

Feature-Geometric Harmonic Serialism and the RUKI Sound Law

A proposal for a modern diachronic phonology

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Abstract

*The RUKI Sound Law, wherein the reflex of Indo-European *s comes down as [ʃ] in Sanskrit after [r u k i], has remained an open question in linguistics for over a century. The problem with this change is that [r u k i] do not form a natural class: there is no way to define them as a set according to articulatory features which both include all of them, and exclude every other segment.*

This project aims to provide a solid answer to the RUKI problem using current analytical techniques. Specifically, it proposes a constraint-based analysis using a modified version of Harmonic Serialism (McCarthy 2016) which has integrated the Clements & Hume (1995) version of feature geometry. It expands on the interpretation that feature changes constitute a single operation in HS GEN. We must explicitly attach a feature theory to the model so that we know which features are available in the derivation. This dissertation proposes Feature-Geometric Harmonic Serialism (FGHS) to address this issue.

This dissertation also addresses concerns about constraint-based diachronic phonology, examining and challenging many of the criticisms levied against it. While FGHS is not itself capable of solving all the concerns, it has the potential to develop into a model which does solve the problems.

*The formal analysis of the RUKI Sound Law argues that it is a telescoping of at least two changes: the first was a general place-assimilation of *s to the place of the preceding segment, with the assimilated allophones later being phonemicized into the singular [ʃ]. This analysis is backed by a statistical analysis of a large sample of Sanskrit tokens of [ʃ] which show that the RUKI set should not be defined as a natural class, but is instead as an “accidental class” shaped by distributional patterns rather than featural characteristics. *s only appeared after a subset of segments, and The RUKI Set were the only ones which would be able to assimilate /s/ to anything other than its organic dental place. Through this analysis, this dissertation shows that derivational-serial constraint-based models are entirely viable for historical research.*

Dedication

To my beloved wife

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1. Introduction

The development of phonology and historical linguistics has always been linked closely together. The Neogrammarians, after all, planted their flag on the claim that there is a process of sound change which is exceptionless, as all apparent exceptions were hypothesized to really just be signs of other rules at work in the data (Ringe & Eska 2013). The ensuing mantra, ‘sound change is regular’, could not be anything but phonological in nature (*Ibid*). However, over the last few decades a growing divide has developed between formal phonologists and historical linguists, beginning primarily with the introduction of Optimality Theory (OT) in the 1990s (Prince & Smolensky 2004). While the phonological innovations of the preceding twenty years had been derived from the commonly accepted *Sound Pattern of English* model (Chomsky & Halle 1968), albeit with significant revision, the shift from generative phonology to Optimality Theory brought with it a revolution in the field’s approach to phonology. Those who accepted OT quickly abandoned the traditional generative focus on featural representations, instead relying solely on the constraint ranking to map a vaguely defined ‘input’ to a more definite ‘output’. Those who rejected OT simply continued working in the reliable generative framework, this being a group which included many historical linguists (Longerich 1998; Ringe & Eska 2013). Thus, both camps became increasingly disconnected from each other in research, assumptions, and methods. It is the considered opinion of this present study that such a divide has been a mistake for both fields, and has left both the lesser for it.

For any Optimality Theorist, or researcher working in any of the numerous derived theories such as Harmonic Serialism or Maximum Entropy (which shall henceforth all be grouped together as ‘Optimality Theorists’ unless there is need to discuss contrasts within that broad family of theories), the loss to historical linguistics is obvious (Goldwater & Johnson, 2003;

McCarthy, 2016). Without adapting to the use of OT, historical linguistics lacks the easy solution to phonological conspiracies on which OT was built. It furthermore lacks, as do all rules-based theories, the firm explanatory power of OT, as the rules fundamentally remain descriptive, while OT constraints explicitly give motivation for why the grammar emerges in the shape it does. It furthermore means that historical linguistics is limited in terms of the modern research and innovations it can access. Only the remaining generativists and the historical linguists themselves can modify and revise the phonological theories and methods in use, rather than historical linguists being able to focus on explaining sound changes while phonologists focus on developing the theory as theory.

For those who immediately reply that there is no reason historical linguists cannot also be phonologists, this is of course completely true. But it does lead into the other issue, which is that the divide between historical linguistics and OT phonology means that such interdisciplinary work becomes much harder. When historical linguistics and theoretical phonology operated from the same theories and held all the same assumptions, it was trivial for innovations and discoveries in one to percolate to the other. Consider the work of Kiparsky (1981), who used the analysis of a historical sound change, the RUKI Sound Law, as part of his argument for a synchronic theory of phonology, that being Lexical Phonology. To be a phonologist was to study contemporary historical linguistics; to be a historical linguist was to study past phonology. But with phonology and historical linguistics divided this unity is lost. Thus, it would be of great benefit for historical linguistics to be brought into the use of OT or some related theory.

However, there is another side to this, as it is not only historical linguistics which stands to benefit from such a reintegration. OT itself suffers as much from this separation as historical linguistics. Since the advent of OT, the focus of analysis has been primarily on synchronic data

and particular changes in particular environments, while largely ignoring diachrony and the broader context of a language. An entire paper can cover a single constraint ranking, and make little reference if any to how this ranking fits in with the overall language in terms of creating an overarching, unified grammar in the old style (Elfner 2016; Gleim 2019; Jesney 2009). Now, this includes much work with factorial typology and the analysis of what languages can and cannot exist, a very important project and one which OT can be justly proud of adding to our understanding of human language. Others will in essence use a language simply as the means by which some new constraint or theoretical mechanism is proved or disproved, passing through one language after another across the article to show evidence in favour of the thesis (Kimper 2011; McCarthy 2003, 2008b, 2018; Tanaka 2013). Now, these are in themselves good things, as synchronic data is the bread and butter of phonological research. Indeed, it would be a worse situation if we could properly model only historical data, and could not explain how any living speakers spoke. Nor are articles like this unique to OT, and the articles cited here are all excellent additions to the field and to phonological study. But it does reveal something of a gap regarding diachrony, leaving a wealth of important data largely underanalyzed.

Optimality Theory likewise often struggles to acknowledge or incorporate an understanding of the particular history of the language in question, as these things run counter to the basic principles of OT. Given the principle of the Richness of the Base, it is in practice impossible to establish a firm and consistent underlying representation, and therefore every phonological alternation must be the result of a single-step, fully parallel derivation. This may or may not capture how language works in the mind of any particular speaker; that is a discussion for another time. It certainly does not at all capture how language changes over time. Particular changes occur and become incorporated by young learners, which then lays the groundwork for

further changes. That is, the outputs of the older generations are taken as material from which a full suite of new inputs must be reverse-engineered by younger generations. Change develops via the failure to properly transmit the actual underlying representations of the language, leading to younger speakers creating differing hypotheses and building a grammar from that. This kind of step-by-step change is the bread-and-butter of historical linguistics, concerned as it is with the various changes which brought one language to be another, but it is totally beyond conventional OT analysis. This is precisely where, from a broad perspective, OT is under-tested. It has proven, albeit with much revision and often through the use of modified theories which diverge from its original form, quite adept at explaining synchronic data. But it has yet to substantially prove itself useful for analyzing historical data. This is not to say that OT is necessarily poor at it, but rather that the research which would show its value, for good or for ill, does not at present exist in sufficient quantity.

This should give reason for pause. It is practically axiomatic in this day and age to assert that language is always changing, and the most obvious way, after the constant churn of lexical slang, of showing this is in phonology. If OT is capable of handling diachronic data, then we should at once turn at least some focus to properly analyzing such data in light of the new models, so that we can better understand language as a whole. But if it is not so capable, then this should be a matter of great concern. Whatever the benefits of OT in analyzing the current state of particular languages, we should be wary of continuing to accept any phonological theory which proves incapable of explaining how language got to its current state.

This then, at the most basic level, is the purpose of this present study: to attempt a reintegration of historical linguistics and theoretical phonology, to show the value of both to the other. The above problems require resolution, and that is exactly what this present study intends

to provide. For this purpose, this dissertation will need to provide that very constraint-based analysis of diachronic data mentioned just above, and will need to do so convincingly.

Now, before we get to the topic of what material the dissertation shall cover in pursuit of this reintegration, some comments must be made as to the choice of theory. As noted, ‘Optimality Theory’ is in some ways a family of theories all working from their common origin in (Prince & Smolensky 2004). Each of the variant theories which have spawned from the original OT proposal have their quirks, their benefits, and their drawbacks. It is therefore important to establish which kind of OT is going to be used in this present study. Despite the above, this present study is not intending to make use, or defend in particular, classic Parallel OT. Whatever its merits, Parallel OT is fundamentally limited, and while it is not as bad for analyzing synchronic or diachronic data as some have claimed, it is far from an ideal choice (McMahon 2000, 2007). Rather, this present study will instead make use of Harmonic Serialism (HS, McCarthy 2016), in particular outlining a modified version called ‘Feature-Geometric Harmonic Serialism’ (FGHS), discussed in detail in Chapter 3.

This dissertation will argue that HS is superior to OT in terms of analyzing diachronic phonology, primarily due to its derivational nature, as opposed to the parallel nature of OT. By acknowledging that operations must apply in sequence, HS is better suited to model the kind of one-by-one changes which actual history shows, without the risk of telescoping changes which may have taken generations to actually develop. However, HS in its conventionally understood form shares a key characteristic with Parallel OT: it in practice ignores the underlying representation. That is to say, HS retains the OT principle of the Richness of the Base, whereby any input can be mapped to a licit output. Under this assumption, the particular structure of the input is irrelevant so long as the broad-strokes are known, as the constraint ranking alone is held

to be sufficient to ensure that the attested output will emerge regardless (McCarthy 2010, 2016). As will be discussed later in the dissertation, the representational agnosticism which Richness of the Base encourages is somewhat at odds with the actual theoretical structure of HS. Specifically, the assumption of Gradualness in HS, while not by any means contradicting the belief that any input can be mapped to some licit output, significantly limits the possible input-output mappings based on the featural structure of the input. To the end of addressing this tension, and better situating the model for use with diachronic data, specifically that data in which we observe successive featural changes over the span of multiple generations, this dissertation proposes a variant of HS which selects a particular feature theory, here that of Clements & Hume (1995), and fully integrates it into the model. This will allow for a better working out of the assumptions embedded in HS Gradualness, and will become essential for the analysis of the data this dissertation intends to work with.

On that note, it is at last time to introduce the primary data for the dissertation. The RUKI Sound Law has been a matter of some discussion for over a century in phonological study. The observed process in Sanskrit, as well as effectively all of the Satem-branch languages of Proto-Indo-European (PIE), whereby *s retracted after any of [r u k i] is quite a difficult sound change to analyze. It has been acknowledged as a problem for decades, with various proposals put forward to try and explain it (Allen 1973; Kiparsky 1981; Longerich 1998; Vennemann 1974; Zwicky 1970). As our understanding of feature theory developed it became only stranger, as the new feature definitions only reinforced the fact that these four segments do not in fact form anything resembling a conventional natural class. Zwicky (1970) did manage to define a conventional natural class, but rather than proposing to have solved the issue, that study rather held it to be both an unusual class by the conventions of its model, SPE, and a mark against that

model for allowing such a class. Venneman's (1974) proposed solution involved the creation of a new kind of natural class, the *relative acoustic* natural class, which would bypass the need to group [r u k i] by any coherent set of features, and instead rely on the idea that all four had a common acoustic effect on adjacent segments. This analysis received empirical support from Longerich (1998), using data from English speakers.

This present study takes a different approach, one based on the work of Allen (1973), who expanded on ideas present in Zwicky (1970) to argue that the problem with RUKI may be that it simply is not a natural class at all, but rather the result of neutralizing multiple separate processes. These separate processes were argued to have been various instances of place-assimilation altering the single fricative of Sanskrit at that stage, whereafter they all neutralized to [ʃ]. It is on this basic assessment that the rest of this dissertation will be based.

Fundamentally, this dissertation asserts that the RUKI Sound Law has never made sense as a conventional natural class because it is not one. Rather, it is what shall be termed an 'accidental class', a set of segments united not by any qualities of the sound themselves, but rather by their distribution in the lexicon of the language. As will be seen in Chapter 5, when assessing a large sample of Sanskrit words, it was found that of those segments which ever actually appeared before *s in meaningful numbers, only [r u o k i e] would be able to trigger any sort of visible assimilation. This is an important point which has not been discussed in any previous study. To this point in the field, it was taken for given that RUKI should be analyzed internally, that is, with references to the characteristics of the set and how they might form a class. This dissertation asserts that this approach, while conventional, was incorrect, and that rather we should consider RUKI as something emergent from the particular lexical entries which existed in Sanskrit at the time. That is, the problem with the existing RUKI analyses is here held to be that they tried to

answer the question of how to make [r u k i] a natural class. This dissertation contends, in contrast, that we should instead seek to answer why we should only see this change after [r u k i]. While the difference between these two angles is subtle, it is important. This dissertation will show that the RUKI Sound Law is best understood as a product of segmental distribution, with [r u k i] forming not a ‘natural’ class, but what might be termed an ‘accidental’ class. The set of [r u k i] is simply the set of segments which could procedurally show evidence of place-assimilation on a following *s, and which were also in a position to actually trigger such assimilation.

The dissertation is structured as follows: Chapter 1 has been the introduction. Chapter 2 covers the Literature Review, going over the sources on which the present study is built, including discussion of Optimality Theory, historical linguistics, Feature Geometry, Harmonic Serialism, and analytical approaches to the RUKI Sound Law itself. Chapter 3 outlines Feature-Geometric Harmonic Serialism, establishing its place in the assumptions of classic HS and demonstrating its use and its own theoretical assumptions. In particular it argues for the need to explicitly incorporate a feature theory into HS in order to properly obey Gradualness, and shows the consequences of such integration. Chapter 4 covers an extended discourse on the reintegration of theoretical phonology, particularly constraint-based models like OT and FGHS, with historical linguistics. It includes a response to the various critiques laid against the use of OT for diachronic research, particularly those of McMahon (2000, 2003, 2007). Chapter 5 discusses the problems of the RUKI Sound Law itself, giving a brief history of its analysis and comparing different approaches. It then discusses the above-mentioned statistical analysis of RUKI, showing that the Sound Law is better explained by reference to segmental distribution than to the featural characteristics of [r u k i]. Chapter 6 gives the analysis proper for the RUKI Sound Law, using FGHS to explain each change independently and the neutralization to [ʃ].

Chapter 7 provides discussion on the RUKI analysis, with reference to outstanding questions and avenues for future research. Chapter 8 concludes.

2. Literature Review

2.1 Introduction

Before we can proceed to the dissertation proper, we must first set the stage. This present study draws on multiple linguistic traditions in the hope of synthesizing them for the greater benefit of the whole field. Specifically, the intention is to reunite Historical Linguists with Optimality Theorists, with a simultaneous integration of Feature Geometry into Harmonic Serialism, and to then show how the union of these two branches of phonology can be of great benefit to ongoing diachronic and synchronic linguistics research. Therefore, quite a bit of groundwork must be done before the full scope of the dissertation can be either appreciated or properly understood. This is not a study which would be entirely transparent to a student of any one of these fields: rather, at least one of them would likely remain opaque without some baseline being established. That is, therefore, the purpose of this chapter.

This chapter covers the broad theoretical background of the dissertation. Section 2.2 briefly covers the RUKI Sound Law, the topic which will be the main analysis of the dissertation in Chapter 6. Further discussion of RUKI can be found in Chapter 5, but this section here will establish the basic framework of the discussion. Section 2.3 covers Feature Geometry insofar as it is relevant to this dissertation. Section 2.4 discusses Optimality Theory, which is given a greater focus in this chapter than the prior two sections, as it will not be discussed in as much detail afterwards. Section 2.5 shifts to Harmonic Serialism, a serial-derivational variant of Optimality Theory which forms the basis of the analytical model this dissertation will propose. This section will include the definition of HS GEN which is in use in this present study, as this is an important part of any HS analysis. Section 2.6 discusses historical linguistics as relevant to

this dissertation, with an eye towards the controversies around using constraint-based models for diachronic analysis. Section 2.7 concludes.

2.2 The RUKI Sound Law

In the Satem branch of the Proto-Indo-European languages, there is a historical rule by which *s became retracted after non-low vowels, syllabic and non-syllabic [r], and velars (Whitney 1895). This set is normally referred to by the acronym RUKI, and this change is consequently the RUKI Sound Law. In each of the major Satem languages, the reflex of retracted *s is a different fricative: it comes down as [x] in Slavic; as [ʃ] in Iranian; and as [ʂ] in Sanskrit (Allen 1973).

The RUKI Sound Law has been an acknowledged problem of Proto-Indo-European (PIE) linguistics in some form or another for over one hundred years. The unexpected and seeming unnatural composition of the triggering environment is noted as being strange at least as far back as Whitney 1884). However, it is not until the 1970s with Zwicky (1970), Allen (1973), and Vennemann (1974) that formal analyses of the change seem to appear. Prior to this point the analysis of RUKI was hedged entirely in Sanskritist terms, with a focus on pronunciation and translation. Other work would focus on the historical linguistic aspect, arguing over the grouping of the RUKI changes across the Satem branch and the order of changes. The issue at hand is why the RUKI set should act as a natural class: what do non-low vowels, velars, and coronal rhotics have in common? Many answers have been offered to this question, though as of yet none seems to have been accepted as consensus.

The earlier stages of RUKI analysis were primarily done from a Sanskritist lens, and therefore do not answer questions in the manner of later generative analyses. The first of these is found in Whitney (1884), who gives a clear description of the pattern we now call the RUKI Sound Law. He covers the environment in which the alternation to [ʂ] occurred, being after a

non-low vowel, the [r] (both consonantal and syllabic), and the dorsal stop. He speaks also of the exceptional environment, as the RUKI Sound Law does not apply if there is a following [r].

However, as the purpose of his work is not to provide a modern linguistic analysis, and is rather intended as a guide for students of Sanskrit to learn how to understand and translate Sanskrit texts into English, he does not go into any particular detail on how or why this RUKI Sound Law emerged. It would be two years later, with Brugmann (1886), that the first attempt to explain the change would be put forward. As described in Allen (1973), Brugmann (1886) posited the existence of a Proto-Indo-European phoneme, being a dental fricative distinct from /s/, which in time developed into the RUKI reflex among other reflexes not relevant to this present study. Given that the debate surrounding RUKI has continued to some degree even to the present, it is safe to conclude that this analysis was not felt to be satisfactory.

Pedersen (1895) is an oft-cited source for the first satisfactory description of the RUKI Sound Law, being the origin of the formulation that PIE *s→x when it followed [r u k i]. Now, this is clearly not the Sanskrit formulation, and that sees *s→ṣ. This is because Pedersen (1895) was researching the Slavic languages, where [x] is the RUKI reflex. As is common with the earlier Sanskritist analyses, he is ultimately focused on giving a reasonable etymology which explains the reflexes.

Martinet (1951) provided a more modern style of analysis, arguing that the output of RUKI, [ṣ], was the ‘high variant’ of underlying /s/, and that the set of high vowels, dorsal stops, and [r] all conferred this ‘high’ quality. Noting that “the apicoalveolar articulation acoustically intermediate between English *s* and *sh* [sic]” was the most likely identity for the RUKI output, he proposed that “the degree of raising of the tip of the tongue would depend on the phonic context, and it is understandable that, when preceded by a closed vowel like *i* or *u*, syllabic or not, or by a

dorsal stop, the articulation would tend to be higher and the sound slightly more hushing” (Martinet 1951). He further holds that if we assume [r] to have “a pretty high apical articulation”, then the same effect would hold for it (*Ibid*). The RUKI Sound Law, then, is not the result of a conventional sound change, whether in a single development or multiple independent process. Rather, it is simply the “phonemicization of the high variant” (*Ibid*). Thus he gives a seemingly reasonable explanation for the RUKI Sound Law. However, his analysis clearly did not entirely satisfy his contemporaries, as it would be challenged in the years which followed. Discussion of these later analyses will be left for when we turn to Allen (1973), as he directly addressed the ‘high variant’ hypothesis. Worth noting is the fact that Martinet (1951) was writing before the publishing of SPE, and therefore before modern phonology as we understand it. Thus, he makes these assertions without the use of any modern feature theory, as indicated by his direct reference to relative articulatory position. Before we move into the period of SPE and generative phonology, however, it is worth noting that we here see the argument that [ʂ] emerged as a phonemicized allophone, rather than the product of what Martinet (1951) terms a ‘common innovation’.

With the rise of generative linguistics came a renewed focus on trying to tease out how RUKI could be made to make sense, or how it could not. Anderson (1968) focuses on the Baltic and Slavic instantiation of the RUKI Sound Law, and so has less to say about the Sanskrit problem in particular. However, his findings, while open to criticism as we will discuss in Allen (1973), do have significant bearing on the matter overall. He agrees with the common concern that [r u k i] simply do not share a proper set of common features. In Anderson’s (1968) case, he is concerned with the lack of common articulatory elements. The best he can put forward as a commonality is to argue that the RUKI segments are all in some way ‘marked’, and that the alternation could be

a spreading of that markedness to the following fricative. However, Anderson notes that markedness-driven assimilation generally has a clear articulatory explanation, which is of course absent from RUKI given that RUKI still has no common articulatory trait.

Zwicky (1970) examined RUKI as a test case for the then-new Greek-letter-variable system introduced by Chomsky & Halle (1968, henceforth SPE). Using that system he successfully defined RUKI as a natural class, but felt more disappointed with the variable system than enthused at having solved the problem. At the end of his squib, Zwicky indicated a suspicion of RUKI being conceived of as a single set, and seemed to indicate a preference for conceiving of it as multiple changes which later converged. Vennemann (1974), following directly on from Zwicky, argued for a radical change in approach: rather than attempting to solve RUKI via common phonological features, he instead proposed grouping them by a common acoustic effect. All of the RUKI sounds, he argued, had a disrupting effect on following /s/, leading ultimately to its reanalysis as retroflex. This theory would later be put to the test by Longerich (1998) and found to have merit, with the RUKI set showing distinctive disruptive effects which were not found in similar, non-RUKI sounds.

Allen (1973) took an opposite approach from Zwicky and Vennemann: he argued that RUKI simply did not make sense as a single change, but rather as four sound changes which overlapped in time, and which later underwent a levelling or neutralization process. Drawing from earlier research on PIE and other languages, Allen notes that in languages with only a single fricative, place-assimilation of the fricative is very common, and that across the Satem-branch languages which underwent RUKI, each has as its reflex of RUKI-/s/ a different fricative which would logically result from one of the RUKI sounds. It would thus make sense that, since PIE has only one fricative, it had allophones for when it followed the RUKI set, with each allophone

assimilating to the respective place of the triggering segment. This explanation has significant merit, as among other things it avoids the primary problem in trying to analyze RUKI: the nonsensical composition of its triggering environment. By denying the unity of RUKI, Allen (1973) is able to focus primarily on the change itself, with a neutralizing rule coming by later to produce the unified reflex found in later Satem-branch languages. Of note is that Allen's (1973) analysis neatly accounts for the varied reflexes across different languages by treating RUKI as four rules which were later neutralized. In any given language, a different allophone of *s could be selected as the basis for the new phoneme, allowing each language to develop a different reflex of *s in response to the conditions of that language. Sanskrit, dealing with a heavy retroflex influence from Dravidian languages, selected [ʂ], while others chose the palatal or velar variants. Notably, none of the Satem-branch languages have RUKI reflexes which are not derivable from at least one of the RUKI segments, which strongly implies a connection between the reflexes and those segments.

Allen (1973) is a very insightful source regarding the RUKI Sound Law. He covers the bulk of the extant research by his day, and systematically assesses them. A number of these analyses are noted to have characterized the RUKI reflex as a "high variant" of *s, notably Martinet (1951) mentioned above. Allen (1973) takes a critical view of such analyses, noting that first, the characterization of the entire RUKI set as [+high] seems untenable, and second, that [ʂ] could not possibly be 'the' high variant, but at most one of several possible high variants. As he notes, it is strange that some 'high' characteristic would drive /s/ → [ʂ] after a [k], rather than → [x]. Allen (1973) also cites Jakobson (1968) for the idea that when a language has only one fricative, that fricative is often very susceptible to place-assimilation, a key point in his own RUKI proposal.

Allen (1973) also cites Benveniste (1937) and Merlingen (1958) as being critical of Brugmann (1886). Benveniste (1937) found that the proposed reconstructed fricative should have resulted in alternating forms which have never been observed or otherwise reconstructed. Merlingen (1958) held that Brugmann's (1886) reconstruction was more of a *post hoc* description than any explanation of the pattern.

Allen (1973) seems to be sympathetic to Zwicky (1970), in that both ultimately hold as suspicious the characterization of RUKI as a single change: the triggering set is too disparate in place and feature-definition to make intuitive sense. Allen (1973) agrees with Zwicky's (1970) concern that if there exists a feature theory which can neatly define the set of RUKI, that it is more likely a failing of the feature system in question rather than a strength.

Allen (1973) cites Morgenstierne (1929) to note that the Kafiri languages, situated on the border of the Iranian and Indian languages, have a different reflex after /i/ versus /r/. Following /i/ *s comes down as [ʃ] or [ç], while after /r/ *s comes down as [ʂ]. Furthermore, neither /u/ nor /k/ trigger /s/-retraction in Kafiri, which would make little sense if RUKI were a unified change occurring at an early stage of Satem's development. From this, Allen (1973) argues that RUKI is better analyzed as multiple sound changes which, in the major Satem languages, were later levelled or neutralized. This view is further supported by noting that in Iranian, the RUKI reflex appears after PIE *ə where it merged with /i/. This implies that the /i/-driven RUKI change was still productive after the ə~i merger.

Allen (1973) further notes an interesting point: in Avestan and Sanskrit, at the very least, PIE *kʲ comes down as a fricative identical to the RUKI reflex. This would seem to imply that *kʲ had been affricating to some degree by the time RUKI was productive, being something like [ks]

or [kç]. The fricative would then have been subject to RUKI, or perhaps a later neutralization process, with the original /k/ later leniting to zero and leaving only the retracted fricative.

Uhlenbeck (1977) asserts that the Slavic and Sanskrit RUKI changes are unrelated, though the grounds for this argument are left somewhat unclear. This kind of treatment is a recurrent issue in attempting to research RUKI that many of the non-generative sources give it so little space: in the grand scheme of Sanskrit, the RUKI Sound Law is something of a minor footnote, and rarely given more than a paragraph or two. While this serves well the purposes of Sanskrit dictionaries or broad linguistic overviews, it makes attempts to analyse RUKI itself rather difficult. In contrast, formal, generative analyses of RUKI often provide significant space for the analysis, but are often light on the historical aspect: they are focused on how RUKI functions as a system, not the winding paths by which it came about in history.

This focus on system rather than history can be most clearly seen in Kiparsky's (1981) analysis, where he proposes that the spreading of [+high] (used as a marker for retroflexion in his paper) triggered RUKI. By applying [+high] to the *r*- and *k*-series RUKI sounds, he provides a unified Lexical Phonology account of RUKI. In order to account for RUKI environments which do not display the retroflex, but rather retain the historical dental, he argues that RUKI reflexes are underlyingly specified for [+high]. While this analysis successfully captures the data, it does not explain how [+high] was spread to those environments and not to the exceptions. At no stage does it seem that Kiparsky is analysing RUKI as a historical development, as something which might have had intervening stages or a complicated development: rather, he is analysing it in synchronic terms. This is fine for his purposes, but leaves much to be desired for one seeking to understand the RUKI Sound Law as a historical change.

