in Chapter 2, much work in historical phonology has, either explicitly or implicitly, adopted a speaker-based approach to sound change that emphasizes articulatory factors. In many instances this approach can be effective and yield an analysis that more or less aligns with that resulting from a listener-based approach, as long as the connection between articulation, acoustics, and perception is relatively straightforward—this is often the case for instances of assimilation. However, the acoustic and perceptual consequences of nasalization are complex and do not follow as clearly from the articulatory factors as other changes might, and thus require a more comprehensive phonetic approach in order to be properly understood. Moreover, hyper-correction changes in general are not amenable to speaker-based approaches, since these changes hinge on the listener's expectations and are sometimes, in a sense, a reversal of the typical effects following from coarticulation. Therefore, this change is doubly suited to an approach that exploits the findings of laboratory phonetics.

The analysis in this chapter is far from a complete treatment of all possible questions surrounding these changes. Of the myriad areas still to be studied, I will consider four possible avenues for further research. The first is a broader investigation of how nasals condition changes in Gmc., with attention to variation in the different dialects. Indeed, the Ingvaeonic languages seem to differ considerably from the other NWGmc. languages in this regard, and not just in that syllable-initial nasals raise mid vowels, as was discussed in this chapter. There are other changes of interest: in Ingvaeonic is also found the change known as the nasal spirant law (the phonetic mechanisms of which are discussed in Ohala and Busà 1995), in which nasals disappear before spirants and the preceding vowel is lengthened (e.g., OE *ūs* vs. OHG *uns* 'us'); similar is the pan-Gmc. nasal loss with compensatory lengthening before [x] as in Go. *brāhta* 'brought', alongside its infinitive *briggan*, phonetically [brɪŋɡɑn]; Anglo-Frisian, a subset of Ingv., shows raising of long low vowels before nasals, as in OE/OF *mōna* 'moon', from Pre-Anglo-Frisian **māna*; there is also the variation between *a* and *o* before nasals in OE as in *hand*/*hond* 'hand'.

Whether these changes can all be connected with one another and to the change investigated in this chapter, some perhaps as the result of a higher degree of subphonemic nasalization in Ingvaeonic, is an open question, but one certainly worth pursuing.

The second area to pursue is further experimental work on the differing perceptual effects of nasalization on front and back vowels. Beddor (1983) found that although experimental data support the predicted direction for shifts of nasalized front vowels, this is not the case for back vowels. Nonetheless, the typological evidence she gathered shows that when front mid nasalized vowels are raised, the same tends to happen for back vowels. Clearly the relationship between nasalization, vowel height, and vowel frontness is complex, and requires more study. The evidence clearly supports the analysis here for the behavior of nasalized front vowels in Gmc., but perhaps other factors are involved with back vowels.

A third area for more research is the typological evidence supporting my claim that the position before syllable-final nasals is more favorable for raising of mid vowels than the position before syllable-initial nasals. Are the different distributions of changes predicted by the phonetic findings supported by evidence from languages outside of Gmc.? A survey of non-Germanic languages could lead to the formulation of a phonological implicational hierarchy, which would speak to tendencies and/or universals.

A fourth area would approach the phenomenon of mid vowel raising in Germanic more broadly by considering the high front segments [i, iː, j] which also condition the change. Although their influence is more amenable to traditional analysis in terms of phonological features, a contrastive analysis between their effect and that of nasals would be valuable. Of interest is the fact that the high front segments cause the change in vowels which are not under primary stress, as in PIE *bhéreti* > OHG *birit* 'bear' 3sg., where the final *i* in the PIE form raised the second *e*, which is not under primary stress. Nasals, however, only condition the change when the preceding vowel receives primary stress.

5

The Phonetic Interpretation of
<gg> in Wulfila's Gothic

"[E]s darf kein rohes phonetisches Material sozusagen mit Haut und Haaren in die Phonologie glatt übernommen werden." - Jakobson (1962:281)

1.1 Gothic <gg>

Certain words in Gothic contain the orthographic sequence <gg>. These words can be divided into two groups, corresponding to two different historical origins of the sequence. In one group of words, Gothic <gg> represents earlier [ŋg]. In some forms this is the continuation of Proto-Germanic *ng, as in siggwan 'sing', and briggan 'bring'. This interpretation is certain on the basis of comparative evidence from the Germanic cognates, e.g., English sing, bring, German singen, bringen. In other forms, such as borrowings from Greek, <gg> also represents [ŋg], for example in aggilus 'angel'.

Indeed, this orthographic convention in Gothic is due to the influence of Greek orthography on Wulfila's creation of the Gothic alphabet and writing system (Marchand 1973:34). When a nasal is followed by a velar obstruent in Greek, it assimilates to the latter's place of articulation. The resulting velar nasal is represented by γ, the Greek grapheme that otherwise represents the voiced velar stop [g]. For example, the source of Gothic aggilus is Greek ἄγγελος 'messenger', phonetically [aŋgelos].

In the other group of words, <gg> represents the reflex of an earlier change called Holtzmann's Law, which will be discussed in more detail in Section 1.2. In this group of words, <gg> always appears as part of a larger cluster, <ggw>, which was the output of Holtzmann's Law. Most treatments of this change suggest that it resulted in Pre-Gothic *[gːw], that is, a voiced geminate velar stop followed by a labiovelar glide. Examples of words having undergone Holtzmann's Law in Gothic are bliggwan 'strike', glaggwo 'exact', and triggws 'loyal'.