An approach to the RUKI Sound Law from something of a different angle is found in Hall (1997). His analysis follows a pattern more akin to Allen (1973) than Kiparsky (1981), arguing for an intermediate stage before full retroflexion of the RUKI reflex. However, rather than focusing on the definition of the RUKI Set as a natural class or on other representational solutions, Hall (1997) argues that we should understand the RUKI Sound Law as an act of repair to address problems in the phonemic system. He follows an analysis, which he cites as the standard one in his period, that the RUKI retroflex fricative is a Sanskrit reflex of an Indo-Iranian palatoalveolar *ʃ, itself being a reflex of Indo-European *s, with a context-free change causing *ʃ > [ʂ].¹ He contends that this change occurred in response to the development of the palatalized velar stop, *kʲ, into an alveolopalatal fricative [ɕ].² He notes that the reflex of *kʲ could not have been the fully palatal [ç] due to the reflex being a sibilant while the fully palatal fricative is not, a point which we will refer back to during the RUKI analysis proper in Chapter 6. What matters for the moment is that the emergence of [ɕ] put Sanskrit into an unnatural phonemic position: it now had a contrast between [ɕ] and [ʃ], a pattern which Hall (1997) notes is unheard of in natural language. Thus the phonemic system shifted in response to this problem, with RUKI [ʃ] undergoing retroflexion in order to maintain its contrast with [ɕ]. He holds that the choice to retroflex [ʃ] rather than [ɕ] is likely due to palatoalveolars being more like retroflexes than alveolopalatals, as the two share [-anterior]. Thus the change would require one less feature change compared to retroflexing the alveolopalatal fricative. While this present dissertation will not follow Hall (1997) in all its assumptions about the development of the RUKI Sound Law, the argument that retroflexion was driven by contrast maintenance is important to keep in mind.

¹ All symbols have been converted to modern IPA for ease of reading, as the original article uses both traditional Indo-Europeanist transcriptions and IPA depending on context.

² The actual change is shown to have several intermediate steps, but for our present purposes all that matters is that the reflex of *kʲ was [ɕ].

There are some further oddities regarding the RUKI Sound Law in Sanskrit. One of the most interesting is that RUKI can be blocked if the *s is followed by [r] (Whitney 1884). Why this should occur remains unclear, as if anything having [r] on both sides should more firmly incentivize retroflexion. Lamentably, few sources seem to give much focus to this phenomenon, and the data on which this dissertation is based provided too meagre an offering to make any meaningful statements about it. Thus, the peculiarities of this interaction must be left for another study, though for now it can be tentatively hypothesized that it is likely some sort of dissimilation process which drives this apparent blocking.

A similarly fascinating oddity is the oft-cited limited application of RUKI within a single word. Some unidentified process prevents RUKI from applying more than once in a word, no matter how many potential loci of change are present. Furthermore, there does not seem to be any clear or simple pattern by which the retroflexing locus is selected: the change can be anywhere in the word, rather than being always, say, the first or the last. This pattern will ultimately have to be discussed in another project, but for now it bears noting that the application of an operation once followed by its blocking is something very natural to Harmonic Serialism. It is to be admitted here, however, that it is also quite natural for Lexical Phonology, and indeed may be more natural to that theory than to HS. There is therefore interesting room with this data to compare these two theories.

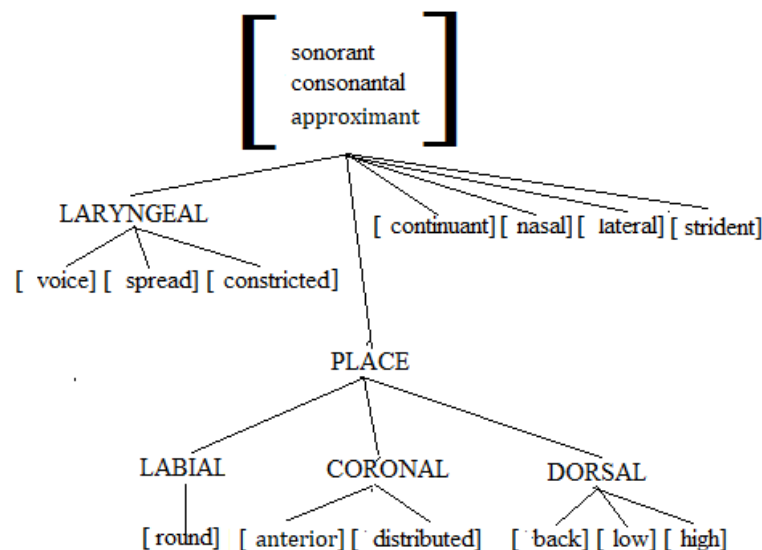
2.3 Feature Geometry

To give a full and proper account of the history and discourse around feature geometry would be a rather epic undertaking, and one not well-suited to the discussion at hand. Nonetheless, some discussion is necessary so as to situate this dissertation in its proper context, and to give context for the assumptions in which it is based.

Fundamentally, feature geometry as it is generally understood is an elaboration of the feature theory of *Sound Pattern of English* (Chomsky & Halle 1968). More specifically, it developed out of the autosegmental phonology of the 1970s, organizing the earlier feature bundles into a hierarchical structure (Martin 2012). This served to better explain patterns of assimilation, as certain features were found to generally be assimilated alongside each other, while other feature combinations rarely, if ever, would pattern together in this way (*Ibid*).

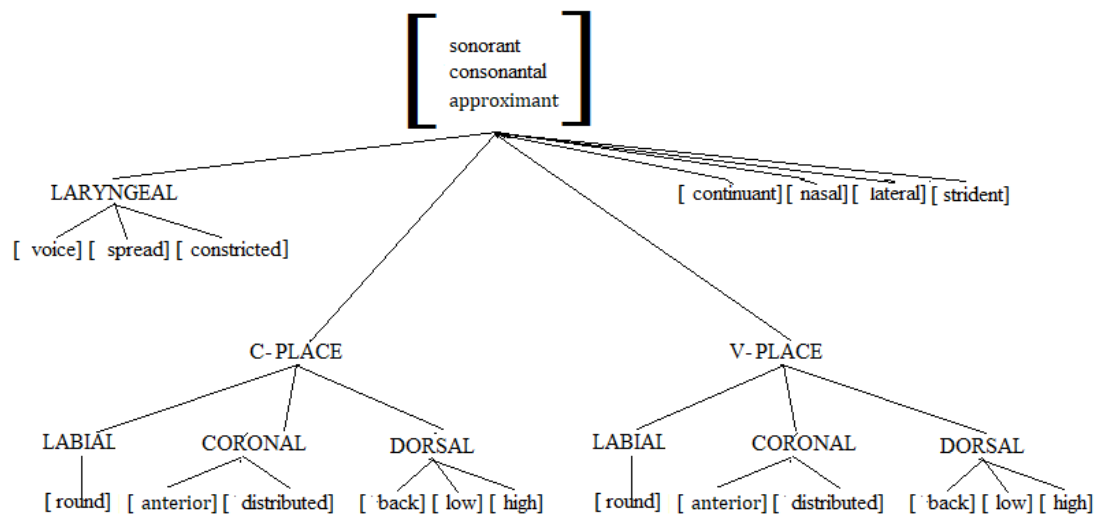
The most popular model to emerge was that of Clements (1985), which used the SPE features in a tree built around a ROOT node and a subordinate PLACE node. The ROOT node governed features relating to the manner of articulation, including [sonorant], [consonantal], and [approximant]. A LARYNGEAL node governs things like [spread glottis] and [voice], and manner-specific features like [lateral], [continuant], and [nasal] are simply made directly subordinate to the ROOT. The PLACE node was immediately dominated by the ROOT, and itself immediately dominated the three specified PLACE nodes, being CORONAL, LABIAL, and DORSAL. These specified PLACE nodes each dominate the relevant place features. An example of the Clements (1985) model is provided below.

Figure 1: Clements (1985) Feature Geometry Tree



The Clements (1985) model was revised over the following decade, ultimately producing the Clements & Hume (1995) model. It was largely the same, but importantly it introduced a split between consonantal place and vocalic place, represented by the use of C-PLACE and V-PLACE nodes. These nodes were essentially duplicates of each other, with the same specified PLACE nodes dominating the same features, but C-PLACE represented the place features of the consonantal portion of articulation, while V-PLACE covered the vocalic portions. A regular segment would have either C-PLACE or V-PLACE, and which kind of PLACE node it had would define whether it was a consonant or a vowel. However, it was possible for a segment to have both a C-PLACE and V-PLACE node at the same time: this would produce a secondarily articulated consonant, with the V-PLACE defining the secondary articulation. An example of this is provided below.

Figure 2: Clements & Hume (1995) Feature Geometry Tree



Other models of feature geometry have, of course, been proposed, but they are not particularly relevant to the present study. The Parallel Structures Model (PSM) is worth noting, since in Chapter 3 one of the analyses this dissertation discusses was originally done in PSM (Morén 2006), and is here reanalyzed using the model this dissertation proposes, ‘Feature-

Geometric Harmonic Serialism”. PSM takes the splitting of C-PLACE and V-PLACE to its logical extreme, and entirely does away entirely with the featural differences between consonants and vowels. Future research may possibly benefit from transitioning away from the Clements (1985) model and to PSM, but for present purposes it is not clear that there is any need to use this less common model over the more widely recognized one. Thus, while it is worth bringing PSM up at this time, it will not play any further role in this dissertation.

The introduction of Optimality Theory (Prince & Smolensky 2004) triggered a split between the old guard generative phonologists, who were primarily responsible for the further development of representational models such as feature geometry, and the new wave of constraint-based Optimality Theorists. OT is discussed in more detail in the following section, but it is worth noting now that from its introduction, OT has generally ignored representational models, as Richness of the Base meant that researchers could be agnostic about the specific featural representations of segments. What mattered was not the specific phonological materials available to GEN, but how those materials were shaped by CON and EVAL. This led to a growing divide in phonology, with generativists continuing to iterate on their representational models while Optimality Theorists left it behind, focusing exclusively on the interaction of constraints, with featural representation being left as an afterthought at best. This dissertation holds that, whatever the benefits of full parallelism and its consequent devaluing of featural representations at the time, this split was fundamentally a tragedy which has left both sides the lesser. While the discussion of how to reconcile featural representation with an Optimality Theory model is a matter for the next chapter, it is worth stating now that such reconciliation is an explicit goal of this dissertation.

Thus, what is important to take away here is the nature of feature geometry in general, and in particular the Clements (1985) model and its revisions. The model which will be proposed in Chapter 3 is based heavily on Clements (1985) and Clements & Hume (1995). While other feature-geometric theories have their merits, they are, for reasons which will be outlined in the next chapter, not presently held to be appropriate for our current purpose. If nothing else, Clements & Hume (1995) serves perfectly well for solving the RUKI Sound Law, as will be seen in Chapter 6.

One last point to be made here concerns not quite Feature Geometry as generally discussed, but rather a point of earlier feature theories which has some bearing on how the model this dissertation will propose is structured. This is the concept of archiphonemes, that is, underlying segments which are not fully specified, and rather have certain features specified based on the surrounding context (Trubetzkoy 1939, cited in Martin 2012). Now, this is not a concept which is much discussed in modern phonological theories. Rather, it seems to have been largely left behind as phonology and representational theories have moved on. This present study does not rest on any particularly detailed understanding of that early idea, but does find that, as a consequence of the adoption of underspecification which is detailed in Section 3, something much like it will also need to be adopted. Thus, to summarize the basic concept, an archiphoneme is “the shared information of two contrastive segments in a neutralization position minus the neutralized feature” (Martin 2012). They are generally marked with a fully-capitalized letter, such as <N> or <I>. This present dissertation will make use of such symbols in a similar capacity, as an underlying representation which does not contain all its features fully specified, and rather attains its full meaning based on context and through feature-filling rules which depend on its structure at the end of phonological derivation. The similarity to archiphonemes

will be referenced several times in the dissertation ahead, but this should not be taken as an unambiguous identification of these underspecified segments as traditional archiphonemes. Rather, it is intended to emphasize that these segments are underlyingly underspecified in some way.

These underlyingly underspecified segments could also be termed ‘generic segments’, this reference being intended to emphasize that it is merely a partial featural representation. Segments like this have been used in HS analyses already, often representing a segment which has undergone Place-deletion as per the two-step deletion process of HS (McCarthy 2018; Tanaka 2013). These segments are specifically placeless, however, as would be expected given their origin. This dissertation will extend the usage of the symbol to refer to segments which are specifically underspecified, but which will consistently be outputted as a certain segment unless otherwise acted upon. These segments and how they are handled in the model to be proposed will be discussed more in Section 3.2.2.

A last discussion which should be had here concerns not so much feature geometry in general, but rather the definition of a particular class of segments: retroflexes. Retroflexes as a class, and retroflexion as a process, is essential to the matter of the RUKI Sound Law, and thus a proper understanding of their nature is important to this present study. In a standard SPE-based feature theory, the retroflex place of articulation is understood to be [-anterior, -distributed], with related feature geometries then assigning those features to a CORONAL node. However, several sources argue strongly that we should instead understand retroflexes as being something like a coronal with a dorsal secondary articulation. This proposal has interesting implications for any analysis of the RUKI Sound Law, and so we shall now turn to discuss these arguments here.

While not the first source to discuss retroflexes, Hamann (2003) stands as a major culmination of research on the topic, and is thus very relevant to the matter at hand. It would be a disservice to the excellent work in that dissertation to attempt to fully summarize it here, and so the focus will rather be on how its findings impact our understanding of the structure of retroflexes and retroflexion as a process. On a basic level, it must be understood that retroflexes are marked crosslinguistically, and this is a fact which any proposal about them must account for this fact. Following from this, Hamann (2003) notes that retroflexes only appear in languages with large segmental inventories.

Hamann (2003) argues for a formal definition of retroflexes based on four characteristics: apicality, posteriority, sublingual cavity, and retraction. To summarize the discussion, this definition holds that retroflexes can be understood as apical coronals, being made with the tongue tip away from its resting position, which are articulated behind the alveolar ridge (posterior) with a large sublingual cavity and a retraction of “the tongue back towards the pharynx or velum” (Hamann 2003:35). This definition is very relevant to this present study, as she emphasizes that retraction here does not refer to the feature [RTR], but is instead better modelled as being [+back]. That is, Hamann (2003) argues that retroflexes are best understood as something like segments which have a primary CORONAL node and some sort of secondary DORSAL node which is specified for [+back]. Now, this definition does not accurately represent what Hamann (2003) actually proposes, but that discussion will be put aside briefly, and taken back up when it becomes relevant. The point here is that this is an important characteristic when we consider the nature of the RUKI Sound Law in future sections.

Expanding on this, Hamann (2003) draws on a tradition going back to Bhat (1974) which has observed a patterning of retroflex consonants with back vowels. Retroflexion of consonants after

back vowels has been observed in a number of languages, and very interestingly, they pointedly do not pattern with front vowels. That is, retroflex consonants often seem to be disallowed from co-occurring with front vowels in various ways (Haman 2003). This can manifest through de-retroflexion, vowel retraction or lowering, diphthongization, or vowel rounding. Interestingly, secondary palatal articulations are also largely incompatible with retroflex segments. The secondary articulation can be deleted or spun off into its own segment, and if this does not occur then the retroflex will often simply cease to be retroflex. These two patterns point strongly towards retroflexes possessing some characteristic which is strongly compatible with back vowels while also being incompatible with front vowels. This supports Hamann's (2003) characterization of retroflexes as coronal segments with a [+back] specification, as front vowels are defined as [-back] and therefore would have difficulty coexisting with a [+back] segment.

Now of course, there is a pointed exception to this pattern, which Hamann (2003) notes and discusses: the RUKI Sound Law itself. In this change, not only does a retroflex fricative co-occur with a front vowel, but it in fact emerges after it. She notes that several analyses of RUKI have treated it as a telescoping of several changes which took place sequentially over a longer span of time. While each analysis differs in some details, they all broadly agree that there was a single Indo-Aryan fricative *s, that it underwent some sort of assimilation, and that sometime after Sanskrit broke off into its own language, the reflex or reflexes of that initial change became the retroflex fricative. Different analyses, including Hamann (2003) herself, make various different predictions as to what the intermediate stage would look like, but all agree in the basic structure of the change. That said, the intermediate stage is the less problematic part of the telescoping analysis of RUKI. As Hamann (2003) notes, the issue is why the later neutralization of these variants would coalesce into the retroflex variant rather than the velar or some form of

alveopalatal. This is further complicated by the fact that the selection of retroflex was clearly not strictly necessary in a typological sense, as other Satem-branch languages ultimately selected other, non-retroflex variants as the reflex for the change.

Hamann (2003) cites Allen's (1954) argument that “retroflexion was already an established process in connection with liquids”, and so retroflex as a category was already available for use. That is, it is argued here that the retroflex fricative was selected because the category was independently present in the system. It is worth noting, however, that Sanskrit would also have had palatal and velar categories, and so this solution does not seem to necessarily fully explain why the retroflex would be the most preferred out of these, even if it was available. Nonetheless, Hamann (2003) notes that under an analysis like this, we can decompose the RUKI Sound Law into a series of changes, with each individual step being perfectly natural in itself. The unnatural appearance of RUKI, therefore, is likely just a sort of historical illusion produced by the opacity of the processes involved.

As we turn back to the bearing of this work on the Feature Geometry used in this present dissertation, we must now turn to Hamann's (2003) criticisms of Feature Geometry in the tradition of Clements (1985). Much of the discussion Hamann (2003) puts forward on this topic is beyond the scope of this present dissertation. For reasons outlined earlier in this section, and further discussed in Section 3.2, this present dissertation assumes Feature Geometry with articulatory features as its featural model. This is not a work which is focused on the nature of featural representation itself, and so that discussion will be left to more dedicated work. However, it is important to acknowledge here that Hamann (2003) disagrees with any attempt to properly represent retroflex segments in a Feature Geometry model, arguing instead that we must turn to more perceptually-based feature theories to properly model phonological segments. Her

discussion of the representation of retroflexes in such a system, specifically focusing on her own proposed feature theory, is an informative read, but as such a model has not been adopted by this present dissertation, further discussion of it will be left aside here.

Regarding the relevance of this work to the present dissertation, the key takeaway is the strong evidence that Hamann (2003) presents in favour of retroflexes having a [+back] specification. She is not the first to propose this, but she provides perhaps the most comprehensive account of the evidence and arguments, and quite convincingly argues for that interpretation. Thus, this will form the basis of this present dissertation's featural representation of retroflexes.

Turning now to other sources which comment on the featural structure of retroflexes, it is best here to return to earlier discussions. Bhat (1974) functions as a fine starting point, being often cited in later works for the structure of retroflexes. The essence of this paper is the argument that retroflexes should be understood not as retracted segments, though it does not seem to settle on a firm concept of how we should define them. It provides a good overview of the information available at that time regarding retroflex segments and the phonological alternations they could be involved with. It should be noted here, however, that Hamann (2003) pointedly disagrees with Bhat's (1974) argument, citing significant later evidence which shows a strong correlation between retroflexion and retraction. This point aside, it is worth noting that despite not holding retroflexion and retraction to be linked, Bhat (1974) does acknowledge a correlation between retroflex consonants and back vowels, a theme taken up by several other sources discussed here.

A more particular response to Bhat (1974) can be found in Hamann (2002). While this article agrees with Bhat's (1974) argument that retraction does not pattern exclusively with retroflexion,

it does contend that retroflexion exclusively patterns with retraction. That is, all retroflexes are retracted, but not all retracted segments are retroflexes. Two implications are immediately drawn from this idea: first, that the non-retracted retroflexes claimed to exist in Tamil and Badaga are in fact not phonetically retroflex; and second, that it is impossible to palatalize retroflexes, as palatalization is incompatible with retraction. Thus, retroflexes will either cease to be retroflex if palatalized, or will simply not palatalize in the first place. The article goes into a more detailed discussion of Badaga and Lardil, which while interesting is ultimately not relevant to this present dissertation. The key takeaway for this present dissertation is that this article provides a clear means of defining the retroflex place of articulation: a CORONAL node specified for [-anterior, -distributed] with an additional DORSAL node specified for [+back].

A similar conclusion can be found in Arsenault(2008), which argues that the CORONAL node is not more structurally complex than LABIAL and DORSAL, but that rather some places of articulation understood to be coronal in fact have secondary articulations. He draws data from a mix of Australian and South Asian languages to support his proposal. He builds a significant pillar of the article on the fact that the presence of marked articulations in a language generally imply the presence of an unmarked articulation, but that this relation does not necessarily hold in reverse. Taking that as the ground, he asserts that nonetheless, a language can prefer the marked form over the unmarked when there is a crowded phonetic inventory. That is, a language which has a large number of contrasts could end up favouring a marked articulation over an unmarked one in order to ensure that “maximal distinction with other articulations” is maintained (Arsenault 2008:5-6). Furthermore, he continues a tradition of questioning the feature [anterior], as its existence implies a natural class of retroflexes and palatals, which contradicts the attested evidence cited in this article and in Gnanadesikan (1994). This problem, he notes, led to the

development of [dental] and [retroflex] as distinct features used to define their respective places of articulation. These features were generally considered to be dependent of monovalent [laminal] and [apical] features respectively, these two features having replaced [distributed] in a number of modern feature theories. However, this has the effect of making not only retroflexes more marked than alveolars, which is to be expected, but dentals more marked than palatals, which is something quite unexpected.

Leaving aside the more detailed discussion of feature definitions, as here the article turns to focus on feature theories which begins to substantively diverge from that adopted in this present dissertation, Arsenault (2008) argues that the best way the model retroflexes is not to give them their own dedicated feature, but rather to specify them with a [back] feature. In this proposal he draws on a wealth of prior research which is discussed in this section of this present dissertation. He argues that retroflexes should be understood as coronals with an attached DORSAL node, thus avoiding the prediction that all segments specified for [back] are necessarily coronal and apical. Rather, most dorsal segments simply lack a CORONAL node, and it is only retroflexes which combine both nodes into a single segment.

Given that the contrast between dental and palatal segments will also play an important role in this present dissertation, it is also worth noting Arsenault's (2008) proposal for the structure of palatals. He proposes that palatals are akin to retroflexes in being coronals with a secondary dorsal articulation, with palatals specifying [high] rather than [back].

Further discussion of retroflexion in the context of coronal features can be found in Arsenault (2009). This article iterates on Hamann's (2003) proposals concerning the featural definition of retroflex segments, specifically her argument that retroflexes should be defined as [-anterior]. Using data from various Indo-Aryan languages he argues that [-anterior] is not actually necessary

to account for the phonological activity of retroflexes in practice. From this, he contends that we should understand [-anterior] on retroflexes as something derived from the conjunction of [-distributed] and [+back]. This feature combination still allows both retroflex and palatal to be defined against dental and alveolar, and against each other. Retroflex is [-distributed, +back] while palatal is [+distributed, -back], while dental and alveolar both lack [back] as features entirely. As a note, this would imply a close connection between dentals and palatals on the one hand, and retroflexes and alveolars on the other, with the members of each pair differing only by the presence or absence of a specified [back] feature.

2.4 Optimality Theory

Optimality Theory (OT) was introduced in Prince & Smolensky (2004) as a radical alternative to more traditional generative phonology. It rejected the use of phonological rules in favour of focusing solely on phonological constraints. These constraints were conceived as being violable, in contrast to the inviolable rules of earlier models. The intention was to produce a system which could go beyond merely describing observed sound changes and actually explain why they occurred. There have been issues and controversies in the development of OT, but overall the model has flourished since its inception.

The basic components of OT are as such: CON, GEN, and EVAL. CON is the constraint set. GEN produces candidates for the analysis. In OT, GEN has few if any functional restrictions. EVAL covers the ranking of the constraints and evaluates the candidates against it. Together these components produce a constraint ranking by which potential outputs can be judged, and then selects the preferred output. It is on a first glance an elegant system, eliminating the need for lengthy lists of stipulative, or at the very least merely descriptive, rules. In practice it requires lengthy constraint rankings to accomplish the same effect, though since older generative

phonology required both long lists of rules and a set of constraints, it can be argued that OT is still simpler from a theoretical perspective (McMahon 2000; Prince & Smolensky 2004).

In Parallel OT GEN is unrestricted, and infinitely many operations can be applied to each candidate. It is left entirely to the constraint ranking to determine the shape of the output. This is a necessary part of the system due to its parallel nature: the entire point of parallel OT is that all operations can occur simultaneously, which circumvents rule-ordering paradoxes and allows for a more elegant analysis of phonological conspiracies. By carrying out all operations in parallel, there is no need to enumerate each operation as its own rule: rather, each particular change is simply the optimal method of obeying a singular constraint, or constraint interaction, with the particular operations being applied determined by the relevant constraint ranking. The consequence of this is that in every analysis, there is in fact a theoretically infinite number of potential candidates. In practice an analysis will only focus on those candidates which are considered directly relevant based on the displayed constraint ranking.

However, a lingering, though largely undiscussed, problem is that there is always the potential for a pathological winning candidate to exist beyond the knowledge of the analyst. Such a candidate would be patently absurd in shape, but would still exist, and thus would be taken into account by the grammar itself, if not the formal analysis. To some degree, this does in fact happen: the concept of pathologies in OT refers to certain candidates which take unattested forms, but which win out over attested outputs when added to the analysis. A pathological candidate is one of the clearest signs that there is a problem with at least one of the constraints in the analysis. It is always good practice to watch out for potential pathologies in any analysis, and any newly proposed constraint must be tested against those constraints already accepted in order to guard against the introduction of new pathologies.

A fundamental principle in OT is “Richness of the Base,” which states that there are no restrictions on inputs. Theoretically, OT can take any input, no matter how malformed it would look like as a surface form, and produce an output pronounceable by the language being evaluated. This is generally held to extend so far as to functionally render the featural representation of the input irrelevant. OT is explicitly agnostic regarding feature theory, and depending on the source in question can either be made to work with any given feature theory, with relevant constraints designed to account for said theory, or that the constraint ranking should simply work regardless of feature theory. This often leads to articles leaving aside any explicit discussion of featural representations. Instead, there is an implicit assumption of something like a modified SPE system, and even that is only commented on insofar as a particular feature may be held to be relevant to the analysis. The particular feature definitions are left largely undiscussed, since what matters most is the mapping of an input to an output. So long as there is a mapping that produces the attested output, most Optimality Theorists will be satisfied.

An important point with CON in OT is that it is, in theory at least, superior to traditional phonological rules in terms of explaining phonological phenomena. Fundamentally, phonological rules are descriptions of patterns. They can be very well-grounded rules, with a solid understanding of the features involved and therefore a clear demonstration of why the pattern played out. But they lack something very important, which is an explanation of why this change happened rather than not. It is well-known that many phonological rules which could happen do not, in practice, happen in every language. That is, indeed, the basis of phonological diversity and, to some degree, the very existence of phonology as a discipline. But it is a notable fact, since it calls into question why certain rules only apply to certain languages. Rules themselves

have little in the way of answers. They are fundamentally, as noted above, descriptions, telling us what did happen.

In contrast, OT constraints are inherently explanatory. No constraint says anything about what did happen. Rather, each one makes a demand that a certain structure be preserved, enforced, or avoided. The interaction of these constraints across the ranked hierarchy then causes particular solutions to emerge organically in response. A constraint which says that form A must become form B in environment C is a bad constraint. Rather, a good constraint says that form A must be avoided, perhaps in environment C. It is up to the interaction with other constraints to determine whether form B is a satisfactory solution; depending on the ranking, it could well result in form D or form N. Every constraint represents some factor in phonology: physiological preferences, typological markedness, the desire to maintain transparent mapping between lexical items and phonetics outputs, etc. Therefore, by hinging the analysis directly to the factors which logically shape phonological output, we dispense with the stipulation inherent to a rule, and create a reasoning as to why certain patterns exist and others do not. Indeed, a constraint ranking itself creates a logical reason for crosslinguistic variation: different speech communities decide that different factors are of different values, as it is inherently impossible to satisfy all possible constraints.

This is related to one of the original selling points of OT, that it allowed for a more coherent explanation of so-called ‘phonological conspiracies’, where multiple seemingly unrelated rules would all ‘conspire’ to prevent a certain structure from emerging. Rules had no clear way to explain these phenomena, because they were solely focused on describing what was happening. Constraints instead could unite what had previously been analyzed as multiple rules into a single

constraint ranking, showing how different factors worked together to obey a single underlying principle: that structure A was to be avoided.

Something notable for OT is that it has no built-in feature theory. This was considered a selling point in the original proposal, with Prince & Smolensky (2004) emphasizing that OT is a theory of computation rather than one of representations. OT is intended to be designed such that any feature theory can be brought to it and the model will still function. In practice this has played out quite neatly. Due to the unrestricted GEN and parallel application of operations, the details of feature definitions or hierarchy are largely irrelevant. It does not matter much if a segment is [+voice] unless the analysis is specifically looking at voicing alternations. Even then, it has been noted that OT is almost agnostic to the shape of the input, that it can take any input and map it to the observed surface form. This idea is obviously exaggerated, but it has some grounding. Due to the global harmonic improvement inherent to OT, the constraint ranking should naturally enforce a limited range of possible words, and should naturally map multiple potential inputs to the same output. After all, if there is a ban on word-final voiced obstruents, for example, it does not matter much whether the underlying segments are voiced, voiceless, or lack a [voice] feature entirely. What matters is that any output obstruent in word-final position will be [-voice].

Now, this explanation does itself hint at a largely ignored but nonetheless existent issue. To define such a pattern, we must acknowledge certain characteristics of the input, and tacitly make a claim as to some sort of representation. This is done regularly in OT analyses, but rarely commented on. Rather, most papers seem to tacitly assume the modified SPE features mentioned above, and then functionally ignore them except as needed. Natural classes will be referred to and used, but often not explicitly defined, relying instead on the reader's presumed familiarity

with SPE features to carry the representational legwork. It must be noted that there is no sign this is an intentional deception, but rather just the result of Optimality Theorists themselves being generally familiar with feature theory.

Thus, much of the discussion inside of OT is focused on CON and EVAL: articles beyond count exist to argue in favour of or against the existence of various constraints. There are arguments over whether or not gradient constraints should be included, or if all constraints should be categorical. There are arguments about whether some constraints exist in language-universal hierarchies, or if some constraints should be defined stringently, such that their ranking is mostly irrelevant via more complex constraints ‘containing’ simpler ones within them. More commonly, the discussion is simply whether a given constraint is necessary to analyze a particular data set, and whether that constraint will produce a pathology or not.

Very important to the ongoing discussion of CON is the existence of language-specific constraints. The orthodox OT position is that all constraints are universal: that is, languages differ in terms of constraint ranking alone, never in which constraints are available. This results from a strong belief in Universal Grammar (UG), and indeed, OT is very much so a UG theory. All the constraints are held to be universal, and all the mechanisms of OT are treated as parts of the UG inheritance. Some, however, argue against this, claiming that certain constraints only exist in certain languages. Such arguments generally arise when dealing with phenomena which certainly look to be language-specific, such as the English stress system. However, the existence of language-specific constraints remains controversial at best, and is in practice a minority opinion.

An ongoing discussion in OT is the relationship of phonology and morphology. While most of this discussion is irrelevant to the present dissertation, there is one point worth covering:

indexed constraints. The theory of Indexed Morphophonemic Constraints is discussed well in Flack (2007) and Jurgec & Bjorkman (2018). Under such a model, CON is able to duplicate universally-available constraints and index those duplicates to certain morphophonemic features. These features can be language-specific, something which is normally considered a violation of the universality of OT constraints. In this model, however, it does not seem to be so dire a problem, as the constraints themselves remain universal: all that is language-specific is the indexation. English alone is proof enough of language-specific quirks, such as the simultaneous existence of Anglo-Saxon and Latinate stress in the language. The only distinction between words falling under one system as opposed to the other is their etymology as assumed (on some level) by the speaker: Latinate words follow Latinate stress, while Anglo-Saxon words follow Anglo-Saxon stress. With indexed constraints, there would simply be some feature LAT which represents Latinate origin, and which several constraints are indexed for. These constraints are then ranked independently of the unindexed original, and can thus be ranked higher than it. Indexed constraints are only active for inputs which bears the relevant feature: thus, IDENT_{LAT}[high] would only protect the [high] feature in Latinate inputs.

Now, it is worth briefly discussing a particular limitation of OT as a model: the problem of operational interactions, especially opacity. Fundamentally, opacity is understood as an instance where one operation interacts with another in such a way that the output is not obvious from the input. This is a major problem for any parallel model of phonology, such as OT, since parallelism disallows the very concept of operational interaction. For operations to interact, they must exist in sequence: A cannot produce environments for B if it does not also precede B. This is known to cause problems in the fully parallel computations of OT. For any candidate which manifests the opaque outcome, there is always another which does not, and which harmonically binds the first

one. The reason for this is that during EVAL, no reference is made to the operations themselves, merely how well a given candidate satisfies the constraint ranking. Thus, if the context which drove the first operation is erased, then OT will only ever detect the post-erasure context, and therefore penalize that candidate for including a surface-unmotivated change. In contrast, candidates which simply ignore the opaque interaction will always harmonically bind their opaque counterparts due to lacking that extra penalty.

Much work in the 2000s focused on various attempts to solve the opacity problem in OT, including Stratal OT and Sympathy Theory, and later even including Optimality Theory-with-Candidate-Chains (OT-CC) (Kiparsky 2000; McCarthy 1999; McCarthy 2007b). The details of these theories are not relevant to the present discussion and so will not be discussed here. They are mentioned simply to note that opacity as a problem in OT has long been recognized and that much work has been done to try and solve it, though such attempts have largely resulted in the creation of new sub-theories or variant theories apart from classic Parallel OT.

2.5 Harmonic Serialism

Harmonic Serialism is a serial-derivational variant of Optimality Theory. It was first proposed by Prince & Smolensky (2004), albeit very briefly. The concept of a serial-derivational constraint-based model was introduced, with a note that it would need to be limited to a single change at every step to remain usable. It was then summarily dismissed as an unnecessary complication over parallel OT. The various problems which Parallel OT has encountered in the decades since, however, has led some, beginning with McCarthy (2008b, 2008a) to reconsider HS as a legitimate alternative.

HS shares most of its architecture and terminology with parallel OT. The basic concepts of GEN, CON, and EVAL are all drawn directly from OT. The key difference is in the definition of

these elements. EVAL is essentially the same as in parallel OT. HS GEN is the most important point of divergence. As noted above, HS holds that at each derivational step, only one change from the present input can be applied to any given candidate. The winning candidate is then fed back in as the input of a new step. This process continues until the winning candidate is identical to the present input, an event called ‘convergence,’ at which point the derivation ends. This change has had major ramifications for the construction of HS, most notably with its CON. There are numerous classic OT constraints which do not function properly in HS. Sometimes this has required the patching in of replacements, while other times the non-function is by design.

One of the key advantages HS holds over parallel OT is the concept of “local harmonic improvement” (McCarthy 2016). In parallel OT, candidates are assessed ‘globally’: the total sum of their violation marks are assessed simultaneously, with a theoretically infinite number of operations being able to apply prior to EVAL. This characteristic is referred to as ‘global harmonic improvement’, as the derivation will seek to improve ‘harmony’, being obedience to the constraint ranking such that violation marks are minimized, in all places at once. That is, since all operations apply in parallel, EVAL will seek out the candidate with the absolute fewest violations of high-ranked constraints out of all possible candidates. Such a system is powerful, arguably too powerful for the purpose of constructing grammars which will produce all and only those languages which exist. Many of the pathologies which plague OT research are a direct result of global assessment, since it is relatively easy to produce a clearly unnatural candidate which will harmonically bind the attested winners. HS in contrast requires that each locus of violation be analyzed independently, with only one unfaithful operation being applied at a time. This principle is called ‘Gradualness’. Thus, while HS and OT EVAL seek a winner according to the same principle, being the one with the fewest high-ranked violations, the options available to

HS EVAL are significantly more limited. There is only ever a small selection of available winners for each step, ensuring that EVAL can never use multiple operations to select an unnatural spoiler candidate.

Gradualness in GEN has led to much of the focus of HS research being on the definition of operations. In OT whether a change constitutes one operation or two means little, since they all apply in parallel anyways. In HS, however, since only one can apply per step, it is vital that analysts know how many changes can be applied at each step. Thus the importance of carefully defining GEN in an HS paper: if two researchers have differently defined operations, then the same constraint ranking will produce different results. This is also why one of the most classic examples of HS is McCarthy's (2018) two-step deletion: it demonstrates a clear example of how to determine whether a change is one step or multiple, and shows how the delineation of operations can produce intriguing new predictions. Two-step deletion, after all, aligns very neatly with theories of Feature Geometry, with deletion first removing the PLACE node and only thereafter removing the ROOT node (which causes full deletion).

This example touches on a point which, though rather vital, has received minimal discussion in HS literature: the importance of feature theory. According to McCarthy (2010), HS assumes that feature changes must be made one-by-one, as feature change itself is considered an unfaithful operation. Furthermore, as seen above, McCarthy (2018) claims that deletion targets feature-geometric nodes, specifically the PLACE and ROOT nodes. These two assumptions together necessitate that HS must have some sort of attached feature geometry to function. If features must change one-by-one, then it is necessary to know which features are present to be changed. This covers both which feature set is in use, as that will determine the basic pattern of available operations, and which features may or may not be underspecified at that stage of the

derivation. If a feature is not underlyingly specified, and has not been inserted at the time of the operation, then it would not need to participate in the ongoing derivation: that is, an operation could functionally cause a change which technically would alter more than one feature, but operationally have only altered one. All of this is vital information to know if performing an HS derivation, but which is normally glossed over in actual HS analyses. The cause of this glossing over is most likely an inheritance from Parallel OT, which as discussed above generally disregards featural representations in favour of pure computation.

The integration of feature geometry into HS will be further discussed in Chapter 3, when outlining this dissertation's primary theoretical model. For now, it suffices to note that, as stated above, the underlying assumptions of HS necessitate at least some systematic knowledge of feature theory to make a derivation work. Indeed, this dissertation will argue that not just some information is necessary, but all of it: the representation, though not necessarily fully specified, must be fully known to ensure the proper development of the derivation. This claim is a step beyond the conventional discourse on HS, though one which does emerge from that discourse by quite a logical progression.

Shifting back to other concerns in HS, it must be acknowledged here that HS traditionally has trouble analyzing certain kinds of opacity. While the local harmonic improvement of HS is superior to the global harmonic improvement of Parallel OT, it is still something of a double-edged sword. To its benefit, it, like global harmonic improvement, makes a clear prediction about why phonological alternations happen: there is an ideal 'harmony' to which every word aspires, and the derivation's purpose is to bring every given word as close as possible to that, striking a balance between all factors as best as possible. The problem is that many instances of opacity are specifically counter to regular conceptions of harmonic improvement. Rather, they are by

definition phonological phenomena which make no sense on the surface: allophones outside of possible environments, alternations blocked without cause, and so on.

This has always been a problem for Parallel OT, as opacity is quite obviously a result of interaction between operations: one operation causes a change, and then another wipes away its context, for example. HS, therefore, is better suited to deal with certain kinds of opacity than Parallel OT, as it can at least order its operations such that they can interact (Elfner 2016; Gleim 2019; Tanaka 2013). It can even resolve the most basic problem of opacity in OT, which is the fact that parallel operations combined with global harmonic improvement does not allow for an environment to have an effect if it is not present. That is, in Parallel OT, if one operation deletes an environment, then the deleted environment can no longer exercise influence over surrounding segments. Rather, there will always be a candidate which does not show such changes which will harmonically bind any candidate which actually expresses the opaque alternation.

HS at least, due to Gradualness, is able to change the current input such that the middle point of an opaque process could in principle simply be encoded, and then a later operation can further alter the sequence of inputs such that opacity is achieved. However, in practice HS has had a middling history with certain kinds of opacity.

To its benefit, HS is capable in principle of modelling some opacity. Tanaka (2013) gives examples using Japanese and English showing HS capable in principle of analyzing instances of all four standard kinds of opacity: bleeding, feeding, counterbleeding, and counterfeeding. This is made possible due to the ordering of operations which HS allows. Similarly, Elfner (2016) and McCarthy (2008b) both provide HS analyses of opaque phenomena. However, these papers do not represent an uncontested view of the matter.

Rasin (2022) provides a recent account of Harmonic Serialism and opacity. Citing McCarthy (2000, 2007b), he briefly describes the position that HS is considered unable to model canonical counterfeeding and counterbleeding. He goes on to describe the results of Elfner (2016) and McCarthy (2008b) as analyzing what he calls ‘shifting’ and ‘counter-shifting’, being a new form of opacity to which HS is well-suited.

The fundamental issue for HS and opacity is that HS is focused on harmonic improvement, and canonical opacity is quite often the opposite of that. In practical terms, opacity can be defined as the appearance of what should not be, whether that be through the overapplication or underapplication of some regular process. This means that the output must, in some sense, be ill-formed. Since harmonic improvement is primarily concerned with well-formedness, it is difficult for any model built on it to produce a form which ultimately disobeys it.

Nonetheless, while HS has met with problems regarding opacity, the situation is not entirely hopeless. At the very minimum, the local harmonic improvement which HS uses remains superior to the global harmonic improvement of OT in terms of solving opacity. Furthermore, as shown in McCarthy (2000) and Elfner (2016), HS is able to process noncanonical counterbleeding opacity. This is a direct result of one of the advantages of HS over Parallel OT: not merely the ordering of operations, but their decomposition. In HS, as noted above, there is much discussion as to what operations are included in GEN. That is, the debate concerns what is and is not an operation. Two-step deletion is a perfect example. Conventionally, we would think of deletion as a single operation: there was a segment in one step, and in the next there is not. However, in HS, McCarthy (2018) shows this to be not entirely accurate. Rather, there must be an intervening step in which first the PLACE node is deleted, leaving a bare ROOT which can

then be targeted for deletion. This is a classic case of decomposing what had been a single operation into multiple, smaller operations which simply occur in sequence.

First, we should look at the problem of single-step deletion. McCarthy (2018) represents with this an OT analysis of the data, which is in practice identical to the first step of an HS derivation which assumes single-step deletion. It concerns consonant cluster reduction in Arabic, wherein /patka/ → [paka]. McCarthy contends that a single-step deletion operation is unable to explain why [paka] is the output rather than [pata], and that instead we need to treat segmental deletion as a sequence of two nodal deletion processes. For this first analysis he uses two constraints, which can be defined as seen below:

- (1) NOCODA: assign a violation mark for every coda segment.
- (2) MAX: do not delete

The analysis itself is reproduced below.

(3) Failed OT Analysis

/patka/	NOCODA	MAX
a. →pa?.ka		*
b. →pat.ʔa		*
c. pat.ka	*!	

As we can see, this results in a tie, that is, a failure to predict a single, consistent output. The problem is that in Arabic, the output is not random, but rather is consistently [pa.ka]. Thus, we see that treating deletion as a single-step operation simply will not suffice. We need something more complex if we want to properly capture this asymmetry.

Thus, we now can turn to McCarthy's (2018) solution to this very problem. To properly explain this pattern, he uses five constraints, listed below. The following definitions are not present in the original text, but have been created here for the purpose of clarity.

- (4) CODA-CONDITION (CODA-COND): assign a violation mark for every segment with a PLACE node which is syllabified into a coda.

- (5) HAVE-PLACE: assign a violation mark for every ROOT node which does not link to a PLACE node.
- (6) MAX(PLACE): do not delete a PLACE node.
- (7) MAX(ROOT): do not delete a ROOT node.

Now follows the analysis.

(8) Step 1: Place-Deletion

/patka/	CODA-COND	HAVEPLACE	MAX(PLACE)	MAX(ROOT)
→ a. paʔ.ka		*	*	
b. pat.ʔa	*!	*	*	
c. pat.ka	*!			

In the first step, CODA-COND requires that something be done to eliminate the presence of a PLACE-bearing coda segment. Operationally the two options available are to either delete the PLACE node of /t/ or that of /k/. Deleting the PLACE node from /k/, however, does not actually reduce violation marks from CODA-COND, and so it is eliminated. The fully faithful candidate is likewise eliminated from consideration, leaving us with the deletion of /t/’s PLACE node as the only viable candidate. This leads us into Step 2, where we can fully delete the segment.

(9) Step 2: Root-Deletion

paʔ.ka	CODA-COND	HAVEPLACE	MAX(PLACE)	MAX(ROOT)
→ a. pa.ka				*
b. paʔ.ka		*!		

Here we see that HAVEPLACE is now the highest-ranking active constraint. Conventionally, we would say that it requires that every segment have a linked PLACE node. In this system, however, we would better describe it as requiring that every ROOT node present in the candidate be linked to a PLACE node. This is because it can be vacuously satisfied by the absence of a ROOT node. This is a necessary facet of its definition, as we would not want it to assign violations for segments which do not exist. However, such a definition also allows the derivation to solve violations of this constraint by simply deleting the offending ROOT node. This is the

solution here, as Coda-Cond prevents any insertion of a new PLACE node. Without the option to undo Step 1, the only solution is to simply remove the offending ROOT node.

(10) Step 3: Convergence

pa.ka	CODA-COND	HAVEPLACE	MAX(PLACE)	MAX(ROOT)
→ a. pa.ka				
b. paʔ.ka		*!	*	

At the third step no further improvement is possible: indeed, attempting to return to the input of the previous step would now incur two violations marks, whereas remaining faithful in the previous step only incurred one. Thus, we see that two-step deletion is able to correctly predict the asymmetry in Arabic. It is on these grounds that McCarthy (2018) asserts and demonstrates the necessity of making deletion a two-step process in HS.

This leads into another important point to discuss, that being a way in which HS, despite being serial-derivational, diverges pointedly from traditional rules-based phonology. In any conventional rules-based grammar, the rules are fundamentally ordered by stipulation. There can be constraints which govern the relative ranking of some rules, but fundamentally the rules exist in the order they need to so that the correct outputs are produced. This in itself is not really worth mentioning much: all grammars rely on this kind of stipulation. The key point is rather that in rules-based phonology, there is not, as a rule, much of a higher force than stipulation, or rather, historical accident, to determine the ranking of rules. They are the way they are because they developed in that order. In contrast, HS does not rank operations: it ranks constraints, like in OT. And this creates a marked difference, because while the order of operations is fundamentally stipulative in rules-based phonology, it is emergent in HS. That is, in each derivation, the order in which operations are applied derives itself from the interaction of constraints. It is possible for two words in the same language to experience a different order of operations, based on how their segments and environments interact with the constraint ranking.

Now, normally the order of operations will remain relatively constant, simply due to the nature of the constraint ranking. But it is nonetheless possible for operations to change order organically in an HS derivation, as the goal is not to enforce a particular sequence of changes, but for the best candidate to be selected from those available at each step. This expands on the explanatory power of constraints which was already an advantage of OT over generative phonology. In OT, rules were put aside so that the patterns they encoded could be emergently generated by an explanatory constraint ranking. In HS, rule ordering is furthermore put aside, not so that it can be ignored as in Parallel OT, but so that it can be emergently generated by an explanatory derivation.

2.5.1 Definition of GEN

In any HS analysis, the definition of GEN is of vital importance, as discussed above. This dissertation is no exception, and so the assumptions and definitions of GEN at play here must be discussed. Not everything will be covered in detail, and so as a general point this analysis makes all the standard assumptions of HS except where noted.

The first, if most basic, point is that this dissertation adopts McCarthy's (2018) assumption that deletion is a two-step process. That is, deletion first removes the PLACE node, and only thereafter can delete the ROOT node, at which point the segment is fully deleted. This assumption is adopted primarily because of the strength of McCarthy's argument, but also because of the implications, discussed above, which it has for the topic of this dissertation: the implication that HS is closely tied to a feature-geometric theory of representations.

Following from McCarthy (2010), this dissertation also assumes that GEN can change only one feature value at every step. One point of difference between McCarthy's assumption in his paper and the assumption here is, however, the explanation and justification. McCarthy does not

at any point in the paper explicitly justify the assumption. No argument was given *per se* for the assumption, but rather, so far as the article itself is concerned, it was simply adopted for the purpose of the analysis. There must certainly be an explanation, but for whatever reason it was not included in the published version. Here, due to its importance for FGHS, it will be more explicitly justified, though it must be noted that the grounds for adopting the assumption here are likely the same in principle as those which were behind its adoption in McMcCarthy (2010).

As will be discussed in Section 3.3, concerning the ultimately incorrect Nodal Faithfulness Model, there is no particularly good reason to assume anything other than what McCarthy (2010) proposes. We must change features one at a time, as our feature theories do not include any unit of organization which could provide a principled grouping of features which engage in non-assimilatory feature changes. That is, when not dealing with feature spreading, there is no clear way to justify changing multiple features simultaneously under the assumption of Gradualness. As well, the definition generally taken of Gradualness is that it limits HS to one unfaithful operation at every step. The changing of a feature meets this definition, as evidenced by the wealth of IDENT[feature], MAX[feature], and DEP[feature] constraints (dependant on whether the analysis assumes binary or privative features). Lastly, as will be shown in Chapter 3, this definition makes a number of interesting predictions about lenition, fortition, and similar feature-changing processes.

A consequence of the confluence of the feature-by-feature assumption and the adoption of underspecification is that this dissertation assumes GEN to be capable of producing something like the old idea of an archiphoneme, such as [S], which can also be termed a ‘generic coronal fricative’. It is not necessarily an alveolar fricative, nor a dental, retroflex, or postalveolar: it is simply coronal to the phonology. It is entirely possible to underspecify a segment beyond the

point where it can be meaningfully identified amidst its peers, and this must be accounted for in the system. In HS, these archiphoneme-like segments act like any other segment in the analysis, and are distinct only insofar as attention is called to their underspecified status. After all, to some degree all underspecified segments would qualify for this descriptor.

This analysis also adopts the common assumption that operations which are not governed by faithfulness constraints can be applied an unlimited number of times at every step: this includes things like syllabification, which can change ‘for free’ at every step (McCarthy 2016). A change in syllabification violates no faithfulness constraints, and would always improve in markedness, and therefore is allowed to simply occur.

For simplicity’s sake, this analysis assumes binary features with underspecification: that is, features can be specified as either [+F] or [-F], or can be unspecified underlyingly. That is, if a feature is specified, it can be specified in the negative or the positive. However, some features in a segment can also be left undefined or underspecified in the underlying form. Unlike other assumptions made here, this one is not due to a hard-and-fast principled stance, but out of convenience. In principle, FGHS should work just as well with privative features. It is, however, more straightforward for the discussion in this dissertation to be able to insert features with either a [+] or [-] value as appropriate in the situation. Specification to either value is different from changing the value of an already specified feature. Changing the value of a specified feature would violate IDENT, as the operation is altering the nature of a present element of the input. In contrast, the specification of a feature would violate DEP, as specification of an otherwise unspecified feature is indistinct from inserting a new feature. The removal of an underlyingly specified feature would violate MAX, and thus be treated identically to the deletion of any other element. Thus, it assumes that GEN can insert and delete specified features as an operation.

2.6 Diachronic Linguistics

Even more than with feature geometry, this dissertation is not the place for a full account of historical linguistics. It is, however, an appropriate place to discuss some key points which will be relevant for the dissertation ahead. This primarily concerns the use of Optimality Theory in diachronic linguistics, as other relevant discussion on this topic has already been covered in Section 2.2 above. It is, however, worth noting that around the time OT broke away from traditional generative phonology, it also largely broke off from historical linguistics (Ringe & Eka 2013).

Attempts were made in the early years to apply OT to diachronic data, with varying degrees of success, and with definite controversy (Holt 2003; McMahon 2000; Ringe & Eka 2013). Just as many were testing out the new model on historical data, so too were many criticizing its use. Some argued against OT as a whole, holding that it was simply a broken model. Others specifically contended that OT was not workable within some specific context, such as historical data or segmental alternations (McMahon 2000).

A key argument this dissertation seeks to address is the criticisms of McMahon (2000, 2003, 2007) against Optimality Theory as a model for diachronic linguistics. Across these papers, McMahon strongly criticized OT both as a model for historical sound change specifically, and more broadly as a general phonological model. The key points of these arguments will be addressed more fully in Chapter 4, but it is worth overviewing them here.

The arguments developed somewhat over the course of the three sources, but with certain recurrent themes. The most enduring idea was that OT works best when dealing with prosodic phenomena, and that it is rather inept with segmental alternations. McMahon (2000, 2003, 2007) also strongly and repeatedly criticizes Parallel OT for being too universal in its approach. As will

be discussed in more detail in Chapter 4, McMahon (2000) contends that many historical developments in language are mere accidents, things which cannot be explained by universal constants but rather by particular circumstances. She even goes so far at points as to assert that certain developments are functionally inexplicable, and that we must simply accept that in one language phenomenon X occurred because it must have occurred. This stands in pointed contrast to the principles of OT, which unequivocally state that constraints are universal, and that in consequence every development in every language should be explicable, in principle, from the application of those universals.

Such claims will be discussed and answered in Chapter 4, but for now it is appropriate simply to note them, and to acknowledge their importance. If these criticisms of OT as a diachronic model are true, then any and all attempts at diachronic OT should cease at once, as they would be nothing more than a waste of time. Furthermore, all told, phonologists should seriously reconsider their use of OT generally, since any phonological theory which cannot explain, in principle, the long millennia of sound change is not likely to in the end be an accurate model of phonology. It could possibly be that what we are examining in synchronic grammars is fundamentally different from what we mean by the analysis of historical sound change: that only synchronic grammars truly ‘exist’, and diachronic study is instead the eliding of many successive synchronic grammars to describe not actual languages or phonological alternations, but rather the differences between two communities separated by time. In that case it could be appropriate to have one model which explains synchrony, and another which describes diachrony. We must however be wary of distinguishing too firmly between these two without good cause, if for no other reason than that sociolinguistics as a field already stands as a sort of ‘diachrony-in-motion’. That is, in sociolinguistics we study sound changes in motion, while in historical linguistics we

study sound changes of long ago. The only fundamental difference between them is the scale of time. If we say that synchrony and diachrony should have entirely different models, then we should not expect to be able to model changes happening in society in that very synchrony. If we do not say this, then we should, in the end, expect that any synchronic model can in principle explain the diachronic means by which that synchrony emerged.

A brief note should be made here that while there has been significant discussion on OT as a potential diachronic model, there has been comparatively little, if any discussion of using HS in historical linguistics. This likely results from the fact that HS is a theory-within-a-theory, simply one variant among many which has emerged over the past thirty years. Thus, it is less likely to be known about or understood by scholars who work outside the OT tradition. Furthermore, its adherents are fewer than those who work with OT more generally, and it is therefore less likely by sheer statistics to have people who work both in theoretical and historical linguistics.