At least two interpretations of the synchronic status of <gg> in Wulfilian Gothic have been advanced in the literature (see Section 4.1). One is that these historically distinct phonological sequences had merged by the time of Wulfilian Gothic, and were therefore pronounced the same way, namely [ŋg]. This is what is suggested by the orthography. The second interpretation is that the <gg> sequence had two different pronunciations in Gothic: [ŋg] from sequences with an original nasal, and [gː] in words that underwent Holtzmann's Law. In this chapter I will consider the evidence in favor of and against these two possibilities, and it will be concluded that the first is the more likely.

1.2 Holtzmann's Law

Holtzmann's Law is the term given to a series of changes, which, put very simply, involve the gemination of the glides *w and *j in the prehistory of the Germanic languages, with different reflexes in the different branches of Germanic. The changes were first identified by Holtzmann (1870), and have received extensive treatment in the literature since then; for a relatively recent literature review, see Smith (1997).

An illustrative example is Gothic *triggws* 'loyal', whose Germanic cognates include ON *tryggr* and OHG *triuwi*. These forms likely originate from a PGmc. root *trew-. It is believed that the first stage of the change was gemination of *w. Afterwards, the first component of the geminate glide was vocalized in WGmc., but developed a consonantal reflex in EGmc. and NGmc.

The glide *j developed similarly: Go. *twaddje* 'two (gen.)', ON *tveggja*, OHG *zweijo*, from PGmc. *twaj-. Note that here, as opposed to the changes resulting from the labiovelar glide, the Go. and ON reflexes differ in their consonantism, although both have a consonantal reflex.

As with any worthwhile problem in historical phonology, there likely exist as many different perspectives on Holtzmann's Law as there are scholars who have written on it. Perhaps all that can be safely agreed upon is that PIE *j and *w geminated after a short vowel, which then led to further changes, the reflexes of which are represented by the Germanic forms cited above. Why the glides geminated, how they developed consonantal reflexes in EGmc. and NGmc., and all the other details obscured behind the veil of prehistory, remain controversial. A range of different approaches has been suggested, including morphological (Kuryłowicz 1967), laryngeal-based (Smith 1941), and syllable-based (Suzuki 1991) analyses.

1.3 Phonetic Plausibility of [gː] > [ŋg]

The purpose of this chapter is not to settle the litany of questions surrounding Holtzmann's Law. I assume, based on what appears to be the current scholarly consensus, discussed below in Section 2.1, that Holtzmann's Law, whatever the change or set of changes encompassed by that term, resulted in the sequences *[gːw] and *[dːj] in Pre-Gothic. These are represented orthographically in Wulfilian Gothic by <ggw> and <ddj>, respectively.

Instead, the present investigation is concerned with whether Pre-Gothic [gː], with Holtzmann's Law as its source, underwent a change to [ŋg] by the time of Wulfilian Gothic. Although this is

what the orthographic evidence and other internal evidence (see Section 4.1) point to, this view has been met with resistance since such a change has been seen as implausible. However, I will argue that such a change is plausible and well-motivated due to universal phonetic constraints. I will further argue that, in light of the structure of the Gothic phonological system, such a change was in fact the most likely to occur among all the possibilities. It follows that <gg> always represents [ŋg] in Wulfilian Gothic.

In addition to settling this question of Gothic phonology, another goal of this chapter is to show how phonetics can aid historical phonology by providing an empirical framework for plausibility in sound change. By considering universal constraints on speech such as the aerodynamic voicing constraint, I will show how such factors can allow the historical phonologist to make certain predictions about sound change, which can then be corroborated by language-specific evidence.

The rest of this chapter will be structured as follows. Section 2 will review the literature surrounding the synchronic interpretation of <gg> in Wulfilian Gothic. Section 3 will consider the universal phonetic motivations for a change from [gː] > [ŋg]. Section 4 will consider the Gothic-specific motivations for such a change. Section 5 will conclude the discussion.

2.1 Literature Review

Most scholars believe that <gg> had two values in Wulfilian Gothic. It is universally agreed upon that <gg> represents [ŋg] in Gothic words whose earlier form has the nasal. The disagreement arises over the interpretation of <gg> from Holtzmann's Law; most scholars hold that it represented [gː]. Again, although this question is in certain respects deeply connected with the group of changes subsumed under Holtzmann's Law and the prehistory of Gothic, my concern here is solely with the synchronic, phonetic interpretation of <gg> in Wulfilian Gothic, after Holtzmann's Law had already taken place.

Nonetheless, it is fitting to begin with the view of Holtzmann, who rejects the double interpretation of <gg>, writing: "[d]ie Gemination gg kommt nicht vor; denn das vorkommende gg ist nicht verdoppeltes g, sondern der gutturale Nasal, oder ng" (1870:22-23). Interestingly, on the result of the change applied to *j, he writes that in Gothic "dd scheint [...] einen nasalen Laut zu haben" (29), a claim that is hardly ever, if ever, advanced by other scholars.

An early commenter against the nasal interpretation, Scherer writes in 1868 that "[f]ür die Nasalierung, die nach der gangbaren Meinung in den genannten Wörtern eingetreten wäre, wüsste ich absolut keine Erklärung" (855).

The double value of <gg> is accepted in many of the handbooks of Gothic and Germanic phonology. Braune (Braune and Heidermanns 2004:73) writes that "[d]as aus *ww entstandene <ggw> scheint jedoch langes (geminiertes) g + w wiederzugeben, also [bliggwan] usw." Wright (1954:10) states "[t]he combination ggw was in some words equal to ŋ + gw, and in others equal to gg (a long voiced explosive) + w. When it was the one, and when the other, can only be determined upon etymological grounds". Krahe (1966:36) writes on Holtzmann's Law that

"[a]us -*u̯u̯*- wird im Got. und Nordischen -*ggw*-", which suggests a geminate velar interpretation of the sequence, not a nasal. Similarly, Hirt (1931:113) writes that from Holtzmann's Law "(nord- und ostgerm. *ggj* und *ggw* entsteht", with no suggestion of a nasal interpretation of <gg> in this context. According to Prokosch (1939:92), after the *ww stage, "[i]n West Germanic, the first part of the lengthened semi-vowel forms a diphthong with the preceding short vowel, but in Gothic and Norse it is narrowed to a stop", with no mention of the possibility of a nasal. Voyles (1992:95) has *ww* > *ggw* as the second stage of Holtzmann's Law into Gothic, but interprets this as "(?gw)", suggesting uncertainty as to the exact phonological value. Nonetheless, he does not state the possibility that <gg> may represent [ŋg] here.

In contrast, a minority claims that the sounds had merged by the time of Wulfila, and that <gg> invariably represents [ŋg], which is the view I will defend in this chapter. Rauch (2011:42) comments that "it seems reasonable to consider all <gg> regardless of genetic origin as [ŋg]. The fact that native speakers are not etymologically sophisticated and the very low functional load (four roots) speak in favor of a homophonous interpretation." Referring to instances of <ggw>, Snædal (2011) holds "that internal evidence points only to /ngw/ and that external evidence cannot be used to support double pronunciation of the cluster" (145). He argues that Holtzmann's Law resulted in [gˑw], a sequence which "found no support in Gothic phonology" due to the absence of the sequence [gw] anywhere in the language. Similar to Marchand, discussed below, Snædal contends that [gˑw] and [ŋgw] must have coalesced due to their similarity, in "a kind of analogy" (149).

Marchand (1973) argues that <gg> only has the nasal pronunciation. His is perhaps the strongest support for this claim found in the literature. He raises five points in defense of his view (88-89). First, <gg> otherwise always signals nasal + velar in Gothic. The only reason to think that it would represent anything else in the words in question is because of their different etymology. Second, the sequence <ggw> is in most cases broken up as <gg/w> in line breaks in the manuscripts, which suggests that all such sequences are the same. The one instance where this is not the case, <trig/gwa>, is paralleled by forms like <hug/greiþ>, where the <gg> is known to come from etymological *ng. Third, when <gg> occurs in larger consonant clusters, it patterns identically to clusters that have a nasal or other sonorant consonant—for it to represent a geminate stop here would appear to violate Gothic phonotactics. Fourth, the Gothic verb *bliggwan* 'strike', derives from PGmc. *bleuwan, a class II strong verb. However, in Gothic it has the preterite singular form *blaggw*, as though it were a class III strong verb. Since class III strong verbs are characterized by having a root with a nasal or liquid, this suggests that the earlier [gg] in *bliggwan* had changed to [ŋg]. Fifth, since Wulfila knew Latin, he could have marked a pronunciation difference orthographically with <ng>. He did not need to rely on the Greek practice of using <gg> to represent nasal + velar. In view of these facts, the internal evidence strongly points towards a single, nasal interpretation of <gg>.

Since geminate obstruents are virtually non-existent in Gothic (see the Gothic consonantal inventory in Section 4.2), then the putative geminates in <ggw> and <ddj> arising from Holtzmann's Law would have been marginal phonemes, which Marchand believes would be more likely to undergo analogical change. Unfortunately, Marchand does not explicitly

formulate the basis for such an analogy; his most direct statement on the matter is simply that "[i]t is not too farfetched to think of analogy in the case of this cluster" (90).

Marchand writes that "the evidence for the double value of *ggw* is only comparative, and I do not believe that anyone, in default of the comparative evidence, would advance the theory that *ggw* had two values. Yet the comparative evidence is to be accorded greater weight than the internal evidence if it is shown that the sound change necessary for the assumption of a single value is improbable" (89). In other words, although all internal evidence in Gothic points to a single value for <gg>, this view may be rejected in favor of comparative evidence if accepting it would also entail the acceptance of an implausible sound change.

Marchand's words here point to the root of the problem. Probably no scholar would dispute that the internal Gothic evidence overwhelmingly points to the nasal interpretation of <gg> in all cases. The real problem is that the change from [gː] > [ŋg] appears implausible. Indeed, Scherer's words above seem to reflect almost a frustration with this possibility. To be sure, those scholars who do believe that all instances of <gg> represent /ng/ have generally not been able to formulate a compelling motivation for the change itself. Marchand and Snædal, for example, both resort—facilely, it could be argued—to analogy without any substantive justification. Rather than accept a seemingly implausible change on the basis of substantial internal evidence, most scholars have chosen to weigh the comparative evidence more favorably, and concluded that <gg> must have represented two different pronunciations depending on etymology.