This is, however, rather a shame, since HS is mechanically better suited to historical work than Parallel OT. Whatever the merits of OT as a model for diachronic phonology, a matter which is discussed further in Chapter 4, it cannot be said to be naturally inclined towards the ordering of changes in a timeline. HS, in contrast, is derivational, and thus shares with rules-based phonology, the propensity for organizing phonological changes into a sequence. This is, after all, demonstrably how language develop over time: it is inconceivable that any speaker would, by a single, parallel derivation, derive modern English from Proto-Indo-European. Rather, we would all accept that Modern English speakers derive their speech from more recent forms. OT certainly is capable, in principle, of capturing the phonology of any given stage of the language. But it does not naturally capture the actual changes which speakers have experienced and passed down through the generations.

2.7 Conclusion

This chapter has been primarily about getting everyone on the same page. It has gone over, with varying degrees of detail, the various fields which are being brought together in this dissertation. Without this information, the chapters to follow may well spiral into incoherence for the unprepared reader. Thus has this chapter been assembled, to ensure that no matter the background of the reader, whether in Feature Geometry, Optimality Theory, or simply historical linguistics, the dissertation to follow will at the very least make sense. The key takeaways are now to be summarized.

The central analysis of this dissertation is the RUKI Sound Law, a historical change in Sanskrit which saw *s become retroflex after any of [r u k i]. This RUKI set is generally speaking indefinable as a natural class, and therefore the change has posed a recurring problem in phonological study for over one hundred years. Most analyses end up finding fault with the treatment of RUKI as a single change to be explained by a single natural class, and instead propose that it be broken down into two or more changes which were later neutralized. Vennemann (1974) and Longerich (1998) instead proposed that RUKI should be understood as a ‘relative acoustic class’, whereby [r u k i] are united not by any traditional phonological characteristics, but by a common acoustic effect on following /s/. We therefore have a strong indication towards an unresolved problem on the phonological side of the change: the ‘relative acoustic class’ analysis fundamentally abandons phonological explanation, and the primary phonological analyses cannot resolve the observed pattern as a single change. Therefore, we must look either outside phonology, or deeper into the data to find the answer.

This dissertation proposes that such answers require a reintegration between constraint-based phonology and featural representations. OT abandoned any kind of featural representation in its

pursuit of pure computation, while feature theorists simply continued using traditional generative methods. Being a derivative of OT, Harmonic Serialism has similarly either ignored or been quite vague about feature representation, but its actual principles, most importantly Gradualness, necessitate a specific knowledge of the representation for the model to actually function. Thus, Chapter 3 will discuss in detail a model for Feature-Geometric Harmonic Serialism. This model will be based on the Clements & Hume (1995) model of feature geometry, as it provides strong tools which will aid the eventual analysis of RUKI, most particularly the split between C-PLACE and V-PLACE.

As regards Optimality Theory itself, the theory has been summarized and explained for the benefit of any reader who is not particularly familiar with it. The fundamental element of OT is the parallel application of operations in a constraint-based, rather than rule-based, model. That is, the output of an OT analysis is organically generated in response to the pressures of the ranked constraint hierarchy: no given constraint necessitates a particular outcome, but simply bans certain situations. Instead of rules each applying their stated changes in order, there is the mechanism of GEN, which simply produces an infinite set of possible outputs, from which one winner is selected. This allows it to dispense with the stipulation inherent in rules-based phonology, as each particular word or phrase can respond to its particular context without needing extra rules to undo earlier changes or some such strange interaction. Instead, the evaluation mechanism simply tests the products of GEN against the constraint ranking, selecting the one which has the least high-ranked violations. However, the parallel nature of OT leaves it unable to account for opacity, as opaque interactions are necessarily predicated on there being an order in which operations occur.

This leads neatly into the more important model for this dissertation, that being Harmonic Serialism. HS introduces the concept of ‘Gradualness’, whereby GEN is limited to only applying one operation to the input at a time. This limits the possible candidates to those within one operation of said input, with the winner of the evaluation being used as the basis for a new evaluation until the winner is identical to the input of its step. This system reintroduces the ordering of operations, though without reintroducing the stipulation of rules-based phonology. Instead, it subjects operational order to the same process that OT did output selection, that is, made it the organic result of the constraint ranking. This both increases the explanatory power of the model, and allows for variation in the order of operations depending on context. HS therefore is better-suited to model opacity than Parallel OT, though due to HS inheriting the concept of ‘harmonic improvement’, whereby every change must reduce the count of high-ranked violations, its ability to model opacity has remained traditionally limited. Nonetheless, HS seems to be mechanically better suited to handle diachronic changes than OT due to its explicit ordering of operations.

Lastly, this chapter has introduced the use of OT in diachronic linguistics. Efforts have been made to apply OT to diachronic data with varying degrees of success, and it seems that over time Optimality Theorists simply gravitated towards synchronic data, while historical linguists often ignored OT. Heavy criticisms were also levied on OT which must be addressed if it is to ever be held as a legitimate model of diachrony. In this debate HS has barely figured, despite it potentially being better than OT for this job.

3. Feature-Geometric Harmonic Serialism

3.1 Introduction

This chapter therefore covers the background for and development of the Feature-Geometric Harmonic Serialism (FGHS) model which forms the structure for the analysis in Chapter 6. Here, we will discuss the key assumptions of Harmonic Serialism (HS), and how they point to a largely undiscussed underlyingly assumption regarding the use of featural representations in HS. From this basis, this chapter develops a modified version of HS which explicitly adopts the Clements & Hume (1995) model of feature geometry, as well as the assumption that features can be underlyingly specified. The adoption of underspecification will be shown to be necessary through comparison to a fully-specified alternative model called ‘Nodal Faithfulness.’ It will show how this model develops from the principles of HS, and argues that this model should be treated as an extension of conventional HS. It will further demonstrate validity of the model through a series of analyses, thereby establishing a baseline for how the main analysis in Chapter 6 will function. Section 3.1 introduces the chapter. Section 3.2 describes the FGHS model itself, outlining its theoretical composition, basic predictions, and basic function. Section 3.3 compares FGHS to its potential alternative, Nodal Faithfulness (NF). NF will be explored through a sample analysis using Chilean Spanish, with its shortcomings shown through the awkwardness of its solution to the problem at hand. This will form the first argument for why FGHS with underspecification is superior to fully-specified NF. Section 3.4 introduces a case study to stress-test FGHS, being a brief study of various lenition processes from across the world. Section 3.5 details the specific lenition analyses, covering Latin, Catalan, Serbian, and Chilean Spanish, the last of which provides a direct comparison to the Nodal Faithfulness analysis earlier and completes the argument for underspecified FGHS. Section 3.6 concludes.

3.2 Feature-Geometric Harmonic Serialism

In McCarthy (2010), there is introduced an assumption that HS must change features one at a time during a derivation. This assumption is not clearly given an explicit justification in the paper, treating it as a logical working-out of the principle of Gradualness, simply listed alongside other operations asserted as ‘unfaithful’, such as syncope and epenthesis. Certainly, it makes sense that if only one unfaithful operation can be applied at every step, then it makes sense that the changing of each feature must be one operation. It is difficult to conceive of what an operation defined as changing multiple features would look like without involving assimilation, that is, an operation whereby featural nodes become attached to each other, rather than individual features themselves actually changing. However, while this assumption is explicitly present, it is never explicitly defined or justified within the article itself.

It is furthermore of note here that one of the basic tenets of HS is that deletion is a two-step process (McCarthy 2016). It is held that a full segment has too much information to be deleted, and so deletion must first remove the PLACE node in a single operation, and then delete the ROOT node in a second operation. The definition of this process involves direct reference to Feature Geometry on the model of Clements (1985). Now, the justification for involving Feature Geometry is not given, and neither is there much focus placed on working out the implications of incorporating it. But nonetheless, it is another point of evidence towards the fact that, unlike Parallel OT, HS must have an explicitly attached Feature Theory. After all, it would be difficult to define deletion as targeting a PLACE node which either does not exist, if we assume some other feature theory which does not use PLACE nodes, or one which we cannot know exists, if we adopt the traditional OT agnosticism regarding featural representation.

Parallel OT was explicitly designed such that it could account for any feature theory (Prince & Smolensky 2004): it was entirely agnostic on the nature of representations, being focused entirely on computation. This was achieved primarily through the parallel nature of OT, in which all operations could occur simultaneously. In such a system the details of the underlying representation are largely irrelevant: so long as there is a broad structure known, operations can be applied to make whatever changes are necessary before the output is ever seen. Thus, while in principle any given OT analysis would adopt a particular feature theory, in practice it is very easy to leave most of its details aside. In particular, OT rarely gives the specific feature definitions of the involved segments, in no small part because full parallelism means that in many cases the specific feature values are simply not relevant. As noted in Section 2.4, if there is a ban on voicing in final position, such as with a high-ranked *FINALVOICE constraint, then it does not really matter whether the input is specified for [+voice], [-voice], or lacks a [voice] feature altogether. The output will end up being voiceless. In contrast, HS, being gradual, must work out not only each of those operations independently, but must order them properly. It is therefore vital to know which features are present or absent, and what values they have. In order to function, HS must therefore have an explicitly attached feature theory. That is, an HS derivation must be concerned with the featural representation of its inputs to a degree beyond that which OT usually considers. Like with OT the specific feature theory being chosen can vary, as the computational system will function regardless. But while OT can in practice often get by without specifying which exact features have which values, HS cannot, as it must explain every feature change independently.

This dissertation will argue for Feature-Geometric Harmonic Serialism (FGHS), a model based on the Clements (1985) model of feature geometry, and its expansion in Clements & Hume

(1995). This is the best-established feature-geometric model, and has on those grounds been selected for use. Furthermore, it is, as noted above, the one which HS already has some connection with. Other options are available, such as the Parallel Structures Model (Morén 2003ab, 2004ab, 2006). However, while these alternatives have their merits, they do not seem to have achieved mainstream popularity after the manner of Clements (1985), and are therefore ill-suited to this early proposal when there is not at present a clear advantage to them regarding the particular analysis at hand. The intention of this dissertation is to establish a theoretical structure in which HS makes explicit use of feature theory to fully work out its assumptions. Due both to the greater popularity in the field of Clements (1985) and the above-mentioned fact that extant work on HS already makes use of that model for deletion, it would be most logical to use Clements (1985) here. However, as will be seen in Chapter 6, the analysis of the RUKI Sound Law itself, the revised Clements & Hume (1995) model is ultimately better suited to explaining the data at hand. Thus, it is this expanded feature geometry which will be assumed for FGHS in principle, though depending on the dataset in question both it and the classic Clements (1985) model will work quite well.

Given the discussion above, a conclusion can be reached as regards the integration of a feature geometry into Harmonic Serialism: that is, a Feature-Geometric Harmonic Serialism (FGHS) can be constructed. This system is intended to provide a principled account of how HS, based on its extant research and underlying principles, should operate with its feature geometry. It further incorporates more innovative elements in order to solve certain emergent issues created by the basic design of OT being used in this context.

The core principles are thus: only one feature may be changed at a time; only one node may be deleted at a time; if a node is deleted, then all dependent features automatically become

disconnected (and are effectively deleted); underlying representations are underspecified in the lexicon; unspecified features receive specification during phonetic implementation via a set of feature-filling rules.

Otherwise, FGHS is identical to classic HS: GEN, CON, and EVAL remain identical. That is, no more than one unfaithful operation can be performed per step; in principle, any constraint which works in HS will work in FGHS, and furthermore the idea of having a grand unified ranking of all the language-universal constraints which determine through their interactions the observed phonology of a language holds true as well. The winning candidate is selected at each step of the derivation via the elimination of constraint-violating candidates according to the constraint ranking.

In McCarthy (2018), it is argued that Parallel OT is incapable of providing a principled explanation of the “coda deletion asymmetry.” This asymmetry is the observation that when there is a word-medial consonant cluster which becomes simplified, the first (or leftward) segment will be deleted and the second (or rightward) will be retained. In Parallel OT, coda deletion as a general process would be explained by ranking NOCODA >> MAX. This causes a problem when dealing with word-medial cluster simplification:

(11) Cluster Simplification Failure (McCarthy 2018)

/patka/	NOCODA	MAX
→ a. pa.ka		*
→ b. pa.ta		*
c. pat.ka	*!	

As can be seen, there is a tie in winning candidates here. In many versions of Parallel OT, such a tie would result in free variation: either candidate could be outputted essentially at random. However, this is not what is observed in the actual data. Rather, candidate (a) [pa.ka] is

the regular output, and onset-favouring candidates consistently win out over coda-favouring ones cross-linguistically.

It is to address this issue that McCarthy (2018) argues for two-step deletion in HS with the following analysis, as we discussed in Section 2.5. In this system, only one feature node can be deleted at a time. Thus, before the ROOT node can be deleted, its PLACE node must first be deleted. Due to this requirement, positional effects will determine which segment will be deleted. Rather than using only NOCODA and MAX, McCarthy invokes four constraints: CODA-CONDITION >> HAVEPLACE, MAX(PLACE) >> MAX(ROOT). The expansion of constraints is necessary to deal with the increased analytical complexity. Note that CODA-COND is defined as banning coda consonants from having PLACE.

(12) Step 1: Place-Deletion

/patka/	CODA-COND	HAVEPLACE	MAX(PLACE)	MAX(ROOT)
→ a. paʔ.ka		*	*	
b. pat.ʔa	*!	*	*	
c. pat.ka	*!			

In step 1, CODA-COND drives deletion of the PLACE node of /t/. Candidate (b) deletes the place node of /k/, but as it is in onset position this does not improve on any constraints, and increases violations of HAVEPLACE and MAX(PLACE). Candidate (c), being fully faithful, remains in violation of CODA-COND. This leaves Candidate (a) as the winner, despite violations of HAVEPLACE and MAX(PLACE), due to its satisfaction of high-ranking CODA-COND. This step therefore shows why coda consonants would be prioritized over onset consonants for deletion.

(13) Step 2: ROOT-deletion

/patka/	CODA-COND	HAVEPLACE	MAX(PLACE)	MAX(ROOT)
a. → pa.ka				*
b. paʔ.ka		*!		

In Step 2, HAVEPLACE becomes the crucial constraint. Having been violated in Step 1, it now demands satisfaction. Candidate (b) continues to violate it by containing [ʔ], a segment without PLACE. In contrast, Candidate (a) simply deletes the ROOT node of [ʔ], vacuously satisfying HAVE-PLACE at the cost of violating MAX(ROOT).

(14) Step 3: Convergence

/patka/	CODA-COND	HAVEPLACE	MAX(PLACE)	MAX(ROOT)
a. → pa.ka				
b. pa.ʔa		*!	*!	

The third and final step is convergence, since HAVEPLACE ensures there is no benefit to reducing /k/ even after deleting /t/. Thus Candidate (b) is eliminated by HAVEPLACE and MAX(PLACE), while candidate (a) violates none of the relevant constraints. Note that in HS, Faithfulness constraints refer to the input of the current step, and thus once a change is integrated it ceases to cause Faithfulness violations.

Thus is established two-step deletion for HS. On the basis of this analysis, it is clear that HS ought to take two steps in deleting segments rather than one, as single-step deletion would simply result in the trouble faced by the Parallel OT analysis above. As McCarthy (2018) further argues, this analysis provides a clear empirical prediction: where full deletion is found, reduction to glottal segments in the same position will also be found.

Now, having established that HS has two-step deletion, several important points emerge. The first is that in order to work out two-step deletion, McCarthy (2018) was forced to commit to a specific feature theory, here being “a simplified feature geometry (Clements 1985; McCarthy 1988)”. That is, two-step deletion as a facet of HS is reliant on Clements-style feature geometry, and could not function without it (or at least something very like it). A world in which phonologists adhered only to a disordered Feature Theory, without any hierarchical Geometry, would be unable to make use of two-step deletion in HS, as there would be no clear PLACE

node under which all Place features are conveniently gathered. It can therefore be concluded that in order to function, at least in matters like this, HS must have an explicitly attached feature theory, and more specifically must make use of a developed feature geometry. This, of course, leads into the quandary of which feature geometry.

While there are many theories which could be selected, only two will be particularly considered here: that of Clements (1985) and Clements & Hume (1995). The rationale for this is simple: it is explicitly a Clements (1985) model which McCarthy assumes in the relevant articles. The only question is whether we should continue to use the ‘simplified feature geometry’ referred to above, or if something more complex will be necessary. This dissertation asserts that in principle, the expanded Clements & Hume (1995) model is preferable over the original Clements (1985) model, for the simple reason that separating C-PLACE and V-PLACE makes it easier to both account for consonant-vowel interactions, and to account for secondary articulations. However, both models will serve just fine depending on the data, and where a split of C-PLACE and V-PLACE is unnecessary it will not be used in the analyses presented in this chapter.

3.2.1 The nature of MAX(PLACE) and MAX(ROOT)

A final aside on this matter is the nature of MAX(PLACE) and MAX(ROOT): these constraints are essential for the principled explanation of the asymmetry which McCarthy (2018) gives. Their ranking relative to HAVEPLACE and CODA COND is the asymmetry in constraint terms: so long as HAVEPLACE and CODA COND are ranked above MAX(PLACE) and MAX(ROOT), place-deletion will occur. However, the use of nodal deletion as an operation opens up the fair question of why we cannot delete the ROOT node first. In McCarthy (2018), the prevention of ROOT-first deletion is taken as an assumption, holding that a ROOT node which has an attached PLACE

node simply cannot be deleted. This is a fair assumption in that paper, but it is worth taking time to question if that assumption is perhaps premature. Certainly, ROOT-first deletion feels at first glance like it should be pathological. After all, what would a ROOTless segment even be like? The results of such an operation would seem to be patently absurd. The result would be a step at which there is a segment which has a place but no root: imagine, for example, a coronal segment which is neither stop, fricative, nasal, liquid, or glide. It is practically impossible to imagine such a segment being pronounced: it would be like articulating [t] and never providing the air for it, and quite possible the result would be something even less developed than that (as [continuant] and [consonantal] are both connected to the ROOT node rather than PLACE). If such a segment were to surface in an output it would be a true unpronounced segment, still bearing meaning but never heard or said. Note that this description assumes that while dependant features would be automatically deleted if their associated node was deleted, other nodes would be to some degree able to endure. Specifically, that the ROOT node and the primary PLACE node are capable of independent survival, while PLACE nodes dependant on the primary PLACE node are likely not capable of such. If we do not assume that specific PLACE nodes are deleted alongside the primary PLACE node, then we would need deletion to be a three-step operation, or perhaps even longer for more complicated segments. As we do not assume three-step deletion, we will go forward assuming that specific PLACE nodes are deleted in the same operation as the primary PLACE node.

However, if we put aside this initial concern and examine actual data we can in fact find some surprising evidence in favour of ROOT-first deletion. We will see when we turn to the Latin analysis in Section 3.5.1 (Cser 2011), and the Catalan analysis in Section 3.5.2 (Hualde 1992). HS, unlike Parallel OT, has the capacity to produce incomplete segments in intermediate

steps. A segment such as [S], being defined as [CORONAL, +continuant, -voice] with no further featural definition, could be produced in the midst of a derivation (further discussion of this concept can be found below in Section 3.2.2). If allowed to surface, this segment would be unpronounceable, as it lacks any definite place of articulation. However, HS never would allow such a segment to be actually pronounced. Leaving the fuller discussion for Section 3.5.1, there must either be constraints which require the full definition of such segments prior to convergence, or there must be feature-filling rules which will fill in the absent features. It is possible that a segment which has a PLACE node but no ROOT node could exist within the same broad sphere. That is, it may be that ranking $\text{MAX}(\text{ROOT}) \gg \text{MAX}(\text{PLACE})$ will indeed produce a rootless PLACE, but that some other constraint (for example, something like HAVEROOT constraint) will drive either insertion of a ROOT node or deletion of the PLACE node.

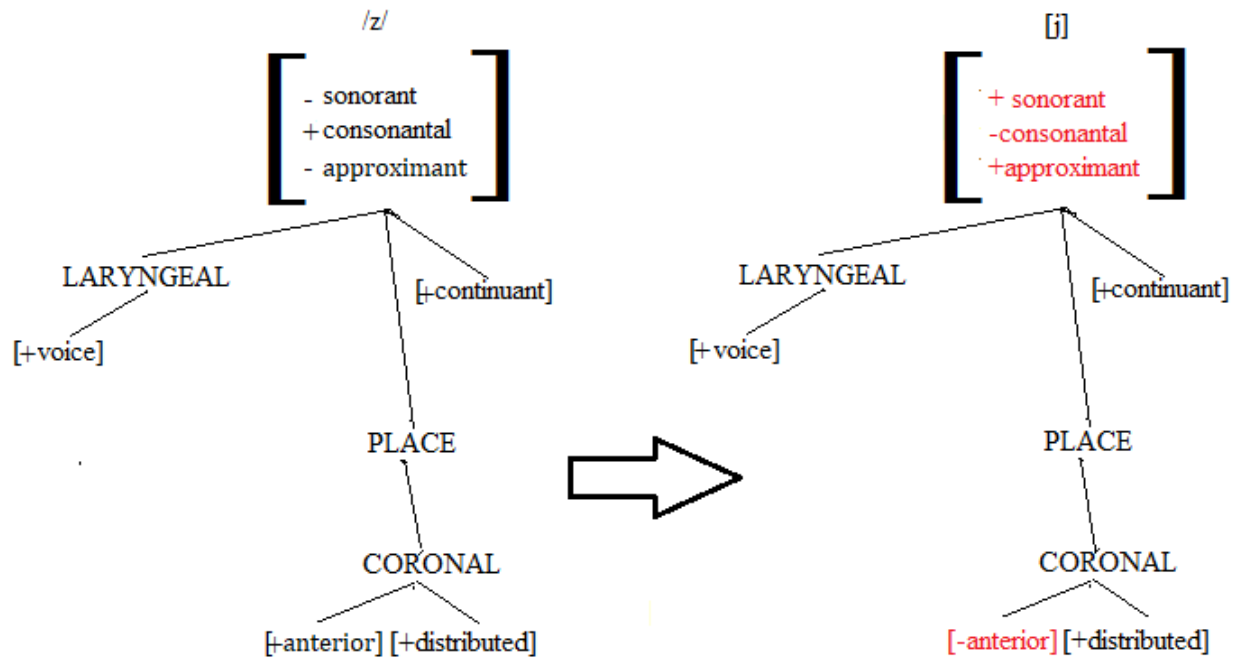
The apparent problem here is that HAVEROOT would permit PLACE-deletion as a solution by vacuous satisfaction: with neither ROOT nor PLACE, there is no segment, and a non-segment would not violate HAVEROOT, as any definition of HAVEROOT which was violated by the absence of a ROOT node when there is no corresponding PLACE node would be violated by any silence in a human being, which is of course patently absurd. Therefore, we would expect there to be two patterns of deletion: one in which the ROOT node is deleted first, and another in which the PLACE node is deleted first. This trouble would not arise in deletion driven by CODA-COND, since that constraint would only ever motivate the deletion of a ROOT node. Nonetheless it is a concern worth noting, as constraints other than CODA-COND can drive deletion: even something as simple as *t could motivate deletion, in which case the order of node deletion suddenly becomes an issue.

Fascinatingly, there is direct data, already noted above, which can bear on this question, and it addresses the above concerns (Cser 2011; Hualde 1992). Section 3.5.1, concerning Latin, and Section 3.5.2, concerning Catalan, give data demonstrating phenomenon in which the most sensible analysis would claim that there is a floating PLACE node. That is, there is a PLACE node which does not have a ROOT node, and this PLACE node being something derived from what was once a full segment. This certainly looks like it could be an example of ROOT-first deletion. Leaving the details of this analysis for the appropriate section, it suffices to say for now that the concerns given above are ultimately unfounded. ROOT-first deletion does indeed seem to not only be possible, but it is actually attested. This makes for a fascinating if unexpected advantage of integrating feature geometry into HS: that it allows us to so easily model both kinds of deletion, with evidence showing the output of the intermediate steps.

3.2.2 Underspecification and FGHS

There is next a matter which must be resolved: how specified are the representations? Once a theory of representations is adopted, it must be decided whether they are fully-specified or underspecified. There are clear theoretical reasons in favour of underspecifying FGHS rather than working with fully specified underlying representations. The key problem is thus: in certain derivations, multiple features must be changed simultaneously to account for the alternation: consider the alternation /z/->[j]. The diagram below shows the necessary feature changes in red.

Figure 3: /z/→[j] changes



If this derivation cannot allow an intermediate [r], then [sonorant], [consonantal], and [approximant] must be changed in the same step, as well as the specified place feature of [anterior] since [z] is dental and [j] is palatal. In a feature-by-feature system with full specification, this change is impossible: four features must each independently be shown to be harmonically improving for the change to take place, and none can produce a non-alternating sound, such as the above-mentioned [r].

There are two potential solutions to this issue. The first would be to expand the number of features which can be changed in a single step. This method, which we might call “Nodal Faithfulness” (NF), allows all features grouped under the same node to change in a single step. Changes made in this manner are governed by “Nodal Faithfulness” constraints, which are violated by a change in the feature-value configuration of a node, rather than by the feature changes themselves. With such a definition, the NF constraints ignore how much has changed

and penalize equally one change or many. This equalizes the weight of feature changes within a node. Furthermore, it must come with a Specified PLACE Exception, which allows the specified place features of a segment to change ‘for free’ at each step. In such a system it would constitute the same number of operations to change from /z/→[j] as for /z/→[r]. If there are then independent reasons for [j] to be favoured over [r], EVAL will select the [j] candidate.

While effective, this solution has several worrying theoretical issues. The most glaring of these is the Specified PLACE Exception: it has no empirical grounding, and is contrary to the theoretical assumptions of HS. In HS, ‘free’ operations may only occur if they are faithful: that is, they must violate no faithfulness constraints. The Specified Place Exception necessarily does violate faithfulness constraints, as Ident[anterior] (among many others) is clearly an existing constraint. It is also suspect on the grounds of it being *ad hoc* inclusion: it exists for the sole reason that Nodal Faithfulness cannot generally account for the derivation, and provides a patch. Now, the other problem here is the definition of feature-changing as being under the node. There is no clear reason why this would be the case: no solid argument can be provided for why feature value-changes would group under the node rather than in some other way. There is well-attested evidence for assimilation by node, but assimilation and feature value changing are not the same thing. Further discussion of Nodal Faithfulness as a model is reserved for Section 3.3.

An alternative, ultimately superior solution, is simply to involve underspecification. The purpose of Nodal Faithfulness is to resolve the problems introduced by feature-by-feature changes in fully-specified representations. It is an attempt to deal with the awkward fact that there are too many features in fully-specified segments to meaningfully change one at a time in HS. However, the same effect can be achieved through simply leaving out the problematic features and specifying only those which are necessary for the phonology. Features which are not

present cannot interfere with the progression of a derivation. Therefore, the derivation can avoid problematic features and focus only on changing, or maintaining, those features which are relevant, without any need for theoretically suspect mechanisms such as the SPE.

A further issue is the language-specific nature of underspecification. While there are universal principles at play, each language is ultimately idiosyncratic in which features are underspecified, and what default specifications are preferred in which context. There exist three broad types of underspecification: Radical Underspecification, Contrastive Underspecification, and Naïve Underspecification (Martin 2012). Within each of these camps there is room for detail and disagreement, most of which is irrelevant to the present discussion.