If the basis of the disagreement has been correctly identified, then it follows that the problem would be resolved if the proposed change were demonstrated to be plausible. There would no longer be a compelling reason, or, to my knowledge, any reason at all, for the comparative evidence to take precedence over the internal evidence. Provided no new evidence comes to light, the interpretation of <gg> as [ŋg] in all instances could be unconditionally accepted. In the next two sections I will attempt to demonstrate why a change of [gː] > [ŋg] is phonetically plausible and well-motivated in Gothic.

3.1 The Aerodynamic Voicing Constraint and Phonetic Plausibility

A change from [gː] > [ŋg] is phonetically plausible due to the aerodynamic voicing constraint (AVC). The AVC and the types of changes to which it is conducive are well known in phonetics. However, since the purpose of the present work is to inform investigations in historical phonology with the findings of phonetics, a more thorough presentation of the AVC and its implications for sound change is appropriate.

I will first explain the phonetic basis of the AVC. I will then explain why voiced velar geminates are likely candidates for sound change according to the AVC. Finally, I will explain what types of changes the AVC predicts for a voiced geminate, including prenasalization, resulting in a homorganic nasal + stop sequence.

The AVC can be stated simply: the vocal fold vibration of voicing requires that subglottal pressure be higher than oral pressure. In view of this constraint, the articulatory gestures required

for the production of certain classes of sounds may either inhibit or facilitate voicing. The following discussion will closely follow Ohala (1997), but it is important to note that much of this derives directly from the basic principles of articulatory phonetics, discussed in introductory works (e.g., Ladefoged 2001; Gick, Wilson, and Derrick 2013).

Although the AVC has implications for segments of many phonetic types, it will be instructive to explain its role in a voiced stop, since this is the Gothic segment in question. In the production of a voiced stop, a complete constriction is made in the vocal tract—at the lips for a labial stop, for example, or by the tongue touching the soft palate for a velar stop. The vocal folds are adducted such that the airflow through the glottis causes them to vibrate, resulting in voicing. Because of the constriction, the air passing through the glottis cannot escape through the mouth. Air therefore accumulates in the oral cavity as long as voicing continues. This results in an increase in pressure in the oral cavity relative to subglottal pressure. Airflow for voicing requires that subglottal pressure be higher than oral pressure[10]. Since oral pressure is rising during a voiced stop, the requisite pressure differential will not be maintained if voicing goes on for long enough. In such a case, airflow will fall below the necessary level for voicing, at which point voicing will cease.

Of course, these aerodynamic factors do not mean that voiced stops cannot exist. Rather, it can be said that the articulatory demands of a voiced stop tend to inhibit voicing. If voiced singleton stops tend to inhibit voicing, then voiced geminate stops must inhibit voicing even more due to their long closure duration. The longer the closure of the stop, the higher oral pressure will rise, and the more difficult it will be to maintain optimal airflow. One phonological implication of these articulatory facts is that a voiced geminate is, all else being equal, more likely to undergo a change than a segment less in conflict with the AVC.

The place of articulation also plays an important role. Oral pressure is determined in part by the size of the oral cavity. The larger the oral cavity, the more air it will take for oral pressure to rise to a level that inhibits voicing. It follows from this that the larger the oral cavity, the longer it will take for oral pressure to rise to a level that inhibits voicing, assuming airflow is the same. Therefore, the further back a stop's place of articulation in the oral cavity, the more inhibitory the voicing conditions will be. Thus, in addition to its status as a voiced geminate, the velar place of articulation of [gː] further inhibits voicing, increasing the bias towards change.

These theoretical considerations are supported by typological data collected in the UCLA Segment Inventory Database (UPSID), which has the inventories of 451 languages. That voiced stops are dispreferred is evidenced by the fact that 96.67% of the languages in the UPSID have voiceless stops, whereas 66.3% have voiced stops. 3 languages, or .67% of the languages in the database, have voiceless geminate stops, whereas only 1, or .22%, has voiced geminate stops. 89.36% of the languages in the UPSID have the voiceless velar stop [k], compared to 56.1% which have the voiced velar stop [g].

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[10] The exact requirement for voicing is that airflow be above 1 to 2 cm H_2O (Catford 1977:29).

To summarize, the phone [ɡɡ] conflicts with the AVC in three ways in that it is 1) a stop, 2) a geminate, and 3) a velar. Together, these three counts against the voiced velar geminate constitute good phonetic motivation for it to undergo change. To be clear, the AVC does not predict that voiced velar geminates cannot occur, nor that they must change if they do occur. It could not, on the basis of the discussion up to this point, be claimed that Pre-Gothic *[ɡɡ] *must* have changed. I therefore make instead a more conservative claim: the phonetic facts presented so far support the internal evidence in Gothic that Pre-Gothic *[ɡɡ] had undergone a change. In other words, I have not yet demonstrated that the specific change of [ɡɡ] > [ŋɡ] is phonetically plausible, but I have demonstrated that, generally, a change from [ɡɡ] to some as yet unspecified segment(s) is phonetically plausible.