Radical Underspecification is, as the name implies, the more extreme of the camps (Kiparsky 1982a). It argues that underlying representations store only those features which are absolutely required to define the segment in question against the rest of the phonological inventory. That is, features which are not contrastive in a language are underspecified, as are any which can be considered to be ‘default’. Default feature values are inserted via feature-filling rules after the fact. Taking this to its extreme is where we see the underspecification of all features which are not absolutely necessary to define a segment against the rest of the inventory. Features underspecified in this way are referred to as ‘redundant’, as they are not necessary to define every segment available in the system. The main disadvantage of this system is that its claims are argued to be too strong, and it fails to properly model all observed languages. That is, it often underspecifies features which we have empirical reason to believe are in fact specified.

Thus came Contrastive Underspecification (Steriade 1987). It holds that so-called ‘redundant’ features can in fact be stored in the underlying representation. This claim is based on the observation that in many languages, there are phonological processes which require the presence

of redundant features in order to function. Thus, it rejects the extremity of Radical Underspecification and instead posits a universal rule for determining if features should be underspecified: that only features which are non-contrastive can be underspecified. This plays out as identifying all minimal pairs in the language and marking the relevant features as 'contrastive'. Any feature which does not distinguish a minimal pair is non-contrastive, and can be underspecified. This model thus resolves several issues in Radical Underspecification, but does have its own holes. It is, in contrast to Radical Underspecification, a universalist theory. Radical Underspecification ultimately treated underspecification on a language-specific basis, that each language could have its own patterns of underspecification relevant to its segmental inventory. Contrastive Underspecification therefore has trouble with any language which displays an idiosyncratic pattern of markedness, such as specifying [u] as the default vowel (Martin 2012).

The third camp is not a principled position; in fact, to the degree it exists as a formal 'type' of underspecification, it derives primarily from the principle of pragmatism. Naïve Underspecification takes the view that the underlying representation should be specified to the extent that is required in order to properly explain attested phonological patterns. It is rather brazenly a pragmatic, *post hoc* model of underspecification. However, it has been noted to be the most accurate model of underspecification available (Martin 2012). Due to the outstanding debate between Radical and Contrastive Underspecification, which as of yet remains unresolved, this dissertation will adopt Naïve Underspecification.

A consequence of underspecification is that, of course, segments do not enter the derivation fully specified. Now, assuming, as the Clements (1985) model does, that features are primarily articulatory in nature, it stands to reason that a segment would be, in practice, unpronounceable if

not fully specified. Imagine, for a moment, if you tried to pronounce a segment without [voice]: not a voiceless segment, but one which is neither voiced nor voiceless. It is practically impossible to conceive such a thing. We can thus assert that all features must be specified at some stage prior to actual pronunciation. Therefore, if FGHS is to use theories of underspecification, then it must also adopt some system to insert underspecified features. Certainly, the pre-OT theories of Underspecification all included some form of feature-filling rule by which all features would become specified by the end (Martin 2012). The issue at hand is how to implement such a thing into an OT environment.

The most obvious solution would be to include constraints which require the specification of features, something like SPECIFY (assign a violation mark for every feature which does not have a specified value), with an example being SPEC[high]. These constraints could either require specific values, such as SPEC[+high], or merely demand that some specification be implemented, with the details left to the rest of the ranking. This system has the advantage of remaining wholly within the OT tradition of constraint-only analyses, and the requisite constraints could be easily slotted into CON. However, there are several glaring issues with such a system.

The most obvious is that feature-filling or feature-specifying constraints would, in principle, be able to be ranked anywhere in a language's ranking. However, factorial typology clearly shows that it is possible, therefore, to rank something like SPEC[high] below a constraint like *[high], or SPEC[+high] below *[+high]. Consider the following toy grammar. We here assume an input of the underspecified segment /I/, which we will treat as a non-back vowel without a specified [high] feature. For ease of discussion, we will only examine the insertion step itself.

(15) *[high] >> SPEC[high]

/I/	*[high]	SPEC[high]
a. [i]	*!	
→ b. [I]		*

If any feature-filling constraints were to be ranked too low, as seen in the toy grammar above, then it could in principle be blocked from ever actually applying. If full specification is required for pronunciation, then we have an unpronounceable segment being produced. This stands in direct contravention of Richness of the Base, by which any input should be able to be mapped to a pronounceable output. Very low-ranked constraints are functionally never obeyed, especially in an HS derivation: given the limited candidates GEN can produce, low-ranked constraints will practically never become active in the evaluation of two candidates. Thus, it becomes possible for a derivation to reach convergence without ever specifying some feature. This would then produce an unpronounceable segment, which is a pathology: definitionally, no language uses an actually unpronounceable segment, since at the very minimum such a thing could never be learned by a new generation, as it could not have any input data for a segment which no adult speaker could ever actually produce.

Conversely, if feature-filling constraints were ranked too high, then they would always be satisfied first and would be unviolated, as high-ranked constraint in OT models are always considered inviolate in practice. This, however, means that the language is effectively fully specified underlyingly, as there would be no way to tell the difference. We can see this latter pattern demonstrated in the toy grammar below.

(16) SPEC[high]>>*[high]

	/I/	SPEC [high]	*[high]
→ a. [i]			*
b. [I]		*!	

Given the constraint ranking in this toy grammar, neither we nor anyone actually acquiring this language would ever have reason to believe that the UR was the underspecified /I/ rather than the fully-specified vowel [i]. Consider the situation if we assume the UR to be /i/ instead.

(17) SPEC[high]>>*[high]

/i/	SPEC[high]	*[high]
→ a. [i]		*
b. [I]	*!	

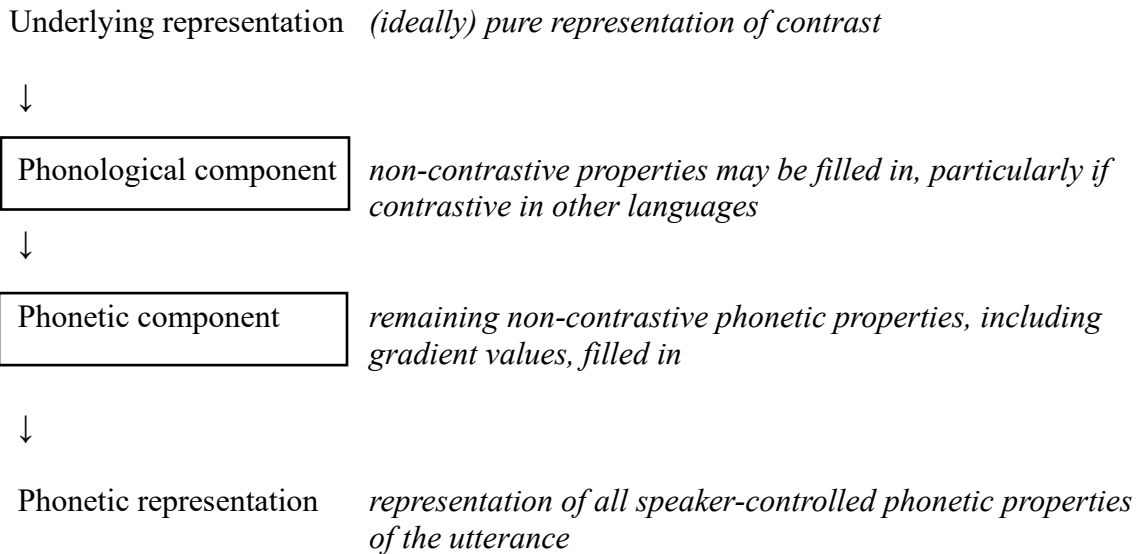
The output is exactly the same. Now, it is a separate matter which UR would be selected by a learner for lexical storage. But it is certainly a problem for anyone wanting to analyze the language, since we could not possibly become aware of the possibility of an underspecified UR.

Now, putting aside the matter of SPEC constraints themselves aside, some feature specification would be solved naturally during the derivation: various constraints and operations would enforce feature specification, such as through assimilation. However, what about those features which are left over? For these, there must be some failsafe system in place.

Thus, we come to an alternative which avoids these problems: the simple use of feature-filling rules. Now, the addition of rules to an OT system is a highly controversial idea, and its proposal here comes with certain caveats. The first is that FGHS does not propose to restore rules to phonology proper. Rather, I argue to integrate something like a concept from Lexical Phonology (Kiparsky 1982), that being postlexical phonology, or similar to the model proposed in Kirchner (1997). In FGHS, there are language-specific feature-filling rules which are situated in the phonetics interface. Phonetic implementation is already language-specific: consider that phonologically English has what we generally describe as a voiced-voiceless contrast which phonetically manifests as voiceless-aspirated (Rogers 2000). If full specification is required for pronunciation, it makes sense that the interface dedicated to pronunciation (with phonology being concerned primarily with abstract phonemes and their alternation) would have a system in place to patch underspecified phonological outputs.

This system is intended to follow after the model elaborated in Kirchner (1997), reproduced below.

Figure 4: Kirchner (1997) Model of Representational Development



Let us take the example covered above, of an underlyingly underspecified /I/ which is to be mapped to a pronounceable surface output [i]. Let us for this example assume that no constraint has pressured it to adopt an actual [high] value: it is defined as a [-back, -low, -round] vowel. The proposed feature-filling model for FGHS holds that when this segment is sent to the Phonetics interface for production, a rule such as follows is applied:

(18) [-back, -low] → [+high]

This rule takes any vowel which meets its structural requirement, and inserts a specified value. There can be as many or as few rules as are necessary for the language or speaker in question. These rules can also vary in complexity, in a manner similar to the selection of allomorphs from a morphological paradigm. In consequence, we would expect these rules to be ordered according to complexity, with the more specific rules applying first and the more general rules being ‘ports of last call’ in order to ensure that something can be pronounced.

A key difference between these and the rules of Generative Phonology must therefore be made very clear. These rules do not layer upon each other. There preferably is to be no

interaction between rules, or at most only the minimal interaction which would be expected from the insertion of a feature causing a segment to suddenly meet the requirements for a later rule. Other than this, however, the feature-filling rules would simply insert missing features, and then the segment is sent off to be pronounced.

The overall system, from a phonological perspective, would thus look like the following: underlying forms would be stored in the lexicon as abstract, underspecified feature bundles. This lexicon would necessarily be language-specific, as lexicons generally are. After one or more items are selected from the lexicon, they are fed into the syntax and morphology to receive position and combination. Once that is done, they are fed into the Phonological Interface, where they become subject to a Harmonic Serialism derivation. Features can be added, removed, or changed during this stage, and they may end up fully specified by coincidence. There is, however, no requirement for full specification at this stage. Once convergence has been reached and an output is selected, that output is sent to the Phonetics Interface for implementation. Here the output consists still of a series of feature bundles, and is most likely still underspecified to one degree or another. The Phonetics interface then has a set of ordered feature-filling rules by which it fills in the default feature values where none are specified. These rules should be ordered like those in Distributed Morphology, with the most specific rules being ranked above the more general: the feature-insertion for a marked sound in the system should apply first, with the least marked feature values being applied last. Once every segment has been fully specified, pronunciation can begin.

3.2.3 FGHS Summarized

Now, the above section has spent much time in discussion, at times trailing off along a train of logic which was ultimately rejected. Such things are necessary when constructing a new

model, so as to ensure that all possible concerns are addressed. Justifying the use of underspecification over full specification is an important matter for a feature-geometric version of a model which traditionally lacks defined representations. However, it can very easily make for confusing reading, leaving the reader unsure of what from the above is to be taken forward as a definite part of the model, and what has been rejected. Thus, before moving on, this subsection will endeavour to summarize the FGHS model in a relatively concise manner.

Fundamentally, FGHS is just an elaboration of the existing assumptions of classic HS. It agrees with HS regarding Gradualness, GEN, CON, and EVAL, and it disagrees with Parallel OT in the same places that HS does, primarily concerning the superiority of serial-derivation over parallelism. Where FGHS differs is not in disagreeing with HS, but in explicitly working out the implications of what HS already tacitly claims. This specifically concerns the adoption of a particular feature theory. McCarthy (2018) adopts a simplified version of the Clements (1985) and McCarthy (1988) feature geometry in order to solve two-step deletion in HS. FGHS argues that we should go a step further and fully adopt not just Clements (1985) in a simplified form, but the fully elaborated model of Clements & Hume (1995), in principle at least.

FGHS is fundamentally built on the principle that feature changes are an operation in HS (McCarthy 2010). That is, every feature must have its specification changed one at a time, in order to satisfy Gradualness. To adopt this assumption, however, HS must also adopt a particular feature theory, as it is not possible to change each feature one at a time if you do not know which features are even available to be changed. In theory, of course, any feature theory could be selected to begin this integration. However, since Clements (1985) is already in principle used by HS, FGHS holds that we should simply iterate on its use. Both Clements (1985) and Clements & Hume (1995) serve the purposes of FGHS well enough, and in practice the former would serve

perfectly fine in any data which does not require a split between C-PLACE and V-PLACE in its analysis. But, for reasons which are demonstrated in the Latin and Serbian analyses in Section 3.5, and further exploited in the RUKI analysis in Chapter 6, the expanded Clements & Hume (1995) model is to be held as the actual chosen feature geometry of FGHS at this time.

It should be noted here that while feature changes must occur one-by-one, deletion can still target nodes, as per McCarthy (2018). If a PLACE node is deleted, then everything dependent on it becomes functionally deleted along with it. From a theoretical point of view, those features or subordinate nodes may still technically exist, but without a ROOT to link to they cannot be expressed. They could become so-called ‘floating’ features, and indeed the Catalan analysis in 3.5.2 relies on the existence of such a thing, but the exact fate of these features in FGHS is a matter better explored at another time. What matters is that unless a feature is ultimately connected to a ROOT node, it cannot be pronounced, and is therefore functionally deleted even if it technically continues to exist in some form.

The next topic is the nature of the input. Parallel OT treats the input rather ambiguously, generally treating the details of featural representations as less important, since the constraints should cause any given input to map to the correct output. HS has not particularly challenged this assumption. FGHS, however, argues that the input must be specifically known, since unless the feature values of a segment are known they cannot be changed during the derivation. In Parallel OT it is possible to gloss this over due to the fully parallel application of operations: it costs the system nothing to apply an extra feature change. In HS, however, if each feature change is itself an operation which must form an entire step, then we must know the underlying value so that we can identify whether or not an entire extra step must pass through EVAL. As part of this knowledge of the input, FGHS must necessarily adopt some form of underspecification, as

discussed in Section 3.2.2. In principle FGHS is committed to no particular theory of underspecification. Both Contrastive and Radical Underspecification have their advantages and their drawbacks, and this dissertation is not the place to debate between them. Therefore, at this early stage of the theory, FGHS adopts instead the so-called ‘Naïve Underspecification’, in which features are underspecified as necessary to make the analysis work (Martin 2012). This is not a particularly satisfying theoretical adoption, but it is a practical one, especially when there are at this point so many moving parts in the theory. Without underspecification, FGHS would become unworkably cumbersome, as will be further discussed below in Section 3.3, and so some version of it must be adopted alongside the feature geometry.

In consequence of the adoption of underspecification, FGHS must also adopt some means of inserting underspecified features. While the obvious solution would be to simply add feature-filling constraints, this is not actually a workable solution, as discussed in Section 3.2.2. If any of these constraints were ranked too high, then the features they require be inserted would be added so early that they might as well be underlyingly specified.

Now, this is not a particular problem, but the next point is: if any were ranked too low in the hierarchy, then it is possible for an output to never actually insert them, if it reaches convergence before those constraints come into play. Thus, we would predict a multitude of pathologies, all of them predicting languages with literally unpronounceable segments, if we assume that all features must be specified for pronunciation to occur.

Therefore, an alternative solution must be adopted, based on the distinction between phonology and phonetics. Phonology is fundamentally about phonemes, and their derivation to allophones. It is not concerned with pronunciation itself, as that is a matter of articulation, which is the domain of phonetics. Thus, as discussed in Sections 2.3 and 3.2.2, FGHS proposes that

features which remain underspecified at the end of the derivation are inserted by feature-filling rules during the Phonetics stage. These rules are language-specific, and fill in default values based on the structural definition of a given segment. Thus, most unspecified segments would be filled in as the default consonant or vowel of a language, while a more specified segment would be filled in according to what it is.

Thus, in practical terms an FGHS derivation should be almost identical to an HS one, save that more attention should be paid to the featural specifications of the segments involved. The outstanding underspecified features can be assumed to be handled after the fact, and do not all need to be resolved in the constraint-based derivation. That is, no more steps are required here than in a conventional HS derivation.

3.3 Nodal Faithfulness vs. Underspecified FGHS

At this point an aside is necessary. As discussed above, there are two possible models that could be used to satisfy the desires of this chapter, each representing a different approach to the problem of feature-by-feature operations. The first, Underspecified FGHS, has been outlined above. The alternative would be the Nodal Faithfulness model introduced above in Section 2.5.1. In this model full specification is assumed for underlying forms. The model is largely identical to FGHS, capable of working with the same associated feature theories and making most of the same assumptions. However, in consequence of its full specification, it must introduce a new kind of faithfulness constraint: the Nodal Faithfulness constraint. A Nodal Faithfulness constraint targets a feature node, specifically the ROOT, general PLACE, for any of the specified PLACE nodes. It is violated whenever there is at least one feature change in the features immediately dominated by, or contained within, that node. Given this definition, it would incur the same number of violations marks regardless of how many changes were actually made. A single

change creates a violation, but three changes would only produce that same, single violation. In practical terms this allows Nodal Faithfulness to correctly model similar data to what FGHS can. However, it makes different predictions about what data we should expect to find.

The key difference is that Nodal Faithfulness constraints imply that nodes are quite internally variable, especially the specified PLACE nodes, as the Specified PLACE Exception, which is necessary for Nodal Faithfulness to function, would imply. According to this principle, the features of the specified PLACE node of a segment can change their values ‘for free’ at each step. This is, of course, a significant violation of Gradualness, and this in itself is likely sufficient grounds to reject the model. Nonetheless, it is worth looking at how Nodal Faithfulness functions in practice, as it serves well as a strong example of why FGHS must adopt underspecification. Without the use of underspecification, Nodal Faithfulness is the only practical means for working with fully specified inputs in HS.

Thus, we will now cover an analysis using Nodal Faithfulness. The purpose of this is to show how any feature-geometric HS would ultimately have to work if it assumes both feature-by-feature Gradualness and full specification in the lexicon. Note that the analysis below does technically work, albeit only through the use of the Specified PLACE Exception. The purpose here is to show how even with relatively straightforward data like that analyzed, Nodal Faithfulness shows significant strain. This will be contrasted in Subsection 3.5.4, where an FGHS analysis of the same data will be shown to be superior.

3.3.1 Stop Gliding: Nodal Faithfulness

The following section has been adapted from Shaftoe (2019), which provided the original version of this analysis. The data to be considered here is from Chilean Spanish (Piñeros 2001). It is a useful data set, as it gives a demonstration of a non-assimilatory feature change, which is

one of the exact situations both Nodal Faithfulness and FGHS are intended to solve. Specifically, this is a lenition process, and one which leads to outputs which are markedly different from the inputs. For the purpose of this analysis, we assume Moraic Theory (Hayes 1989; Zec 1995). This section will involve showing the justification for the Specified PLACE Exception, and therefore that assumption will not be used until it is introduced in context partway through the derivation.

Let us first examine the data, show below from (Piñeros 2001).

(19)/a <u>d</u> kirir/	→	[a _j .kirir]	“to acquire”
(20)/e <u>t</u> niko/	→	[e _j .niko]	“ethnic”
(21)/k <u>a</u> ptura/	→	[k <u>a</u> _w .tura]	“capture”
(22)/a <u>s</u> urdo/	→	[a <u>w</u> .sur.do]	“absurd”
(23)/ko <u>r</u> e <u>k</u> to/	→	[ko.re <u>w</u> .to]	“correct”
(24)/do <u>g</u> ma/	→	[do <u>w</u> .ma]	“dogma”

Chilean Spanish has no phonemic glides or glottal obstruents (Sadowsky & Salamanca, 2012). [h j w] are available as allophones, while [ʔ] is completely absent. [w] is omitted from the chart below for the same reasons it is omitted from the IPA chart. Note that the chart lists the coronal stops as dental, which is the accurate place of articulation. However, since there is no contrast between alveolar and dental in Chilean Spanish, the alveolar symbols will be used throughout this section for the sake of convenience.

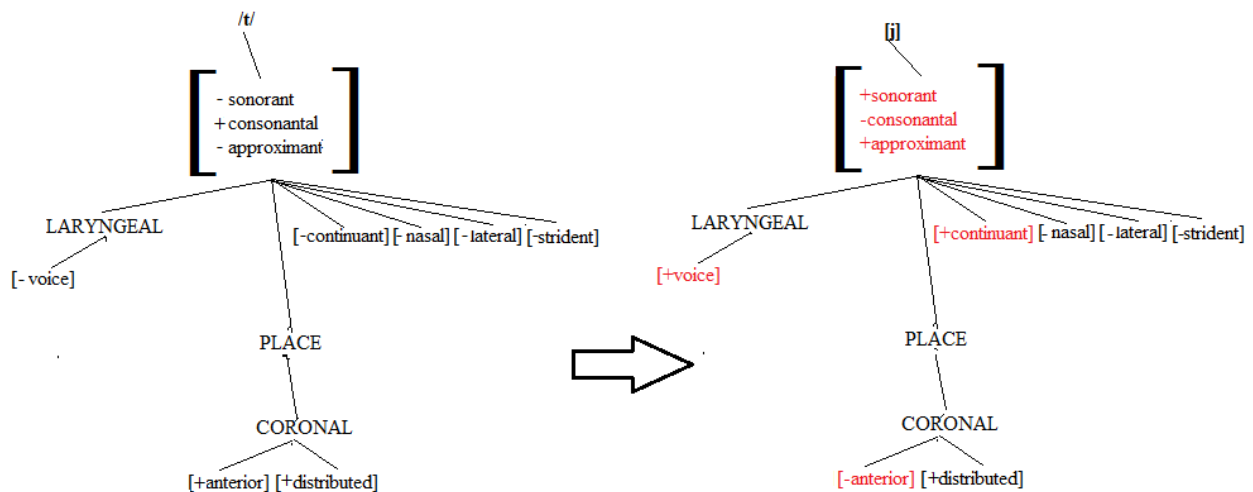
Table 1: Chilean Spanish Phonetic Inventory

	Bilabial	Labio-dental	Dental	Alveolar	Postalveolar	Palatal	Velar	Glottal
Plosive (stop)	p b		t̪ d̪				k g	
Affricate					tʃ			
Nasal	m			n		ɲ		
Tap/Flap				ɾ				
Trill				r				
Fricative		f		s		ʃ	x	h
Lateral Approximant				l				
Approximant						j		

As shown above in (19)-(24), in coda position, Chilean Spanish stops will lenite into glides, with /t d/ leniting to [j] while [p b k g] generally lenite to [w]. Meanwhile, no sonorants undergo any kind of lenition in coda position, most importantly [r]. [h] emerges from non-word-final coda /s/, but that analysis is left for another time. The key interest of the coda stop gliding is that no coda sonorants glide: only the stops do. Thus, any analysis must account for the fact that the stops must not pass through any sonorant segment on the way to becoming glides, despite glides being the furthest consonant from a stop. Limiting the discussion to coronal stops, the central issue is that [r] is a better choice in almost every regard: it is [+consonantal] as opposed to [j]'s [-consonantal], and being alveolar is closer in position to dental stops than the palatal [j]. Since underlying [r] does not glide, and since HS cannot distinguish between derived and underlying segments in any given step, the question is obvious: why [j]?

The diagram below shows the overall changes which must occur.

Figure 5: Overall change of /t/→[j]



This present study proposes that this phenomenon results from a minimum sonority requirement for mora-bearing segments: only [+sonorant] segments may licitly bear morae, which are assigned to any coda. For the purposes of this present dissertation, the discussion here

will focus on the coronal stops and their participation in this stop gliding process. This is because the coronals have the more complex derivation, and therefore serve the best as an example of the troubling means by which the Nodal Faithfulness model solves difficult featural problems. Note that the derivations in this subsection will focus on underlyingly unvoiced segments. This is for the sake of being comprehensive: the voiced equivalent undergoes the same procedure, omitting only the voicing step itself.

The constraints required for this analysis are as follows:

- (25) WEIGHT-BY-POSITION (WBP) (Hayes 1989): assign a violation mark for every coda which does not have a mora attached.
- (26) *OBSTRUENTMORA: assign a violation mark for every obstruent segment which bears a mora.
 - a. *VOICELESSSTOPMORA>>*VOICELESSFRICATIVEMORA>>*VOICEDSTOPMORA>>*VOICEDFRICATIVEMORA
- (27) *SONORANTMORA: assign a violation mark for every sonorant segment which bears a mora.
 - b. *NASALMORA>>*LIQUIDMORA>>*GLIDEMORA
- (28) *SEGMENT: assign a violation mark for every instance of the specified segment.
- (29) DEP[mora]: do not add a mora to a segment.
- (30) DEP[segment]: assign a violation mark for every instance of the specified segment which was not in the input.
- (31) MAX[NODE]: do not delete the specified node
- (32) IDENT[F]: assign a violation mark for every instance of the specified feature where it does not match the value of its correspondent in the input.
- (33) IDENT[node]: assign a violation mark for every output segment which does not match the feature values of the specified node of its input correspondent.
 - a. IDENT[coronal node]: assign a violation mark for every output segment which does not match the CORONAL node features [anterior, distributed] of its input correspondent.

While some of the above constraints will be immediately familiar to anyone who works with OT, such as IDENT and DEP, others require some further discussion. The constraint Weight-by-Position is a direct conversion from the same concept expressed in Hayes (1989), whereby syllable weight is dependent on the presence of a coda. The constraint as used here is based on Moraic Theory (Hayes 1989; Zec 1995) and the updated version of WBP which came with it,

specifying that codas have a mora assigned to them based on their position in the syllable. This constraint is used as the basis for the analysis to follow, as its primary purpose is to drive the insertion of morae into a word.

Now, in OT it is common to have a sort of opposite to every constraint. Not necessarily a direct negation, but rather to have constraints which, directly or indirectly, create pressure towards the opposite outcome relative to a given constraint. Such is the case in this analysis. WBP drives the insertion of morae: the *SEGMENTMORA constraint family instead motivates the deletion of morae. *SEGMENTMORA stands for a fixed-ranking constraint family, which in turn represents the crosslinguistic preference for morae to be assigned only to higher-sonority segments (Hayes 1989; Zec 1995). It can be divided into two subfamilies, being *OBSTRUENTMORA and *SONORANTMORA. *OBSTRUENTMORA always outranks *SONORANTMORA, and each of these include several constraints which have their own internal ranking shown in the list above.

The *SEGMENT constraint is another constraint family, one which is far more commonly seen than *SEGMENTMORA. It simply represents some restriction against the use of a particular segment. The general definition is given in the list above, and any given particular *SEGMENT constraint will simply specify a particular segment it bans.

The MAX[NODE] and IDENT[NODE] constraints require some discussion. MAX[NODE] disfavors any deletion of a feature node, whether that be ROOT, the general PLACE, or some specified PLACE. IDENT[NODE], however, is where things become somewhat more complicated. This is the titular ‘Nodal Faithfulness’ constraint for which this model is named. It is a constraint which is violated by changes in the feature values of those features which are immediately connected to the specified node. However, it is not concerned with the number of feature changes

which are occurring: it is impossible to acquire more than one violation mark per specified node, as it only checks whether the configurations are the same or not. If there is any difference between the input and output, then a violation mark is incurred. It does not matter whether a single feature is changed, or if all of them are. As discussed above, this is necessary for fully-specified HS with featural representations to function. Thus, while it is certainly an uneasy assumption, we will assume the existence of such constraints for the purpose of illustrating how a Nodal Faithfulness analysis would work.

The initial step of this present derivation is simple: mora insertion. This initiates the lenition process, seeing underlying /t/ glide to output [j], as the *OBSTRUENTMORA constraint family will henceforth require further changes to be satisfied.

(34) Step 1: Mora insertion

etniko	WBP	*OBSTRUENTMORA	DEP[MORA]
a. → et.ni.ko μ		*	*
b. et.ni.ko	*!		

The derivation is presented with the choice to either insert a mora or not.³ DEP[MORA] disfavours the addition of any mora not present in the input, while *OBSTRUENTMORA disfavours the addition of morae to any obstruent. However, WBP demands that codas bear a mora. Candidate (a) violates DEP[MORA] and *OBSTRUENTMORA in order to obey WBP. Candidate (b) violates WBP to satisfy *OBSTRUENTMORA and DEP[MORA]. Since WBP is ranked higher, candidate (a) wins, and the output of Step 1 is fed into the next step.

The addition of the mora now places the input under the purview of the *OBSTRUENTMORA family, and it must contend with that constraint family's internal structure. Thus,

³ Features changes are possible at this step, but this analysis assumes that WBP is undominated, and thus mora insertion is expected to be the first step in practice.

*OBSTRUENTMORA has been removed from the ranking, and replaced with its member-constraints. The first step of this is shown in Step 2, below.

(35) Step 2: Voicing

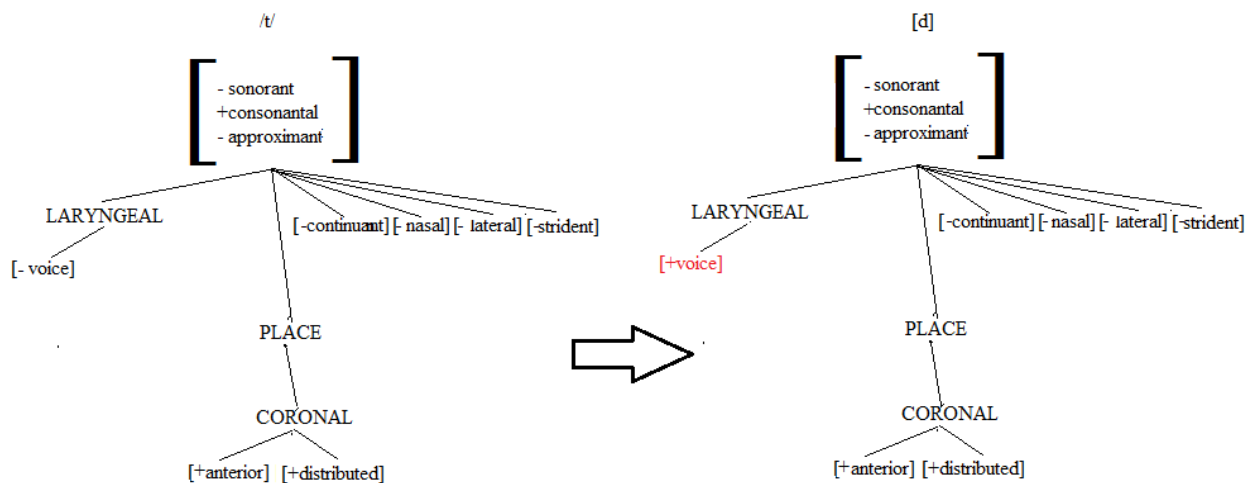
et.ni.ko μ [-voice] [-continuant] CORONAL	*?	DEP	*VOICELESS STOP MORA	*VOICELESS FRICATIVE MORA	*VOICED STOP MORA	IDENT [voice]	IDENT [continuant]
a. →ed.ni.ko μ [+voice]					*	*	
b. et.ni.ko μ [-voice]			*!				
c. es.ni.ko μ [+continuant]				*!			*
d. eʔ.ni.ko μ ~~CORONAL~~	*!						
e. e.tə.ni.ko μ		*!					

This second step offers a wide array of options. Candidate (b) attempts to remain faithful, violating *VOICELESSSTOPMORA to satisfy IDENT[voice], IDENT[continuant], and MAX[PLACE]. Candidate (c) violates IDENT[continuant] to satisfy *VOICELESSSTOPMORA, though in doing so it also violates *VOICELESSFRICATIVEMORA. Candidate (d) attempts to vacuously satisfy the entirety of *OBSTRUENTMORA by PLACE-deleting to [ʔ]. However, this violates a high-ranked MAX[PLACE], omitted here for space, and *?. Candidate (e) attempts to render the situation moot by epenthesizing a [ə] to absorb the mora, thus vacuously satisfying all IDENT and *OBSTRUENT MORA constraints at the cost of violating DEP. Candidate (a) violates IDENT[voice] and

*VOICEDSTOPMORA by voicing to [d], allowing it to satisfy *VOICELESSSTOPMORA. Since those constraints are low-ranked, this leave Candidate (a) as the winner at this step.

The high ranking of *ʔ eliminates (d) from consideration immediately. As noted above, there is also a MAX[PLACE] constraint which is not very highly ranked: if [ʔ] were allowed to win, the derivation would simply PLACE-delete at the following step rather than lenite, following McCarthy (2018).⁴ The faithful candidate (b) is eliminated by markedness considerations: moraic voiceless stops are the most marked of the sonority curve, and without a high-ranked faithfulness constraint to protect it a change must be made. The high-ranked DEP constraint rules out candidate (e). Thus, the choice comes down to either frication, as fricatives are more sonorous than stops, or voicing, since a voiced segment is more sonorous than an unvoiced one. As the ranking shows, in this situation voiced stops seem to be more sonorous than voiceless fricatives. Since it is one step to either [s] or [d], and [d] is the more sonorous choice, candidate (a) wins out (Parker 2002:55, 226).⁵ This derivation can be seen in tree form below, in Figure 6..

Figure 6: /t/→[d]



⁴ The reasoning for this solution over simply ranking MAX[place] high in the derivation is not relevant to this present dissertation, but can be found in Shaftoe (2019).

⁵ See the above Shaftoe (2019) for further discussion of why we must derive to [d] rather than [s] here

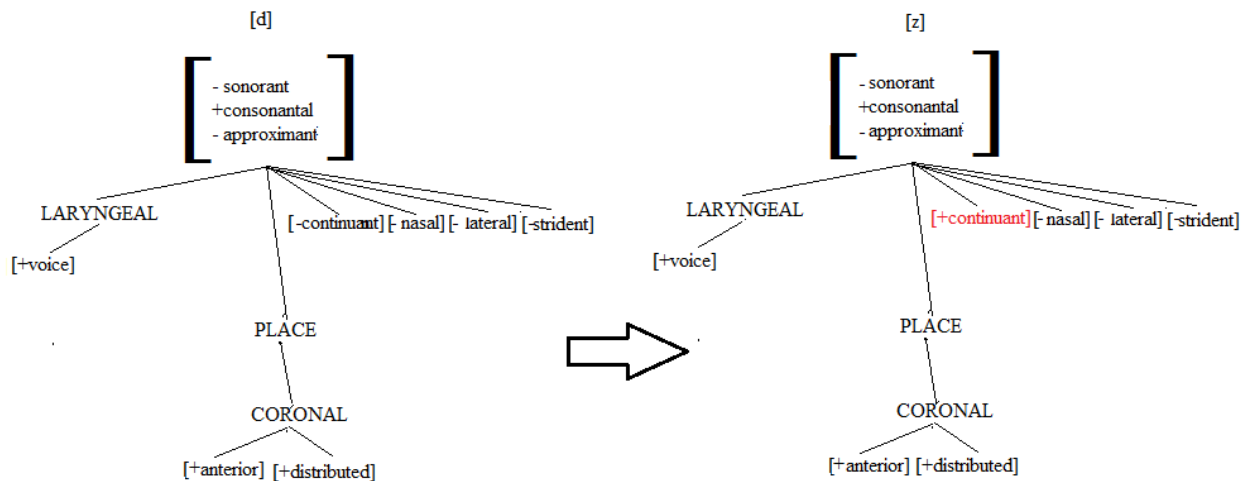
Note that there was no option for lenition directly from [t] to [z], even though both [s d] were offered as options. This is because while [s d] are each only one step away from [t], their changes are focused on different feature nodes. The feature [continuant] is dominated directly by the ROOT node, while [voice] is part of the LARYNGEAL node. Thus, as per the assumptions in Sections 3.2 and 3.3, both of these features cannot be changed at the same time. Only one of the two nodes under consideration can be altered. Thus, [z] was not a licit option at this step.

In step 3, however, [z] finally comes under consideration.

(36) Step 3: Frication

ed.ni.ko μ [+voice] [-continuant] CORONAL	*VOICED STOP MORA	*VOICED FRICATIVE MORA	IDENT [continuant]	*z
a. ed.ni.ko μ [+voice] [-continuant]	*!			
b. → ez.ni.ko μ [+voice] [+continuant]		*	*	*

The choice here is whether to converge or to lenite further. Candidate (a) is faithful, satisfying IDENT[continuant] and avoiding the markedness violation on *VOICEDFRICATIVE MORA. However, in doing so it violates *VOICEDSTOPMORA, which is the highest-ranked of the three. In contrast, candidate (b) obeys *VOICEDSTOPMORA by changing to [+continuant], though this in turn violates the lower-ranked *VOICEDFRICATIVEMORA and IDENT[continuant]. Thus, the ranking clearly favours candidate (b). This change is represented in Figure 7, below.

Figure 7: $[d] \rightarrow [z]$ 

The frication of the input leads the derivation to its next, most crucial step. The proper derivation of this step will require some explanation, as well as a new assumption not yet used in this derivation. Important to note is that this derivation must, if done properly, converge on the output [j]. As the next step will show, this is a task easier said than done. Note that the inclusion of palatalized [ʒ] is used only to consider a conceivable, though seemingly not actually possible, path to [j]: palatalization of the fricative. This would align the CORONAL features correctly for a follow-up transition into palatal [j]. However, while it has a more convenient PLACE, it is still a voiced fricative, and would therefore have the same sonority as the input [z]. Thus, the candidate is included only to show why a fricative palatalization solution does not seem possible.

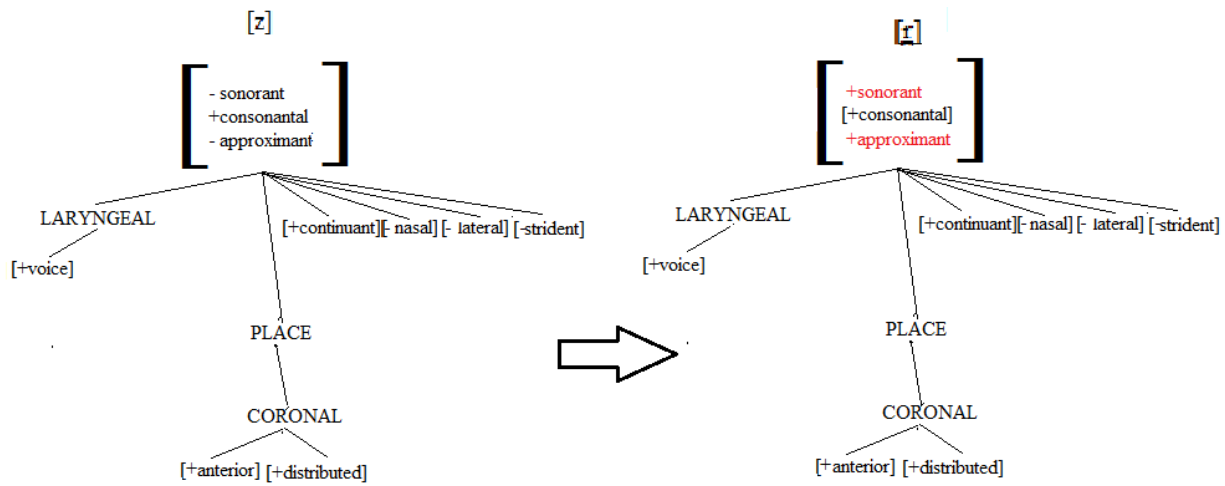
(37) Step 4: Approximation

ez.ni.ko μ [+voice] [+continuant] CORONAL	*VOICED FRICATIVE MORA	MAX[PLACE]	IDENT [ROOT NODE]	*LIQUID MORA
a. eʒ.ni.ko μ [+voice] [+continuant] [-anterior, +distributed]	*!			
b. ez.ni.ko μ [+voice] [+continuant] [+anterior, +distributed]	*!			
c. ← eɹ̥.ni.ko μ [+voice] [+continuant] [+anterior, +distributed] [+approximant]			*	*
d. eh.ni.ko μ ~~CORONAL~~		*!		

Four candidates are considered at this step. Candidate (d) offers PLACE-deletion to vacuously satisfy all the *OBSTRUENTMORA and *SONORANTMORA constraints, being blocked only by the ranking of MAX[PLACE]. Candidate (a) is, of the three, the most reasonable for further derivation into [j]: it agrees with the [anterior, distributed] values of [j], where [z] agrees more with dental [ɹ̥]. However, there is no clear harmonic advantage to this palatalization; it does not seem to actually increase sonority to any meaningful degree, and it would also violate any IDENT constraint which targets any of the relevant features. Furthermore, candidate (c) harmonically binds candidate (a). The difference between [z] and [ɹ̥] is a single step, changing the values of the CORONAL node. Equally far away is dental [ɹ̥], which has only differences in the ROOT node, changing [z]’s [-sonorant, -approximant] features into [+sonorant, +approximant]. There is no

harmonic advantage to palatalization at this step, as [ɹ] will always be more sonorous than either [z] or [ʒ]. Thus, while candidates (a) and (b) are eliminated by violating some variant of *VOICELESSFRICATIVEMORA, [ɹ] satisfies it and wins. It does this despite violating IDENT[ROOT NODE].

Figure 8: [z] → [ɹ]



Thus, in this step a problem arises, rooted in the specifics of the CORONAL node. The attested output is known to be [j]. However, [j]’s CORONAL node is valued as [-anterior, +distributed], while that of [z] is [+anterior, +distributed]. Furthermore, there is a possible [+anterior, +distributed] approximant: dental [ɹ]. If we retain the basic assumption that only one node can be changed at a time, then any alveolar alternation into [j] must pass through [ɹ]. Important to note here is that Chilean Spanish does not allow dental [ɹ], not even allophonically (Sadowsky & Salamanca 2012:74). Since [j] would differ from dental [ɹ] by features from two different, being [anterior] and [consonantal], Gradualness would prevent [j] from appearing as a candidate at the next step. These two facts taken together imply that any derivation to dental [ɹ] would result in a following step that made the segment alveolar [r], as [j] would not yet exist as a candidate and the input of dental [ɹ] demonstrably will not be allowed to surface. Since the regular Chilean

Spanish [r] does not lenite to [j], the derivation would logically end there, as HS has no means of differentiating the derived [r] from its underived counterpart. Thus, the derivation cannot be allowed to pass through an [ɾ] stage, as that would create a paradox: one set of [r] would lenite to [j], while another did not, and yet both would be under the same conditions. In any form of HS, there is no inherent difference between underlying and derived segments: the constraints target the feature definitions at the present step, not the history of the segment. Therefore, this derived [r] should surface just like the underlying /r/ does.

The solution is to reconsider the Gradualness assumptions at play. To this point this derivation has acted on the assumption that only the immediately dominated features of a single node can be changed in one step. This alveolar-to-[j] problem requires an addendum to be resolved: the Specified PLACE Exception. Under this principle, in addition to changing any number of features within a node in one step, it is possible to change the constituent features of the specified PLACE node in the same step. That is, the constituent features of the CORONAL node can be revalued at the same time as the ROOT node features. Note that this does not allow multiple nodes to be changed: one cannot change the ROOT node features and change the PLACE node to change from CORONAL to LABIAL. The PLACE changes must remain internal to current specified PLACE node of the input at that step. What it does allow is for a single step to change, say, ROOT node features as well as the features of the specified PLACE node, such as [anterior, distributed].

Under this new assumption, consider an updated Step 4, below.

(38) Step 4, redux: Gliding

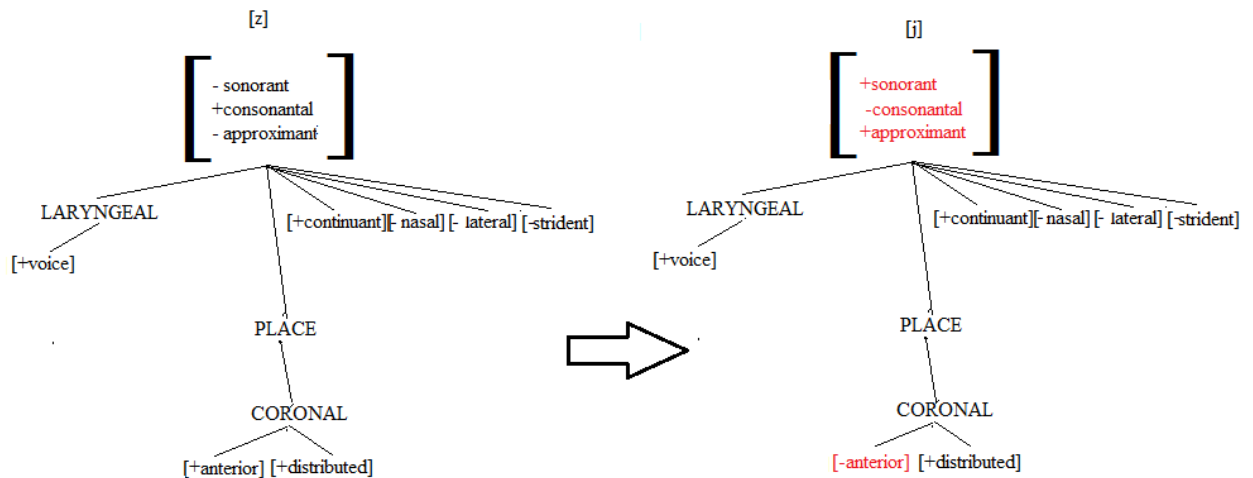
ez.ni.ko μ [+voice] [+continuant] CORONAL	*VOICED FRICATIVE MORA [alveolar]	*VOICED FRICATIVE MORA [palatal]	IDENT [ROOT NODE]	*LIQUID MORA	*GLIDE MORA	IDENT [CORONAL NODE]
a. eʒ.ni.ko μ [+voice] [+continuant] [-anterior, distributed]		*!				
b. ez.ni.ko μ [+voice] [+continuant] [+anterior,-distributed]	*!					
c. er.ni.ko μ [+voice] [+continuant] [+anterior,-distributed] [+approximant]			*	*!		
d. →ej.ni.ko μ [+voice] [+continuant] [-anterior,+distributed] [+approximant]			*		*	*

Here, the same step is shown again with a new fourth candidate. Candidate's (a-c) are the same as in the first attempt at Step 4. The new candidate (d) glides and palatalizes into [j], a change made possible under the new assumption. Elsewhere, IDENT[ROOT NODE] would be used to prevent the gliding of underlying moraic [r] into [j], due to the two segments disagreeing on the feature [consonantal], and that derivation therefore incurring a violation mark. In this derivation, however, derivation to either of these segments would make changes to the ROOT node of [z], and thus both options violate the constraint. This causes a tie, allowing moraic

sonority principles to take effect. Thus, candidate (d) wins due to *GLIDEMORA ranking below *LIQUIDMORA.

The changes are shown below.

Figure 9: [z]→[j]



This brings the derivation to its final step, convergence.

(39) Step 5: Convergence

ej.ni.ko μ [+voice] [+continuant] [-anterior, +distributed] [+approximant] [-syllabic]	IDENT[Syllabic]	*GLIDE MORA
a. →ej.ni.ko μ [+voice] [+continuant] [-anterior, +distributed] [+approximant] [-syllabic]		*
b. e.i.ni.ko [+syllabic]	*!	

At this step the derivation can either converge or continue on to fully vocalize. Vowels, after all, naturally bear morae and thus would be exempt from minimum sonority concerns. Thus, from a markedness perspective, they would be the most favoured mora-bearers. This is borne out

in the tableau through the absence of any markedness constraint disfavouring it. What candidate (b) does violate, however, is the relevant faithfulness constraints. At present, this study does not make claims regarding of the position of the feature [syllabic], save that it does not seem to be in the same place as the ROOT node features [consonantal, sonorant, approximant]. Thus, IDENT[syllabic] is used to represent the faithfulness restriction against, among other things, glides becoming vowels. IDENT[syllabic] ranks above *GLIDEMORA, indicating that it is better to avoid changing a segment's syllabicity than for a glide to be moraic.⁶ Thus, candidate (b) is eliminated and the faithful candidate, (a) wins. This causes the derivation to reach convergence.

3.3.2 Nodal Faithfulness Discussion

Thus, from the above analysis we can conclude a few points. The first is that, albeit through the use of the rather dubious Specified PLACE Exception, the Nodal Faithfulness model was able to successfully model a non-assimilatory feature-changing process, that being the lenition of /t/ into [j]. This is important to comment on, as there is a difference between a model which is fundamentally broken, in that it fails to correctly model the data it is intended for, and one which is cumbersome or theoretically suspect. The latter is what we face with Nodal Faithfulness. As seen above, it is entirely possible to create a derivation which correctly predicts the attested input-to-output relationship observed in Chilean Spanish.

This leads into the second point, which is that the means by which Nodal Faithfulness is able to succeed are problematic. The model should, all told, have failed at the original Step 4, where it became impossible to avoid deriving into dental [ɽ], and then on to non-dental [r], on the path to

⁶ Note that several other constraints might also prevent full vocalization just as effectively as IDENT[syllabic]. ONSET bans onsetless syllables, which a new vowel would naturally form. Similarly, VOWELHIATUS, which disfavors adjacent vowels, would be violated by the resulting V.V sequence. Further research would be required to determine which of these constraints is actually preventing vocalization in Chilean Spanish. For this present analysis, however, IDENT[syllabic] functions adequately, and will continue to be used.

[j], as [j] itself could not be a licit candidate at that step when assuming feature-by-feature changes. This was a major issue, as underlying /r/ does not lenite into [j] when moraic, meaning that there must be some other difference between underlying /r/ and this derived [r] if that derivational path were to succeed. No such difference was apparent, and so it produced a wrong output. This outcome was averted in the alternative Step 4, which invoked the Specified PLACE Exception to make [j] an available candidate at that step. Thus, by permitting a change directly from [z] to [j], the problem of [r] was avoided. For a broader analysis to work, all that is required is to make it such that no [r], whether underlying or derived, would be a target for lenition. This can be simply handled by inserting IDENT constraints which protect sonorants but not obstruents. This is starting to shift into looking like quite a reasonable analysis, and it is along these lines that in Section 3.5.4 the later FGHS analysis of this same data will proceed. However, at the present time, the issue remains that this rather solid path forward is built in a shaky foundation.

The Specified PLACE Exception is obviously *ad hoc* at best, being based on no broader observed patterns. It is an invention of convenience, intended to solve a problem which cannot be solved when assuming both feature-by-feature changes and full specification of underlying segments. As noted, without it [j] could not be a candidate at Step 4 without the SPE. If we question the SPE, rather than simply accept it without external justification, then we find it has no real grounds. Keep this in mind when reading the FGHS alternative, and see how the same data is much better explained through the use of underspecification.

3.4 FGHS and Lenition

This leads into the purpose of the rest of this chapter. Before further work can be done regarding the reintegration of modern phonology and historical linguistics using FGHS, the

validity and usefulness of FGHS must first be ensured. To this end, the following section will cover a selection of assimilation and lenition processes. The assimilation processes have been selected to expand on the core ideas introduced in McCarthy (2008a, 2018), that is, to show a fuller account of how nodal feature geometry is essential to HS. The above-mentioned sources introduced it as necessary for explaining how deletion works in HS. This section will show the implications of the adoption of nodal feature geometry of the broader theory. The lenition processes are used to explore more mundane processes and show how even they require a knowledge of the feature structure to properly account for. Included in the assimilatory processes are several instances of what seems to be ROOT-first deletion, analyzed from the floating PLACE nodes which are left behind.

To that end, this section will cover a crosslinguistic survey of three lenition processes and one assimilation process, so as to test FGHS in the field. The selection of lenition as the primary topic is very important: the key to investigating FGHS is what can be called ‘non-assimilatory feature alternations.’ Cases of assimilation do involve knowledge of the feature structure of the segments involved, but are more concerned with the reassociation of feature bundles.

Assimilation allows for multiple features to change at once through the assimilating segment attaching to the relevant node of the other involved segment. That is, features undergoing assimilation do not need to necessarily ever change themselves: they are simply replaced by features with a different specification, generally by the reassociation of feature nodes between segments.

Here we will primarily focus on segment-internal changes, as these are generally the best suited for testing out this model. In these cases, the features must actually change their specification, or (depending on which features are underspecified) be inserted anew with a

particular specification. Hence the long discussion above of how many features can be changed at once, as that is crucial to analyzing the progression of one segment into another via non-assimilatory means. In lenition processes not driven by assimilation, this is what is observed: features are changed not to agree with surrounding segments, but to achieve some other end.

It should be noted that many phonological processes, even cases of non-assimilatory lenition, are relatively simply procedures. Consider voiced stop spirantization, in which voiced stops fricate under a variety of environments cross-linguistically (Kirchner, 1998). In an alternation of /d/→[ð] the only feature change would be [-continuant]→[+continuant] (Hall 2007). Such alternations are well within the capacity of FGHS, but do not particularly test its derivational aspect: being only one operation long they are too fast, procedurally speaking, for the broader featural structure to bear on the outcome. It is only in more extreme alternations, in which multiple features change, where FGHS becomes important.

3.5 FGHS Analyses

The following examples will be used to demonstrate the usefulness of FGHS: coda stop gliding in Chilean Spanish; coda /l/ vocalization in Serbian; ROOT deletion and place assimilation in ancient Latin; place assimilation and ROOT deletion in Catalan. Each of the phenomena has been analyzed before, using other models. All the data here is drawn from published papers noted in the relevant sections, and the analyses to follow are designed as adaptations of these analyses into FGHS. The purpose of this section is not, therefore, to solve unanswered questions in phonology. Rather, its purpose is specifically to show how FGHS works by using data which is already understood and has already been analyzed in other reputable models. After all, a model which cannot explain data which is known to have been solved by another model is, in the end, a waste of time and effort. Thankfully, as these following analyses

show, FGHS is at the very least equally as capable as the models originally used to analyze this data. Note that the Chilean Spanish analysis here is a direct response to that given in Nodal Faithfulness above, demonstrating the superiority of FGHS over Nodal Faithfulness.

Each of the following sections acts almost as a small paper of its own. They assume the theoretical framework discussed through this chapter, and move directly into a short explanation of the data followed by relevant analysis and discussion.

3.5.1 Latin

At a certain early stage of the history of Latin, there is evidence of a floating consonantal PLACE node (Cser, 2011). Words which in the prehistory of Latin had initial [gn] sequences saw reduction of the [g], leaving the overt pronunciation of these words as only initial [n]: [gnoskere]→[noskere]. However, the [g] does not seem to have been fully deleted, as evidenced by two things: first, that only prefixes which ended in coronal segments could be attached to these words; and second, that those morpheme-final coronals would assimilate to velar place when attached (Cser 2011). It is the second fact which is most interesting. From a surface perspective, these alternations make little, if any, sense. Consider the prefix *in-*: the concatenation of *in-* to [noskere], with two coronal nasals becoming adjacent, somehow outputs to [ɲ.noskere]. This could be argued to be an instance of dissimilation, but the grounds for such a claim are vague outside of the obvious surface data. The key question is, of course, why the velar place should be selected over any other option.