However, it follows from the AVC not only that segments like [ɡɡ] are likely to change, but also in what ways they are likely to change. As discussed above, at least three of the articulatory features of [ɡɡ] conflict with the AVC, inhibiting voicing. Therefore, if such a segment were to change, one prediction is that it would become voiceless. Another prediction is that it would change some other feature in order to maintain voicing.[11] Below we will consider the various possible outcomes of [ɡɡ] in view of the AVC. In this section I will limit the discussion to segments which involve as few changes in phonological features as possible, but in Section 4.2 I will consider a wider range of possibilities.

If [ɡɡ] were to devoice it would result in a voiceless geminate. Since the long closure duration of a geminate inhibits voicing, then speakers may not voice the segment for its entirety, or not voice it at all. This would result in a segment like the voiceless geminate [kː], or possibly something that could be transcribed as [ɡk]. In either case, the segment could be perceived by listeners as the voiceless geminate. Thus, one possible outcome for [ɡː] would be [kː].

The manner of articulation could also change to facilitate voicing. Since it is the complete closure of a stop which inhibits voicing, an obstruent with incomplete closure, such as a fricative, may better facilitate voicing. However, the aerodynamics of frication also pose their own constraints, and in fact there is a bias against voiced fricatives (Ohala 1997). Optimal frication requires that oral pressure be as high as possible relative to atmospheric pressure (the pressure of the ambient air outside the speaker's mouth). This is directly in conflict with optimal voicing, which, as stated above, requires relatively low oral pressure. Nonetheless, we can still consider voiced fricatives as a possibility. A change in manner from stop to fricative would result in the geminate voiced velar fricative [ɣɣ].

Another possibility is a shorter closure duration resulting in a voiced singleton stop. Although voiced stops are dispreferred by the AVC, they do not inhibit voicing as much as a voiced geminate. In an attempt to maintain voicing for the duration of the geminate stop, a speaker may not produce a stop as long as a normal geminate consonant. Such a stop could be misperceived by listeners as a voiced singleton stop. In the case of [ɡː], this would yield [ɡ].

[11] Garrett and Johnson (2013: 62) suggest that the AVC predicts that voiced stops will devoice, all else being equal, and that the other possible outcomes are motivated by contrast maintenance. Although this raises an interesting question, it is not central to the discussion here, because the other possible outcomes, which are all voiced, are still necessarily constrained by the AVC.

A forward place of articulation would also facilitate voicing. The further forward the constriction in the vocal tract, the larger the oral cavity. Pressure will rise more slowly in a larger oral cavity, since there is more space for the air to fill. As compared to a velar stop, then, a palatal stop would be less inhibitive of voicing, and would be another possible route for [ɡɡ] to take if it were to undergo a change, resulting in [ɟɟ].

In addition to devoicing, which avoids the AVC problems entirely, frication, simplification to a singleton stop, and palatalization address the three ways in which [ɡɡ] conflicts with the AVC. However, there are at least two other possible articulatory strategies for facilitating the pressure differential necessary for voicing. One such strategy is to lower the glottis during the production of the stop. Lowering the glottis effectively increases the size of the oral cavity, and decreases the size of the subglottal cavity. All else being equal, this will lower oral pressure and raise subglottal pressure, which will facilitate voicing. The reason this could result in a sound change is because the downward movement of the glottis during a voiced stop resembles the articulatory gestures involved in the production of an implosive stop. In the production of an implosive, the glottis is lowered and oral pressure falls such that when the oral constriction is released, air first flows into the mouth, and then back out, which gives the implosive its characteristic sound. In some productions of a voiced geminate, the glottis could be lowered to such a degree that an implosive is produced. Thus, another possible outcome of [ɡɡ] is [ɠ], the voiced implosive velar stop.

Lower oral pressure could also be maintained by allowing air to escape through the nasal passage. Lowering the velum opens the velopharyngeal port, such that some of the air flowing through the glottis would enter the nasal cavity instead of the oral cavity. This would keep oral pressure lower and facilitate voicing. If the velum is raised again during the last part of the segment, then the segment would still have many of the characteristics of an oral stop. Such an articulatory gesture would result in a prenasalized stop, or homorganic nasal + stop cluster. Thus, another phonetically motivated outcome of [ɡɡ] is [ŋɡ][12].

An understanding of the AVC and basic articulatory phonetics has allowed us to make predictions about what types of changes [ɡː] could undergo. We have determined that the following changes are possible: devoicing resulting in [kː], frication resulting in [ɣː], simplification resulting in [ɡ], palatalization resulting in [ɟː], implosion resulting in [ɠ], and prenasalization resulting in [ŋɡ]. With the possible exception of frication resulting in [ɣː]—because of the bias against voiced fricatives (Ohala 1997)—all of the changes are phonetically plausible.

We can now strengthen our previous claim. Not only does the phonetic evidence support the possibility that Pre-Gothic *[ɡɡ] underwent a change in the first place, it also shows that, among other potential changes, the change of [ɡɡ] > [ŋɡ] is plausible. Importantly, prenasalization of voiced stops is not only theoretically plausible, but also attested in other languages. For example, the prenasalized stops in Mixtec are believed to derive from earlier plain voiced stops (Iverson

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[12] Although there is debate over whether prenasalized stops should be viewed as their own complex segments or simply as sequences of nasal + stop, we will treat them as the latter (see Feinstein 1979).

and Salmons 1996a:168), and in certain dialects of Japanese, earlier voiced geminates are realized as sequences of a nasal followed by a voiced stop (Ohala and Ohala 1991:213).