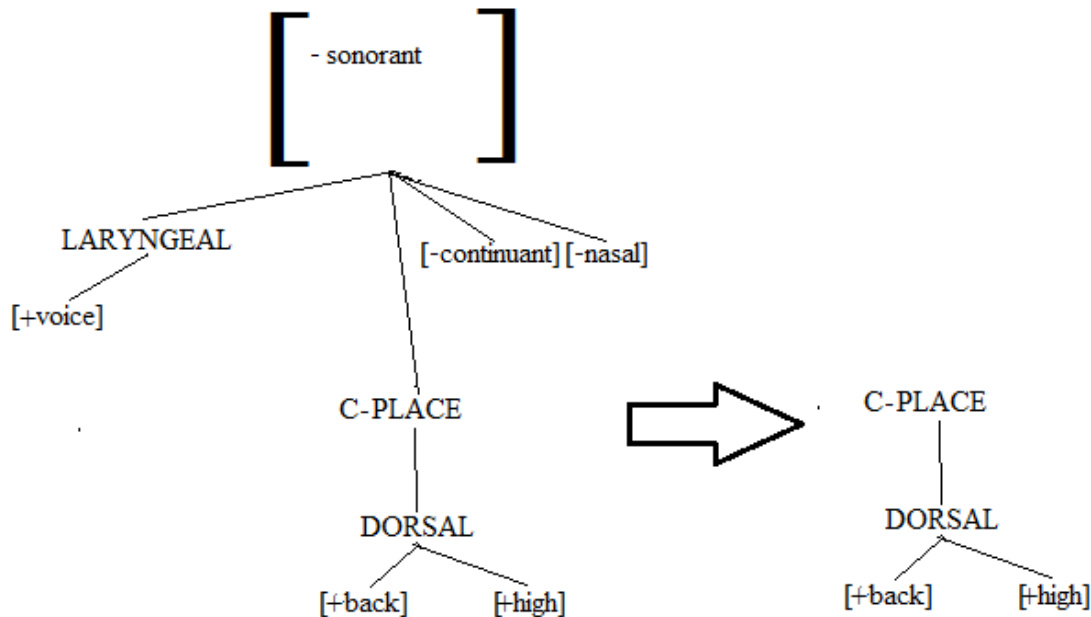
The solution is, as argued by Cser (2011), is to analyze the reduction of [g] not as full deletion, but as reduction to a floating PLACE node: that is, as the deletion of the ROOT node. If the PLACE node remains behind, then both the above facts are to be expected. Non-coronal consonants and vowels cannot properly link with the floating PLACE node, and due to an

apparent refusal by Latin to delete it, the resultant output would cause a crash: therefore, the affixation is simply banned. As regards the assimilation of morpheme-final coronals, it is well-attested that coronal place is ‘weaker’ than dorsal and labial. This weakness often manifests as underspecification of coronal PLACE, though it can also be represented as constraints which ban coronal PLACE. Either way, the product would be a segment which lacks a native PLACE node, and could therefore provide an easy home for the floating velar node. The result would of course be a velar segment, as is attested in the data. The sequence can be represented as such:

(40) $[\#gn] \rightarrow [\#[DORSAL]n] \rightarrow [in+[DORSAL]n] \rightarrow [i\eta.n]$

The deletion of the ROOT node is shown below in a diagram from Cser (2011).

Figure 10: Diagram of ROOT-first deletion, adapted from Cser (2011)



The requisite constraints are as follows:

- (41) $\#gn$: assign a violation mark for every instance of word-initial [gn]
 - a. According to Cser (2011), [g] was lost as a full segment word-initial sometime in the prehistory of Latin; due to a lack of information on this change, it has been represented by the above temporary constraint
- (42) MAXROOT: do not delete the ROOT node
- (43) MAXC-PLACE: do not delete the C-PLACE node

- (44) HAVEROOT: assign a violation mark for every segment which does not have a ROOT node
- (45) HAVEPLACE: assign a violation mark for every segment which does not have a PLACE node
- (46) NOLINK[PLACE]: do not add an association line to a PLACE node
- b. Note: this constraint can be specified to target either C-PLACE or V-PLACE, or could be used to refer to any association line linking to either kind of PLACE node
- (47) CODACOND: do not have PLACE in the coda
- c. Note: this does not ban segments having PLACE while in coda, just that the PLACE node be in an onset (McCarthy 2008)
- (48) *FINALSTOP: assign a violation mark for every word-final stop

With the constraints established, we can begin the analysis. Here we begin by reducing the morpheme-initial /g/ to a floating PLACE node.

(49) Step 1: ROOT-deletion

/#gn/	MAX[C-PLACE]	*#gn	MAXROOT	HAVEROOT
a. #?n	*!			
→b. #[C-DORSAL]n			*	
c. #gn		*!		

In Step 1 the restriction against word-initial [gn] sequences must be satisfied in some manner. Putting aside the discussion of why the [n] is not reduced instead, there are two options for achieving this: either reducing the [g] to [ʔ] by deleting its C-PLACE node, or reducing it to a C-PLACE node by deleting its ROOT node. If this environment is to trigger velar place assimilation in prefixes, and block the affixation of prefixes which cannot so assimilate, then it cannot be the C-PLACE node which is deleted. Rather, the ROOT node must be deleted here, leaving behind a floating C-PLACE node. This is represented by the high ranking of Max[C-PLACE], which prevents candidate (a) from winning.

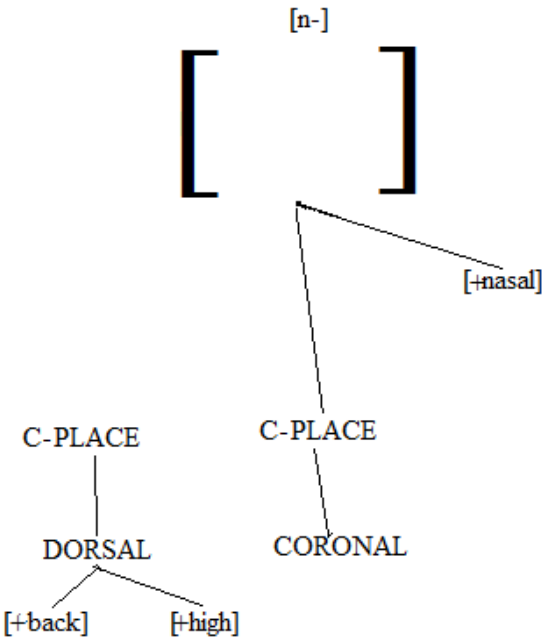
(50) Step 2: Convergence

#[C-DORSAL]n	MAXC-PLACE	*#gn	MAXROOT	HAVEROOT
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a. #n	*!			
→b. #[C-DORSAL]n				

The derivation converges in the second step, as nothing further happens when dealing with this process. While not directly analyzed here, it remains something of an open question as to how the ROOTless C-PLACE node was handled in actual speech: it was obviously left unpronounced, but whether this was due to it being deleted by some process before production, or simply being left unparsed, is not clear. Do note that this change seems to have affected the lexical entry: it does not seem that the ROOT node was continually re-deleted, but that it was absent from the underlying representation (Cser 2011). Thus, the structure would resemble the diagram below:

Figure 11: Diagram of rootless C-PLACE and follow [n], adapted from Cser (2011)



After the ROOT-deletion had occurred, its reflexes continued to trigger place assimilation to velar in prefixes. A situation would thus arise in which a prefix ending in a coronal nasal, such as *in-*, could attach to a word which began phonetically with another coronal nasal, such as

gnoscere [noskere], and be pronounced [iɲnoskere]. This clearly shows the persistence of the velar C-PLACE node.

(51) Step 1: Place Assimilation

/iN+[C-DORSAL]n/	MAX[C-PLACE]	HAVEROOT	HAVEPLACE	NO LINK [C-PLACE]
→ a. iɲ.n				*
b. iN.[C-DORSAL]n		*!	*!	
c. iN.n	*!		*	

In Step 1 the ROOTless C-DORSAL node must be resolved. It is a standard assumption that coronal segments are underlyingly placeless, since coronal is the default place and will be inserted automatically. There are therefore three options for resolving this situation: the C-DORSAL can be deleted, which would violate MAX[C-PLACE]; the situation can be left as is, with a placeless nasal and a rootless C-PLACE node; for the C-PLACE node can attach to the preceding nasal, making it velar. Since Max[C-PLACE], HAVEROOT, and HAVEPLACE outrank NO LINK[C-PLACE], Candidate (a) wins out: it avoids deleting the C-PLACE node, and provides a place for the nasal and a root for the C-PLACE node, all in a single operation.

(52) Step 2: Convergence

iɲ.n	MAX[C-PLACE]	HAVEROOT	HAVEPLACE	NO LINK[C-PLACE]
→ a. iɲ.n				
b. iɲ.N	*!		*	

With the C-PLACE reassociated there is no need for further changes, and the derivation reaches convergence at step 2. Note that HS nasal place assimilation follows a similar pattern to two-step deletion, with PLACE-deletion followed by reassociation. The PLACE-deletion has been omitted here despite the conventional analysis and despite Cser including it in his analysis, due to the assumption that the nasal in *in-* would be underlyingly placeless. Since the assimilation

only occurs with coronal segments, it is most reasonable to assume that the coronal segments are underlyingly underspecified for PLACE. Even Cser (2011) argues that coronals were allowed to attach to the floating [C-DORSAL] node due to the “weakness” of coronal place, which in feature-geometric terms would be explained as being underspecified.

The next matter to attend to is what happens when there is not a conveniently placeless consonant to take the floating PLACE node. In particular, what happens when a vowel precedes the floating PLACE node? As Cser (2011) notes, the empirical answer is that it simply did not happen. Forms such as **renoscere* and **regnoscere* are both conspicuously absent from surviving Latin data. The reason for this is somewhat explained by the partial derivation given below. This will only cover one step, as nothing more is required to make the relevant point.

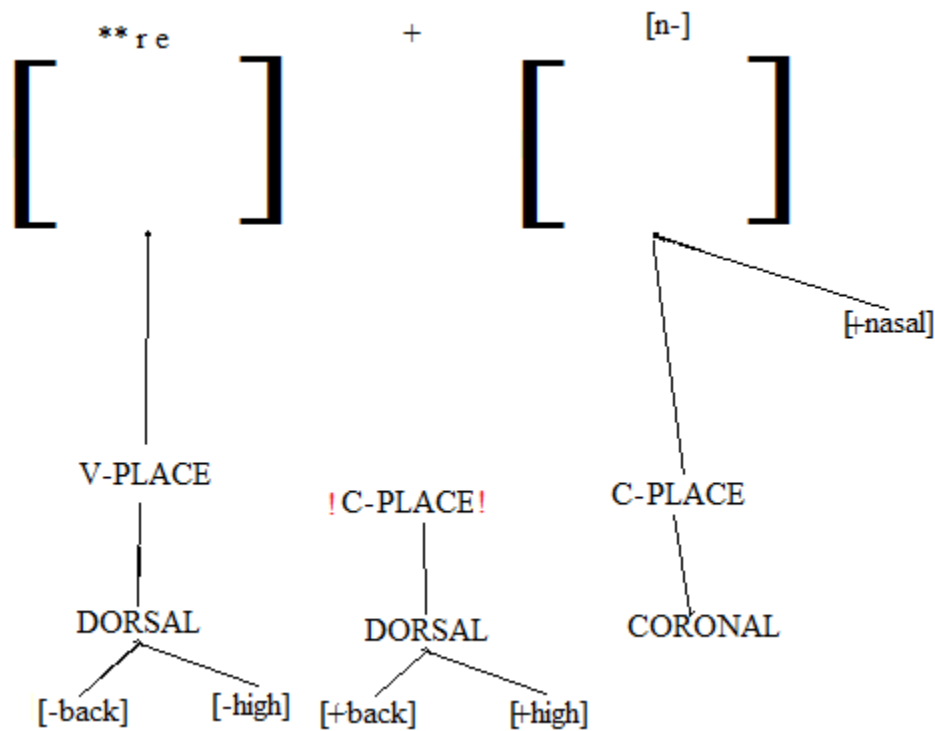
(53) Step 1: Crash

/re+[C-DORSAL]n/	MAX [C-PLACE]	*?	DEP [ROOT]	HAVE ROOT	HAVE PLACE	NoLINK [C-PLACE]
a. r?.n		*!				*
←b. re.[C-DORSAL]n				*		
c. re.gn			*!			
d. re.n	*!					

Some notes on the tableau above are in order. The first is the use of <?> as a segmental symbol. It represents that the output of this operation is unclear: it is presently unclear what would result from attaching a C-PLACE DORSAL node to [e]; it should result in a consonant with a secondary articulation, as per Cser (2011), but which segment exactly would emerge is not entirely obvious. Furthermore, it does not ultimately matter, as this form is never attested. Since there is no attested Latin segment of this form, we can assume that there is some constraint which would ban it from surfacing, leading to the *? constraint. This constraint is functionally

temporary, simply representing the fact that Latin did not use or allow this segment to emerge. Since it is never observed, the details of its prohibition are not currently relevant, though perhaps would be interesting material for future research. The feature-geometric situation is depicted below, in another diagram from Cser (2011). We see here that there is no licit node for the floating C-PLACE to dock with, as the following nasal has a C-PLACE and the preceding vowel has a V-PLACE. It thus produces a malformed structure.

Figure 12: Diagram of Assimilation Crash, adapted from Cser (2011)



The deletion of the floating PLACE node is banned for the same reasons it was banned in the earlier analysis, that being the high ranking of MAX[C-PLACE]. Since this outranks everything else in the derivation, save potentially for whatever constraint bans [?], there is no available option to eliminate it. This leaves a C-PLACE with nothing to dock to, creating a pronunciation crash. That means that the only solution which would allow a pronounceable word to emerge would be to reinsert the ROOT node for initial [g], which would incorrectly predict an output

such as **regnoscere*. Thus we are left with an insoluble problem, as the only available options all violate the data as observed.

Fascinatingly, however, it is this very problem which is the source of the solution. As Cser (2011) says, the actual Latin solution seems to have been to simply ban the use of phonologically incompatible prefixes, leaving forms such as **renoscere* and **regnoscere* unattested. That is, the language had no coherent solution to the interaction of the floating [C-DORSAL] node with a vowel, and so it instead simply prevented them from ever interacting. This is an important point to take away for phonology generally, and FGHS in particular: that not all phonological problems have phonological solutions. Distribution, and other non-phonological linguistic factors which amount to distribution, can decisively shape or even solve phonological problems. Indeed, as the analysis above shows, there is no good phonological answer for what should happen if that floating [C-PLACE] node follows [e]. But that problem is irrelevant if it never actually does interact with [e]. By preventing the two segments from being adjacent within a word, Latin prevents any such insoluble problem from arising in practice. This should be taken as a strong example of alternatives to simple derivation and constraint ranking when dealing with difficult problems. That is, if an environment never actually exists, it does not need to be accounted for in the constraint ranking.

From this we find the full explanation for the data. Where there is a placeless preceding segment, prefixation is allowed, since the floating C-PLACE can simply attach to it. Where there is a preceding PLACE node, however, either an illicit segment would emerge, which was banned by the grammar, or the C-PLACE would be left floating without a home, intervening between the prefix and the root. This would seem to have risked some sort of phonological crash, and so such interactions were simply banned, leading to the asymmetric distribution of prefixes in Latin.

This data also strongly demonstrates two principles for FGHS. The first is that it must allow ROOT-first deletion, as otherwise there would be no way to explain the floating [C-DORSAL] node. This is a point which will be explored more in the Catalan analysis below. The other principle is the importance of underspecification in FGHS. Without underspecifying the coronals in the prefixes, there is no clear way to explain why coronal-final prefixes were allowed to attach for *gn words, while other prefixes were not.

3.5.2 Catalan

The next example comes from Catalan, as per Hualde (1992). Catalan has no phonemic /ŋ/, but does have nasal place assimilation (Hualde, 1992). This leads to allophonic [ŋ] emerging before velar stops. This process interacts opaquely with word-final stop deletion, which can leave orphaned [ŋ] in word-final position. This process can be optionally blocked when it precedes a vowel, producing the situation shown below, cited from Hualde (1992):

(54) *El ba[ŋk] obre*

(55) *El ba[ŋ] obre*

I will argue that this process violates the conventional HS deletion method, and requires instead ROOT-first deletion. In doing so it demonstrates the necessity of feature-geometric HS, as without accurate awareness of the feature-geometric structure of the segments (and intersegmental interactions), incorrect predictions would be made about the progression of the derivation. FGHS predicts the possibility of this process by delineating the two steps of HS deletion into independent operations: PLACE-deletion and ROOT-deletion.

We will use the following constraints to derive /bank/→[baŋ]

(56) HAVEPLACE: assign a violation mark for every segment which does not have a PLACE node

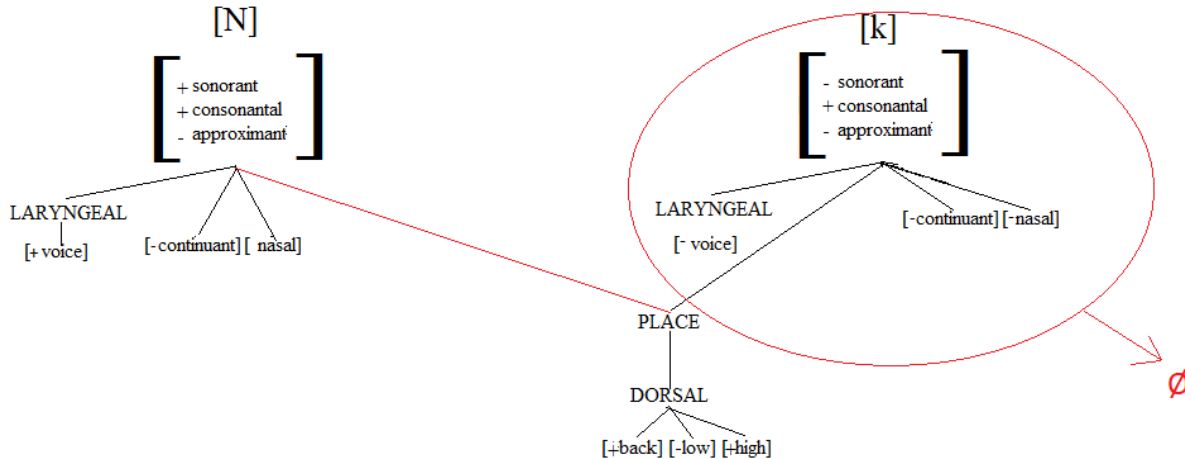
(57) NO LINK[PLACE]: assign a violation mark for every association line in the candidate which is not present in the input

(58) *FINALSTOP: assign a violation mark for every word-final stop

- (59) MAX[ROOT]: assign a violation mark for every ROOT node in the input which does not have a correspondent in the output

We can see the overall change in the diagram below.

Figure 13: Diagram of /baNk/ → [baŋ]



With the groundwork established, we can now turn to the analysis itself.

(60) Step 1: Nasal PLACE assimilation

/baNk/	HAVEPLACE	NO LINK[PLACE]	*FINALSTOP	MAX[ROOT]
→ a. baŋk		*	*	
b. baN?	*!		*	
c. baN[C-DORSAL]	*!			*
d. baNk	*!		*	

At this step HAVEPLACE needs to be satisfied on [ŋ]. This blocks any application at this step of PLACE-deletion for [k], as deleting that C-PLACE node only adds a new violation of HAVEPLACE. As well, at this stage deleting the ROOT node off the [k] fails to immediately resolve the HAVEPLACE violation. Thus the solution is to link the velar C-PLACE to [ŋ]. This violates NO LINK[PLACE], but as HAVEPLACE outranks it the assimilation still wins.

(61) Step 2: ROOT deletion

baŋk	HAVEPLACE	NO LINK[PLACE]	*FINALSTOP	MAX[ROOT]
→a. baŋ				
b. baN?	*!*		*	

It is thus at Step 2 that ROOT deletion becomes a viable option. With HAVEPLACE satisfied, the derivation must now resolve the violation of *FINALSTOP. There are two options: the derivation can either engage in conventional HS deletion, or delete the ROOT node first. Something which FGHS predicts which is missed by regular HS is that at this stage, PLACE-deletion (the conventional first step in full deletion) would not only reduce [k] to [ʔ], but would also reduce [ŋ] to [N]. These two segments share a PLACE node as a result of Step 1; therefore, the deletion of PLACE for one automatically deletes PLACE for the other. While this would satisfy CODA COND (not here depicted), it would fail to satisfy *FINALSTOP due to the continued presence of [ʔ]. Instead, [k] must have its ROOT node deleted. The result of this would be to leave the C-DORSAL node still attached to [ŋ].

(62) Step 3: Convergence

baŋ	HAVEPLACE	NO LINK[PLACE]	*FINALSTOP	MAX[ROOT]
→a. baŋ				
b. baN	*!			

At this step no further improvements can be made, as all relevant constraints have been satisfied. Thus the derivation reaches convergence. This process shows the importance of incorporating specific information about the feature geometry in HS: without that, the double-place-deletion possible in Step 2 would go unpredicted, and without opening up to ROOT-first deletion the process in general cannot be analyzed.

3.5.3 Serbian

The Serbian analysis here is based on Morén (2006), and is both an adaptation to FGHS, and to a Clements & Hume (1995)-style feature geometry. Observe the data, from Morén (2006):

(63) /'ɔral/	→	['ɔ.ra.ɔ]	“eagle”
(64) /'pɛval/	→	['pɛ.va.ɔ]	“sang”
(65) /'ka:lan/	→	['ka:.lan]	“dirty”
(66) /'val/	→	['val]	“wave”

In this data, there is an alternation between /lʲ/ and [ɔ] when in coda position. This is therefore a rather classic case of vocalization, something which Morén (2006) notes is often difficult in traditional feature theories but is made very easy by the Parallel Structures Model he uses. The analysis to follow here will show that it is also entirely possible to model this change in FGHS via the use of Clements & Hume (1995).

Before getting into the analysis proper, we must first briefly discuss notation and the nature of [ɔ] in this data. Something interesting is that Morén (2006) does not ever represent the output [ɔ] as its own syllable. Rather, without any comment, he consistently marks it as part of the same syllable the underlying /lʲ/ had been part of prior to vocalization. This decision implies that, despite the lack of any direct symbolic marking, the resulting vocoid is a glide rather than a full vowel. This proposal has some interesting backing in the fact that if preceded by a consonant, /lʲ/-vocalization is blocked and the /lʲ/ instead becomes syllabic (Browne (1993). This is very relevant, as it shapes decisions in terms of what the present derivation is attempting to accomplish. It should be noted that the following discussion is a consequence of using Clements & Hume (1995): the Parallel Structures Model which Morén (2006) uses does not seem to have the issue outlined below, as there the /lʲ/ directly vocalizes into [ɔ].

There is a potential problem hanging over this particular vocalization in FGHS, which is that the /lʲ/ is understood as being velarized in Serbian, thereby explaining why it vocalizes to a back

vowel. However, it surfaces as [ɔ] rather than [u]. In Clements & Hume (1995) the latter vowel is much more like velarization than is [ɔ]. Indeed, velarization is represented in that model as being a consonant with a V-PLACE node identical to that of [u]. This is a problem that could perhaps be resolved inside of a derivation, but here the matter will instead be dealt with here.

This is where the relevance of [ɔ] being a glide rather than a full vowel comes into play. If Serbian /l/ fully vocalizes into a full vowel, then there is no clear reason why it should not then become [u]. There are three possible solutions in theory, the first two of which would be derivational, while the third is more a matter of establishing preconditions. The first solution is that there is some constraint which prevents vocalization to [u], and makes [ɔ] the preferable choice at the time of vocalization. This runs immediately into the problems listed above, and is all told precisely what we are at present attempting to avoid. The second solution is to say that there is some constraint ranking which would first cause vocalization to [u], and then derive that [u] into a final [ɔ]. The causes for this are unclear at best, and without more specific details on the featural nature of that intermediate [u], it runs into the same problem observed with the Chilean Spanish data in 3.3.1 above, and which will be revisited in 3.5.4 below: HS does not distinguish between underlying and derived segments. An [u] is an [u] as far as EVAL is concerned, unless we could demonstrate some difference in the feature definitions which those symbols represent. After all, if underlying /u/ were to differ in its featural definition from the derived vowel labelled as [u] for convenience, then there could be an operation which targets one and not the other. Lacking any clear motivation for introducing such a distinction, however, we must move on to the third option. This is to reject the idea of winning a competition with [u] entirely, by invoking the above-discussed point that in this data, the [ɔ] being discussed seems to be a glide rather than a full vowel. If it were a glide, then it would not be competing with [u] for

realization, as the difference in syllabicity, however one chooses to represent it, would be an easy way to distinguish them. So long as there is something like IDENT(syllabic), or some other constraint which fills the same role, in a high-ranked position, then we would not expect [u] to be a viable candidate at all. Therefore, [ɔ] would not be competing against what is clearly a better vowel for the situation, but against the glide inventory of Serbian.

This is where things become quite interesting. Serbian only has one phonemic glide, marked as [v]. This glide is not identical to [w], but is instead purely labial. Therefore, as is obvious, it lacks any dorsal V-PLACE node. This means that it cannot appear as a candidate within a single operation from input /lʲ/, and is therefore not a viable competitor to [ɔ] at the crucial moment. This assumption will shape the derivation shown below. It allows for the analysis to take on a shape rather like that of the second proposal above, wherein we would first derive to [u] and then lower to [ɔ]. That direct path is, as noted, not clearly likely. There is, however, a similar path through the glides. We have noted elsewhere that in FGHS, it is possible to produce purely intermediate segments, that is, segments which only emerge as part of a derivation and are never allowed to surface in a language. This data gives us a clear example of this, as rather than deriving through [u], we will instead derive through [uɣ], the glide counterpart to [u]. This provides the featural difference mentioned above: a difference in [syllabic], or whatever feature is held to distinguish glides and vowels.

Thus we come to the constraints for this analysis. They are as follows:

- (67) *CODA/l: assign a violation mark for every [l] in coda position
- (68) MAX[lateral]: do not delete [lateral]
- (69) *uɣ: assign a violation mark for every non-syllabic, non-[-high] dorsal glide (that is, for every [uɣ])
- (70) DEP[high]: do not insert [high]
- (71) DEP[LABIAL]: do not insert a LABIAL node
- (72) IDENT[syllabic]: assign a violation mark for every [syllabic] feature which does not correspond to its specification in the input.

With the constraints established, we can begin the derivation, as seen below.

(73) Step 1: Gliding

/pe.val/	IDENT[syllabic]	*CODA/l	MAX[lateral]	*ʷ	DEP[high]
a. pe.val		*!			
→ b. pe.vaʷ			*	*	
c. pe.va.u	*!		*	*	
d. pe.va.l	*!				