In view of the substantial internal evidence in favor of the interpretation of <gg> representing [ŋg], the phonetic evidence connecting this interpretation to the reconstructed form *[gː] appears to be decisive.

4.1 Phonological Plausibility in Gothic

In addition to the phonetic evidence adduced above, there is phonological evidence from Gothic that can strengthen our argument. The purpose of the previous section was to demonstrate that the change of [gg] > [ŋg] is phonetically plausible. It was not yet necessary to show why the prenasalized stop specifically, among all the possibilities enumerated, would be the outcome of the voiced geminate, since considerable internal evidence already pointed to the conclusion that Gothic <gg> represented [ŋg]. The aim was only to show that the change was plausible, not that it was *more* plausible than any other conceivable change.

However, the argument for the interpretation of <gg> from Holtzmann's Law as [ŋg] is strengthened by evidence that [ŋg] was in fact the most likely outcome of Pre-Gothic *[gg]. I will argue that evidence from Gothic phonology shows that the supposed change is in fact the most likely change to have occurred. To be clear, I do not mean that I will be uncovering other internal evidence of the type used to argue that the orthographic sequence <gg> must have represented [ŋg], such as that presented by Marchand (see Section 2.1). Rather, what I intend to argue is that even in the absence of such evidence, given the possibilities determined by the AVC, careful examination of Gothic phonology would reveal that if a change were to occur, the resultant [ŋg] was not only a plausible outcome, but in fact the most probable one.

I see at least three benefits to this exercise. First, it will further complement the considerable internal evidence and my phonetic plausibility argument. As discussed in Section 2.1, the missing piece in the current state of research on this issue is an argument for phonetic plausibility. Nonetheless, in historical phonology, where the data are often so incomplete and difficult, every available piece of evidence ought to be exploited in order to achieve as much certainty as possible. Second, it may serve as an example for how to approach similar problems where the internal evidence is not so clear. Third, it may serve a useful rhetorical purpose, in that it will reassure a perhaps skeptical historical phonologist that phonetics is not everything—domain knowledge of individual languages is essential to historical phonology.

I propose that all of the possibilities considered in Section 3.1—the voiceless geminate [kk], the voiced geminate fricative [ɣɣ], the voiced singleton stop [g], the voiced palatal geminate [ɟɟ], the velar implosive [ɠ], and prenasalized [ŋg]—would have been from time to time produced by Gothic speakers. The picture becomes more accurate if we do not think of these different segments as entirely discrete categories with respect to the original [gg]. For example, speakers could produce a range of variants between completely voiced [gg] and completely voiceless [kk]. Similarly, there is a continuum of possible lengths between geminate [gg] and singleton [g],

different degrees and durations of velum lowering are possible between a fully oral stop [ɡɡ] and prenasalized [ŋɡ], and so on.

Recalling Ohala's listener-based categories of sound change introduced in Chapter 2, a change from [ɡɡ] due to the AVC would fall into the category of "confusion". The listener-based model assumes that listeners try to reproduce what they hear. Confusion-type sound changes occur when a speaker produces an utterance with a certain articulatory configuration which is perceptually similar to an utterance with a different articulatory configuration. In such cases the perceptual similarity may "confuse" the listener as to the articulatory gestures which produced the utterance, and go on to reproduce the utterance with a different articulatory pattern than that of the speaker.

The sound change would occur when a listener perceived an utterance with one of these variants as something other than the intended [ɡɡ]. Although each of the variants differs from [ɡɡ] in at least one articulatory aspect, they all share one or more articulatory features with it which could lead to perceptual confusion, such as velar place of articulation, stop articulation, or voicing, all of which would result in acoustic similarities.

In principle, any of the proposed outcomes could have been the result of the sound change. However, it stands to reason that if perceptual confusion is the cause of the change, then the most likely reflex would be a segment, or sequence of segments, which already existed in the language. If some variant of [ɡɡ] was close to a perceptual category a speaker of Gothic already had, then a listener should be more likely to misperceive the variant as belonging to that category, than to misperceive another variant as belonging to a perceptual category which does not exist in the language.

This claim is relatively intuitive and follows from the easily observable fact that speakers adapt foreign words to their native phonology. It is more robustly supported by work on perception of native and nonnative contrasts, such as in the Perceptual Assimilation Model (PAM), (e.g., Best 1993; Best 1995). According to the PAM, once speakers have become attuned to the phonology of their native language, a process which begins in infancy, this affects their perception of non-native contrasts. Phones which are close to existing categories in a speaker's native language will be mapped to those categories. This may lead to speakers having difficulty perceiving contrasts that do not exist in their native language, if, say, the two contrasting phones are similar to a single phoneme in their native language. However, a speaker will be able to perceive non-native contrasts quite well if the contrasting phones do not resemble any native phonemes (Best, McRoberts, & Sithole 1988).

In the case of Gothic, we can therefore predict that of any possible allophonic variants of [ɡː], those which are not otherwise contrastive in the language will be less likely to be perceived as distinct from [ɡː]. But if one of those variants is closer to another phoneme in Gothic, then it has a much higher chance of being mapped to that phoneme, since Gothic speakers would be attuned to this particular contrast.

4.2 Gothic Phonology

At this point a brief overview of the Gothic consonant inventory is in order. The inventory outlined here is taken largely from Rauch (2011:47-49).

Voiceless stops   /p/ /t/ /k/ /kʷ/

Gothic had a four-way voiceless stop series. The labial, alveolar, and velar stops had both aspirated and unaspirated allophones, whereas the labiovelar stop did not have an aspirated allophone.

Voiced stops   /b/ /d/ /g/ /gʷ/

Gothic had a four-way voiced stop series, parallel to the voiceless series. The labial and alveolar stops were voiced fricatives post-vocalically, but stops elsewhere. /g/ was a voiced fricative in all positions except after nasals, in which case it was a stop, and word-finally, in which case it devoiced to [x]. /gʷ/ only occurred after nasals.

Fricatives   /f/ /θ/ /h/ /hʷ/ /s/ /z/

The Gothic fricatives did not have any allophones.

Nasals   /m/ /n/

Both nasals probably had voiceless allophones when occurring word-finally in clusters, as in *bagms* 'tree' and *taikns* 'sign'. /n/ had the allophone [ŋ] before velars.

Liquids   /l/ /r/

The liquids also probably had voiceless allophones word-finally in clusters, as in *fugls* 'bird' and *akrs* 'field'.

Approximants   /w/ /j/

The approximants did not have any allophones.

We shall consider each of the phones enumerated in Section 3.1 as possible outcomes of a change from [gg] according to the AVC. Although there is no [kk] in the inventory above, orthographically geminated *kk* does appear in loanwords such as *aikklesjo* 'church', which is a borrowing from Greek ἐκκλησία. Although it likely represents a geminate in Greek, it is uncertain whether it would have actually been pronounced as a geminate in Gothic—Wulfila may have simply preserved the spelling. More importantly, even if Wulfila himself, a speaker of Greek, pronounced the word with a true geminate, it would still have been a non-native phoneme for Gothic speakers, and perhaps infrequently occurring, depending on the extent of Christianization in the population, and thus likely not a robust perceptual category.

Although there is no voiced geminate fricative [ɣɣ] in Gothic, the /g/ phoneme was in all positions except postnasal realized as the voiced velar fricative [ɣ]. In Section 3.1 we considered as few featural changes as possible in determining the possible outcomes of [gg]. Considering all further changes which could then happen to these reflexes would not be methodologically sound, since in theory there is no limit to the changes which could occur. However, we will consider the possibility that [ɣɣ] simplified from a long fricative to a short fricative [ɣ]. <gg> for [ɣ] is unlikely for three reasons. First and most importantly, our discussion in Section 3.1 should be recalled, in which we noted that the change from [gg] to a voiced fricative would be unlikely because frication and voicing pose conflicting demands on oral pressure. Second, Snædal (2011:149) notes that there is no <gw> sequence medially in Gothic except for in *bidagwa* 'beggar', which Lehmann (1986:67, B46) suggests may be a scribal error for *bidaga or *bidaqa. This is relevant because the <gg> sequences resulting from Holtzmann's Law always occur as part of the larger cluster <ggw>, which would entail the introduction of a new cluster, [ɣw], to the language. Whether the absence of an attested [ɣw] in Gothic is evidence for a phonotactic rule forbidding it, or simply an inductive gap, is uncertain, but it is another piece of evidence to consider. Third, although this section is focused on evidence from the structure of Gothic phonology, in the case of [ɣ] it is worth noting that Wulfila's orthography decisively precludes a singleton fricative interpretation. Since orthographic <g> would have represented [ɣ] in the positions in question, there would be no reason for Wulfila to write such sequences with <gg>.

An allophone of /g/, the singleton voiced velar stop [g] only occurs after nasals; elsewhere /g/ is realized as the fricative [ɣ]. This affords certainty that Gothic did have a phonotactic restriction against [Vg] sequences. This would rule out misperception of [gː] as [g], since Pre-Gothic *[gg] always occurs postvocalically.

There is no evidence for palatal obstruents or implosives of any kind in Gothic. Since we are operating on the principle that existing categories in the language would be the most likely candidates for reflexes of [gg], this rules out the possibility of [ɟɟ] and [ɠ].

Prenasalized [ŋg] is the final possibility. Words with [ŋg] are abundant in Gothic (see Section 1.1). These have the same orthographic representation as the cluster in question, <gg>, but derive from PGmc. *[ŋg]. It can be considered a normally occurring cluster in Gothic.

Of the possible outcomes of Pre-Gothic *[gg], all save for [ŋg] either do not occur in Gothic, are marginal phonemes, or would violate a phonotactic constraint if they occurred in the words in question. Although universal phonetic principles limit the possible reflexes of [gg], it is the Gothic-specific phonological constraints which make [ŋg] the most likely outcome. Coupled with the substantial internal evidence that has been adduced by other scholars, the phonetic analysis supports my claim that [ŋg] as the Wulfilian Gothic reflex of Pre-Gothic *[gg] is not only a plausible reality, but in fact the most likely one.

5.1 Conclusion

In this chapter I have argued that Gothic <gg> represented, in all cases, underlying [ŋg]. I argued this by attempting to show that the proposed change of Pre-Gothic [gg] > [ŋg] is phonetically plausible due to the aerodynamic voicing constraint. I further argued that by viewing the change in light of the AVC, predictions can be made about the possible outcomes of the change. Of these possible outcomes of [gg], the phonological structure of Gothic points to [ŋg] being the most likely. From my review of the literature on the subject, it is evident that although internal evidence supports my view on the interpretation of <gg>, it has been rejected by scholars who see the change [gg] > [ŋg] as implausible. If my argument has been successful, then it should resolve the disagreement, and settle this difficult aspect of Gothic phonology.

Beyond contributing to our knowledge of Gothic, the analysis here also shows the value of phonetics in understanding sound change. More specifically, it shows the value of using universal phonetic principles to inform notions of plausibility in sound change. Indeed, Ohala (1993:237-8) suggests that for historical phonologists, "plausibility is determined inductively, that is, by what the linguist has previously encountered in other human languages," adding that "the inductive constraints on posited reconstructed forms and the sound changes that apply to them do not require that the linguist actually understand why languages are structured as they are or behave as they do, all that is necessary is to be aware of structure and behaviour frequently encountered". The disagreement over the interpretation of Gothic <gg> seems to have hinged on historical phonologists working in Germanic not knowing that prenasalization is a change which may occur to voiced stops. Perhaps this is because prenasalization does not otherwise occur in the early Germanic dialects, and is rare or non-existent in the other historical Indo-European dialects. No matter the reason, it is clear that historical phonology is well served by incorporating the findings of phonetics into its practices. At the same time, I have also attempted to show that language-specific phonological factors are still integral to the study of sound change, and the use of phonetics should serve as their complement, not replacement.

6

Conclusion

1.1 Conclusion

Many past approaches to historical phonology have focused on description of sound change; in cases where scholars have attempted to understand what causes change, they have typically sought the answer in articulatory patterns. However, many sound changes are not amenable to a straightforward articulatory analysis. They often require a more detailed understanding not only of articulation, but other phonetic factors such as acoustics, aerodynamics, and perception. The result is that some sound changes are understood either not very well, or not at all. In order to improve the analysis of such problems, in this study I have investigated three sound changes in the early history of Germanic with an approach grounded in phonetics.

In Chapter 3, I considered OHG *i*-umlaut, a long-standing problem in the field. Although umlaut-type changes are common in Germanic, and other types of vowel harmony are widely attested in diverse languages, I showed that by attending to all the relevant phonetic factors, the change could profitably be reanalyzed, despite the vast literature surrounding it. I concluded that OHG *i*-umlaut was a type of hypo-correction, and that the phonological conditions in the late OHG period, coupled with individual variation in coarticulation, conspired to form the necessary circumstances for the change to occur. In Chapter 4, I investigated the raising of nasalized mid vowels in the early Germanic dialects. This change has been well documented in the literature, but there have been very few attempts to actually explain why nasals condition the change. By surveying the articulatory, acoustic, and perceptual properties of vowel nasalization, I showed that the change is best understood as an instance of hyper-correction. This model predicts the observed changes, as well as some of the variation in the change's conditioning environment among the dialects. In Chapter 5, I evaluated two different interpretations of the orthographic sequence <gg> in Gothic. I argued that Go. <gg> represents [ŋg] in all instances, regardless of etymology. The literature on this subject has generally rejected such a view, because it presupposes an earlier change of *[gg] > [ŋg], which many scholars have viewed as implausible. By evaluating [gg] in the light of the aerodynamic voicing constraint relative to the structure of Gothic phonology, I concluded that such a change was in fact highly plausible, thereby strengthening the argument for the single interpretation of <gg> as [ŋg].

Each of my analyses of the three sound changes stands on its own, but together they serve a larger theoretical goal: to demonstrate the value of the study of both phonetic production and phonetic perception to historical phonology. In each of the chapters I identified how phonetics

can help solve a more general type of problem, not just the specific sound change investigated in that chapter. OHG *i*-umlaut, discussed in Chapter 3, exemplifies sound changes in which the basic mechanism is already well understood. By more closely considering the intricacies of the phonetic factors of sound change, in particular, individual variation in coarticulation as well as listener compensation for coarticulation, I have shown how even supposedly well-understood changes can be better analyzed. The raising of nasalized vowels, discussed in Chapter 4, is an instance of a sound change where the environment has been identified, but the conditioning is not well understood. Here a deeper understanding of the phonetics of the conditioning environment was shown to be necessary to explain the change. The issue of Gothic <gg> discussed in Chapter 5 raises the question of phonetic plausibility. Probably most scholars who reject a change of [ɡɡ] > [ŋɡ] as implausible do so simply because they are not familiar with such a change. However, the aerodynamics of voicing shows that this change is plausible. Historical phonologists equipped with this and other phonetic knowledge will be better able to assess the plausibility of individual sound changes, even if they had not encountered such changes before.

The treatments of the sound changes here demand further work. I have suggested areas for more research in each chapter, but it is important to reemphasize that the understanding of these changes would best be served by experimental work which models the conditions of each change as closely as possible. Although in many cases the articulatory and acoustic properties of different phones are well established, it is crucial to test the perceptual side of sound change with experiments involving listeners.

I have had two goals in this dissertation. The first was to advance the state of research on the three sound changes I considered. The second was to demonstrate how phonetics can benefit the study of sound change in historical phonology. I will have been successful in both of these goals if the reader is persuaded to consider applying an approach similar to mine to other sound changes.

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