Due to a high-ranked ban on coda /l/, the segment must undergo some sort of change. A simple solution would be to make /l/ syllabic. However, this option is not permitted in Serbian unless the /l/ is preceded by another consonant in the initial coda: this implies that Ident[syllabic] is blocking the syllabification of /l/ directly. Therefore, the easiest solution is to simply delete the [lateral] feature: without this feature *CODA/l would be automatically satisfied, as the resultant segment could not be a lateral at all. The CORONAL C-PLACE node would logically be underspecified, as CORONAL usually is. After underspecifying out other redundant features, /l/ would be defined by [lateral] and, on the basis of its involvement in this process, a DORSAL V-PLACE node. Since HS allows resyllabification as a free change at each step, there are consequently two possible outputs of deleting [lateral] out of a dorsalized /l/: [ʷ] and [u]. These are essentially the same segment, being vocalic dorsal segments. The only difference is that one is syllabic and the other is not. Due to IDENT[syllabic], Candidate (c) fails, leaving Candidate (b) as the winner. Note that [w] does not appear as a candidate here due to Gradualness: it requires the insertion of a LABIAL node on top of deleting [lateral], and thus is not an available candidate.

(74) Step 2: Rounding

pe.vaʷ	IDENT[syllabic]	*CODA/l	MAX[lateral]	DEP[LABIAL]	*ʷ	DEP[high]
a. pe.vaʷ					*!	
→ b. pe.vaɔ						*
c. pe.va.ɔ	*!					
d. pe.vaw				*!		

At Step 2 a key issue must be resolved: why is [ɰ] not the output? After all, it is the glide form of the default dorsal vowel. The answer must derive from segmental inventory.

Demonstrably, Serbian permits a glided form of [ɔ]. However, there is no evidence that Serbian permits [ɰ] in any position or environment. There must therefore be some constraint *ɰ which intervenes. So long as it outranks DEP[high], there is a clear solution: insert [-high] to the DORSAL V-PLACE, which will prevent it from deriving into [ɰ] or [u]. This would leave [ɔ] as the only segment available: Serbian has /ɔ/ phonologically, and thus there cannot be any high-ranked constraint banning it. Note that here [ɔ] stands for some sort of uvular glide, as there is no clear indication that it is acting as a syllable nucleus, as discussed above. There is a potential alternative option, of gliding to [w], as this is a typologically common segment. However, that solution is clearly not adopted and so there must be a reason for it to not emerge. The most likely solution is a ban on the insertion of a new LABIAL node which outranks DEP[high].

In Step 3 the derivation reaches convergence, as no further improvements can be made.

(75) Step 2: Rounding

pe.vaɔ	IDENT[syllabic]	*CODA/l	MAX[lateral]	*ɰ	DEP[high]
a. pe.vaɰ				*!	
→ b. pe.vaɔ					
c. pe.va.ɔ	*!				

Now, there is another alternative analysis here: if Serbian /l/ is uvularized as opposed to velarized, then the second step is unnecessary, as [ɔ] would be the logical output. This analysis would not make the same prediction as the above, whereby there is an explicit ban on [ɰ].

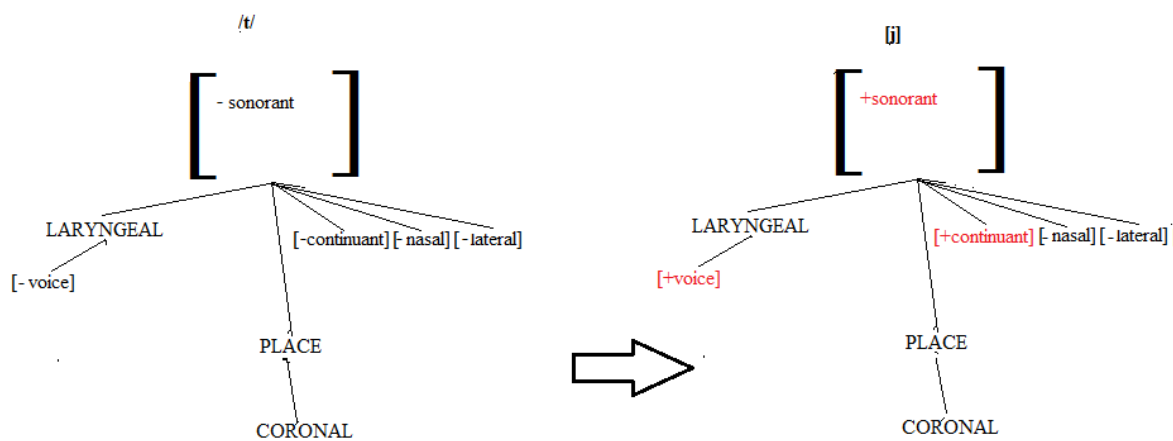
However, for the purpose of this data, both analyses provide an accurate model.

3.5.4 Chilean Spanish

The last case study is found in Chilean Spanish. As the data has already been discussed in Section 3.3.1 above, we do not need to go over it again here. To refresh what was discussed

there, we found that fully-specified NF was unable to properly model the alternation of /t/→[j] with the use of an *ad hoc* device called the ‘Specified PLACE Exception’, a mechanism which has no clear theoretical justification. This left us with the problem of how to handle the many feature changes required to derive from underlying /t/ to surface [j] without passing through an intermediate stage of [r], as [r] does not lenite in Chilean Spanish. The solution to this problem is underspecification: by leaving out most of the features of these segments, it is possible to permit frication to [z], and then make a single jump into generic sonorancy. From there, if [r] is assumed to be specified for [+consonantal], while [j] is does not have [consonantal] underlying specified, then a simple change of [-sonorant] to [+sonorant] should neatly solve the issue. Thus, observe a new diagram showing the changes required for /t/→[j] after we underspecify irrelevant features.

Figure 14: /t/→[j] with underspecification



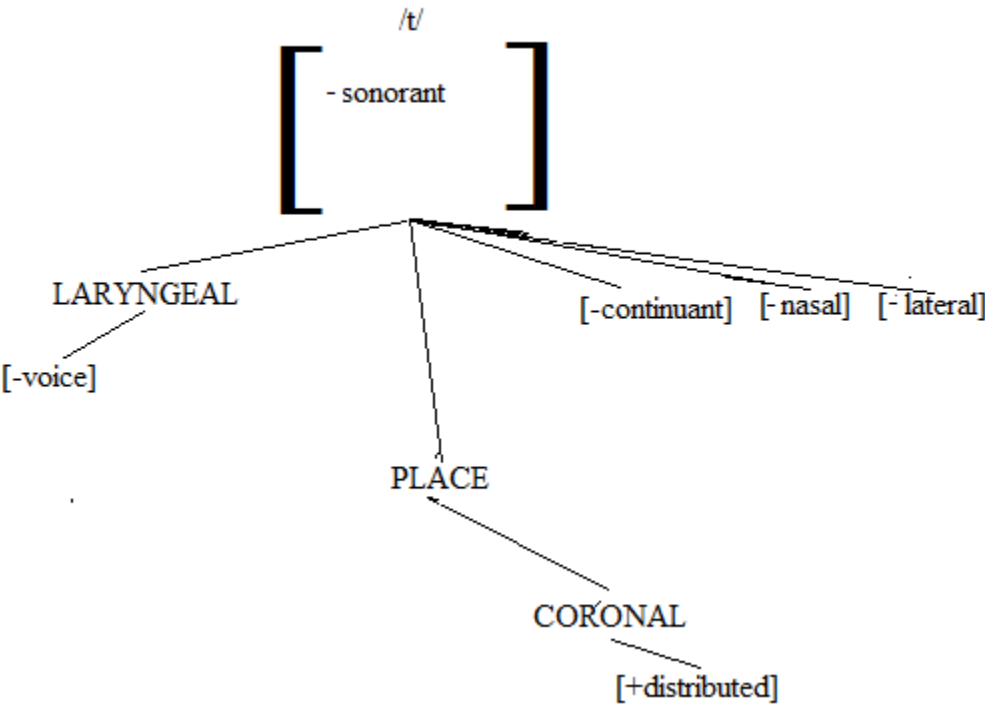
The following constraints will be used for the FGHS analysis presented below.

- (76) WEIGHT-BY-POSITION (WBP) (Hayes 1989): assign a violation mark for every coda which does not have a mora attached.
- (77) *OBSTRUENTMORA: assign a violation mark for every obstruent segment which bears a mora.
- (78) *SONORANTMORA: assign a violation mark for every sonorant segment which bears a mora.
- (79) DEP[MORA]: do not add a mora to a segment.
- (80) IDENT[feature]: do not change the specified value of the indicated feature. feature.
- (81) *z: assign a violation mark for every instance of [z].

With the constraints now defined, we can turn to discuss the analysis. The begin, let us observe the underlying structure of /t/ in Chilean Spanish.

(82) Underlying features of /t/

Figure 15: Underlying features of /t/



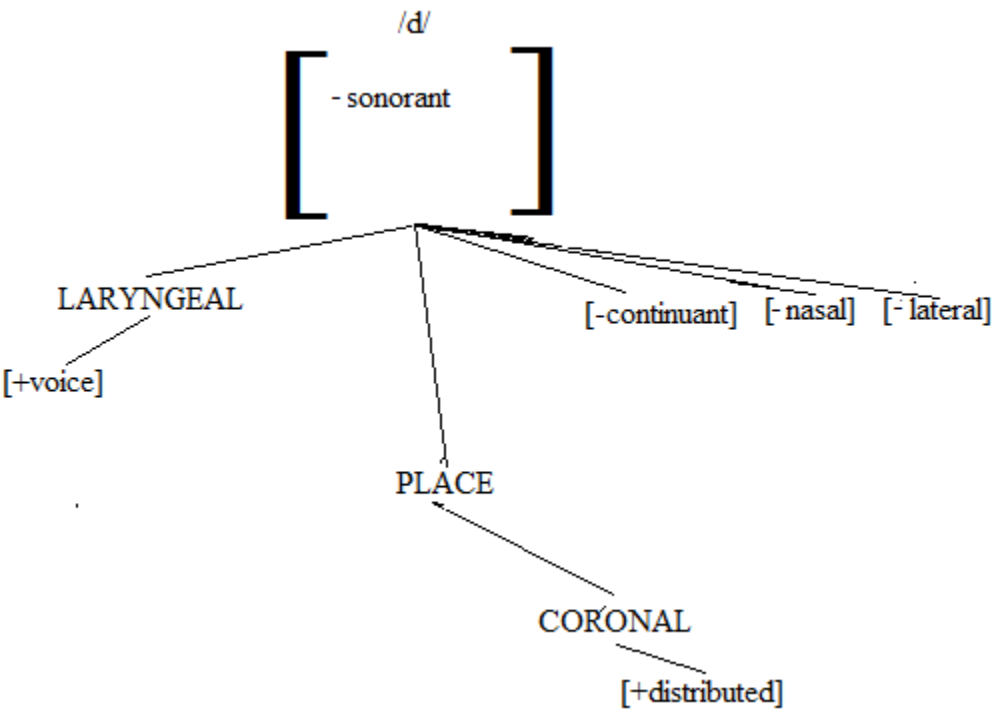
(83) Step 1: Voicing

et.ni.ko	*VOICELESS STOP MORA	*VOICELESS FRICATIVE MORA	*VOICED STOP MORA	IDENT [voice]
→ a. ed.ni.ko			*	*
b. et.ni.ko	*!			
c. es.ni.ko		*!		

At step 1 the input is coda /t/. Due to sonority requirements on mora licensing, it must become more sonorous. A high-ranking DEP and *? prevent PLACE-deletion and epenthesis as solutions to mora licensing. Only two options in a feature-by-feature HS derivation are to either fricate or voice. Since voiceless fricatives are less sonorous than voiced stops, Candidate (a)

wins. This is also necessary due to coda /s/ in CS PLACE-deleting to [h] and vacuously satisfying moraic sonority.

Figure 16: Featural structure of [d]



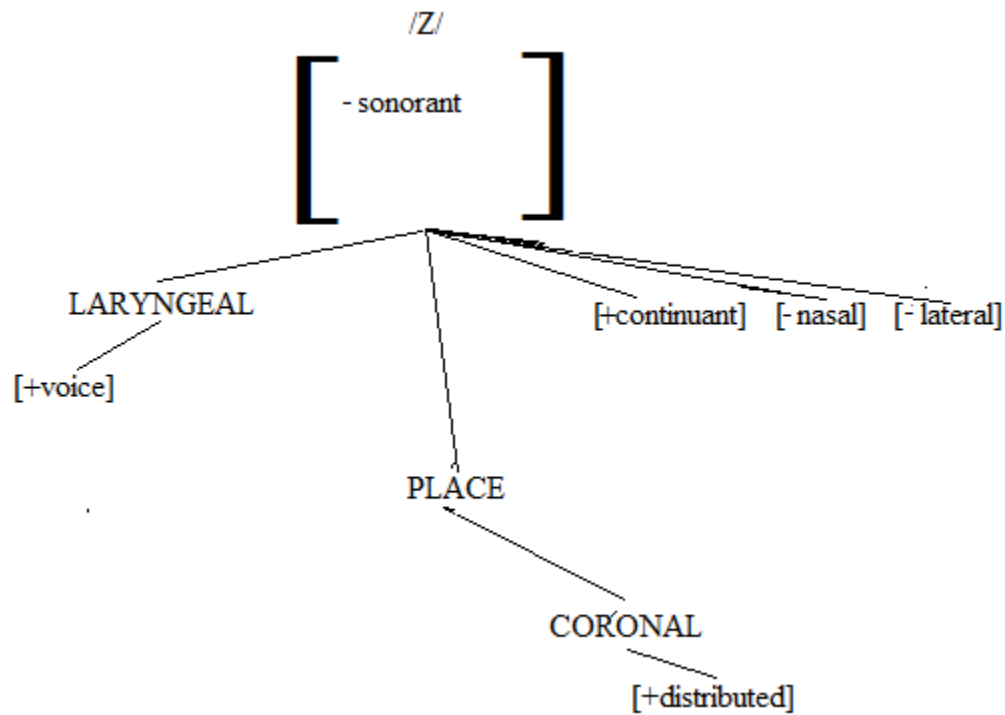
(84) Step 2: Frication

ed.ni.ko	*VOICED STOP MORA	*VOICED FRICATIVE MORA	IDENT [continuant]	IDENT [nasal]	*z	DEP[strident]
a. ed.ni.ko	*!					
→ b. eZ.ni.ko		*	*			
c. ez.ni.ko		*	*		*!	*!
d. eḏ̃.ni.ko	*!			*		

At Step 2 input /d/ must further lenite to satisfy mora licensing. Shown here are two options, both of which represent some form of frication. It is presently impossible for /d/ to become a sonorant in a single step due to needing to change both [sonorant] and at least one other feature: either [continuant] for liquids and glides, or [nasal] for a nasal stop. Candidate (d), [ḏ̃], shows a hypothetical first step towards nasalization: as can be seen, it technically remains a voiced stop

(as it is not a full nasal at this step) and provides no harmonic improvement. The remaining competition is thus between (b) and (c), both of which represent frication to a coronal fricative. The difference between them lies in the feature [strident]. [Z] represents an archiphonemic coronal fricative: it is simply some manner of voiced fricative with coronal place, and does not necessarily correspond to any surface consonant in CS. [z] in contrast is specifically the voiced alveolar fricative. CS has a blanket ban on surface [z]. It would furthermore always be less harmonic to add a feature than not if the additional feature is unneeded; it can also be noted that adding this feature would arguably violate Gradualness, since we would be both changing [continuant] and adding [strident] in a single step. However, it is entirely possible to assume that [strident] would simply be underspecified at this stage and would only receive a value during phonetic production, in which case it would have no bearing on the analysis and the constraint it violates would not be activated. Nonetheless, [Z] wins at this step.

Figure 17: Featural structure of [Z]



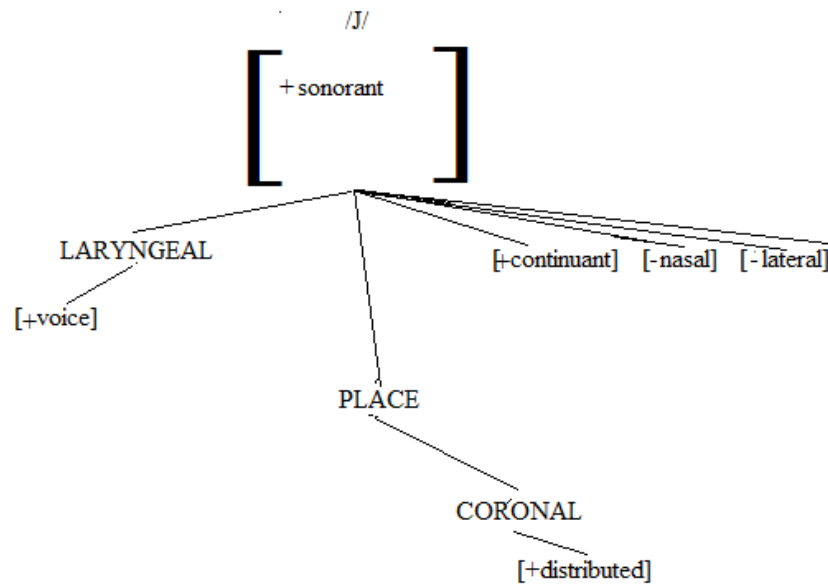
We can now turn to Step 3:

(85) Step 3: Gliding

eZ.ni.ko	*VOICED FRICATIVEMORA	IDENT [sonorant]	IDENT [distributed]	*LIQUID MORA	*GLIDE MORA
a. eZ.ni.ko	*!				
→ b. eJ.ni.ko		*			*
c. eɾ.ni.ko		*		*!	

The generic fricative [Z] is then fed into the final non-convergence step. It is now possible to change the [sonorant] feature in a harmonically-improving operation. First, we should quickly note that while Chilean Spanish has an alveolar tap [ɾ], Gradualness disallows it from appearing here due to differing from [Z] by both [sonorant] and [continuant]. Similarly, [r] is not actually available at this step, and is only shown to demonstrate how it would fare if it were available. As we have specified our dental inputs for [+distributed], the [r] therefore differs from [Z] by two features: [sonorant] and [distributed]. With each feature change being its own operation, [r] is prevented from being a candidate here by Gradualness. There are therefore only two sonorant candidates: [ɾ] and [J], which represents a generic coronal glide. Since *LIQUIDMORA outranks *GLIDEMORA, candidate (c) is eliminated. Thus the derivation instead converges on [eJ.ni.ko].

Figure 18: Featural structure of [J]



/Z/ and /J/ stand-in as representatives for ‘generic’ segments or archiphonemes, as discussed in Section 2.5.1. That is, /Z/ is not specifically the alveolar voiced fricative, but rather stands in for a voiced Coronal fricative; likewise, /J/ is a Coronal approximant. These segments are not identical to any of the phonemic segments in Chilean Spanish, but are allophonic-only feature configurations.

Underspecification necessarily leaves out features which are needed for phonetic pronunciation: it does not propose that underspecified features do not exist, but are simply not specified in the lexicon. In rules-based phonology these features can simply be added throughout or at the end of a derivation. In HS, however, there is no clear way to insert underspecified features consistently.

If feature-insertion constraints are ranked too high, then the features will be harmonically improving too early in the derivation, and thus will be inserted prior to the processes which rely on them being underspecified. Conversely, if ranked too low, then it could be that some features will never be inserted at all, leaving us with a necessary-feature-insertion problem still. The solution to this issue is to assume that it is the phonetics interface, rather than the phonology itself, which inserts underspecified features. If this is so, then phonological derivations can output generic segments such as /Z/ and /J/; they will be specified into particular segments at the phonetics interface and be made fully pronounceable then.

I argue that if we are to take seriously McCarthy’s (2010) proposal that HS derivations are feature-by-feature, then we will need to also invoke Underspecification in order to make the derivations work. To not underspecify features will cause crashes or make incorrect predictions: to get from [Z] to [J] in a fully specified derivation we would need to change [approximant,

sonorant, consonantal], while Underspecification allows us to limit this to just changing [sonorant].

We thereby see that FGHS makes significant predictions about lenition processes: cross-linguistically, we should see lenition processes at each intermediate step of the derivation presented here. It predicts that HS derivations need not ever be fully specified, and can converge with ‘incomplete’ or ‘generic’ segments: full specification is predicted to be a function of the phonetics interface.

3.6 Conclusion

The purpose of this chapter has been to outline and demonstrate Feature-Geometric Harmonic Serialism (FGHS) as a phonological model. We began by introducing the idea that the assumptions of classic HS imply a need for an explicitly associated feature theory. McCarthy (2018) takes us a step further, explicitly using a form of Clements (1985)-style feature geometry to explain deletion, making direct use of ROOT and PLACE nodes. From this starting point, this dissertation has articulated a full revision of HS in order to work out the implications of integrating feature geometry into a serial-derivational constraint-based model. The result of this has been the FGHS model. FGHS was compared to a potential alternative, Nodal Faithfulness, which primarily differed in that Nodal Faithfulness assumed full specification of features underlyingly, while FGHS assumed some form of underspecification. A crosslinguistic study of three lenition processes and one assimilation process was performed to show how FGHS works in practice, demonstrating that it is capable of correctly analyzing data we already know and understand. Part of this study revisited the Chilean Spanish data used to demonstrate Nodal Faithfulness, showing the superiority of FGHS as a model, with underspecification eliminating the need for the more cumbersome and concerning parts of Nodal Faithfulness. What remains

now is to take FGHS and apply it to new data. After all, it is one thing to make a model which can correctly model previously analyzed data. It is another thing to make one which will correctly model data which we have not yet solved, namely, the RUKI Sound Law.

However, before we can turn our attention to the FGHS analysis of the RUKI Sound Law, which is of course the primary purpose of this dissertation, there are other matters that must be attended to first. Of these, the most pressing is the validity and general usefulness of constraint-based models for analyzing historical linguistics in principle, which will be the topic of our next chapter.

4. Historical Linguistics and Optimality Theory

4.1 Introduction

In addition to reintegrating feature geometry and constraint-based phonology, this dissertation seeks to reintegrate modern theoretical phonology with diachronic linguistics. Historically there has been a strong connection between theoretical phonology and diachronic linguistics: after all, the Neogrammarians were driven primarily by a phonological assertion, that sound change was regular (Ringe & Eska 2013). However, since the advent of Optimality Theory, theoretical phonology and diachronic phonology have largely parted ways. Despite some valiant efforts in the early years, most Optimality Theorists seem disinterested in diachronic work, preferring to focus on synchronic data and how that shapes our understanding of CON, GEN, and EVAL. Elsewhere, diachronic linguists seem to have largely abandoned OT as a model for their work, if any significant number ever accepted it in the first place. Ringe & Eska (2013), a work which expressly sought to reintegrate historical linguistics with modern linguistic theories, rejects OT as a viable model for diachronic change, preferring to instead maintain traditional generative rules-based phonology. Earlier criticisms were levied by McMahon (2000, 2003, 2007) to similar effect, arguing that OT was a flawed model which should not be applied to historical sound changes.

This dissertation argues that such dismissals were premature, and furthermore that the ignoring of diachrony by Optimality Theorists has been a significant loss to the field. Many languages and phonological phenomena exist, or are attested, only in diachronic data, having been worn down by time. Furthermore, all diachronic speech was once synchronic, and therefore should from that angle fall under the purview of any synchronic phonological theory. Noting of course that sometimes what we perceive or describe as a single phonological change is in fact

multiple changes layered in sequence, diachronic data should not in principle pose more of a problem to any viable phonological theory than synchronic data does.

As this dissertation has already adopted Harmonic Serialism as its theoretical model over Parallel OT, the detailed examination of how a constraint-based diachronic linguistics model should be structured will be focused on FGHS. Any defense of diachronic OT offered here is intended only to defend the principle that constraint-based models are legitimate options for diachronic study, not to argue that Parallel OT itself is necessarily the best choice for such research.

This chapter therefore has two matters which it must address: first, whether Optimality Theory-based models can in principle be used to analyze diachronic data; and second, the nature of diachronic Harmonic Serialism. The second question will be left for later in the chapter. The first question will be divided into two subsections. First the focus will be on a small literature review examining the history of OT and historical linguistics, with an eye towards the rate of success and the controversies of the shift to OT. The other part, first referenced above in Chapter 2, is more argumentative. As indicated above, historical linguists have largely rejected OT as a diachronic model. Ringe & Eska (2013) specifically cites McMahon (2000) as their justification for this rejection, on the grounds that her work has thoroughly debunked OT as a diachronic model. If this dissertation is to stand, it is therefore imperative that the criticisms of McMahon be addressed. If she is correct, then any further examination of the RUKI data in an FGHS environment is pointless. Thus, if an FGHS analysis is to have any chance, it must be demonstrated that McMahon's criticisms are, at the very least, not fatal to the cause of OT, or potentially unsound entirely. This shall be demonstrated in Section 4.2, accepting that certain of her criticisms are sound or at least demand a more significant response than can be properly

explored within the scope of this dissertation, though not always as biting as she portrays them, but nonetheless showing flaws in many of the more damaging arguments. Section 4.3 will outline a system of diachronic FGHS, discussing the implications FGHS has for diachronic study, and examining the scope of phonology in explaining sound change.

4.2 Response to McMahon

McMahon has written several critiques of diachronic Parallel OT, ranging from 2000 to 2007. Each of these advances a different argument, and the 2007 article shows a shift in her focus away from attempting to debunk OT as a whole towards limiting OT to prosodic phenomena (leaving other phonological effects to rules). Of these, McMahon (2000) is the firmest rejection of OT, as it ultimately seeks to undermine the entire model, though the others will need to be addressed in their due time. McMahon (2003) provides an argument which functions poorly as a criticism of modern OT-based models, but does serve well as a warning on bad practices which were more common in the early days of OT. McMahon (2007) provides one of the clearest challenges to modern OT in the form of the Great Vowel Shift, showing that parallel OT is ill-equipped to explain chain shifts. A full examination of this particular challenge is beyond the scope of this dissertation, and thus must be left to future research. Nonetheless some comments can be made about the argument advanced by McMahon (2007) as a whole, which will be discussed in Section 4.2.3 below.

It should be noted that this section is primarily concerned with the arguments as arguments, rather than as products of their time: as will be noted where relevant, some of McMahon's arguments were much more biting when they were originally put forward than they are in a modern OT context. For the purpose of this present dissertation, what matters is the content of the arguments in that modern OT context, as the intention of this section is to demonstrate that,

while there are definitely problems which OT models must contend with, constraint-based phonology is not inherently illegitimate as a model for diachrony. Of further note is that this dissertation is interested in defending diachronic OT only insofar as is necessary to defend diachronic FGHS. The following section will be explicit when the response to McMahon's criticisms relies on the structures and design of FGHS, rather than the Parallel OT she is directly critiquing.

4.2.1 McMahon 2000

McMahon (2000) is a full monograph, and therefore a full exploration of every argument and criticism is regrettably beyond the scope of this dissertation. This section will therefore focus on what can be regarded as the key points. The crux of McMahon's (2000) argument is that OT has numerous flaws which are fatal in a diachronic context: it has trouble analyzing common segmental effects and requires increasingly complicated machinery to resolve this problem; OT is claimed to only work well with prosodic data; OT fails, even in principle, to explain every sound change which has ever occurred; OT has significant trouble with opacity, and requires increasingly complex machinery to resolve this problem; OT constraints are universal, which McMahon argues prevents them from accounting for language-specific phenomena; OT has a chicken-and-egg paradox since constraint reranking is supposed to trigger phonological changes, but it's not clear which comes first. Each of these points must be addressed in turn.

The Argument from Excess Machinery, as it might be called, is one which was much more fair when it was levied than it is now. As can be seen in McMahon (2000) itself, in the early days of OT there was a much fiercer debate on the relative merits of rules-based Generative Phonology against OT. In that context, the relative elegance of the two theories stood as a salient factor. Generative phonology used both rules and constraints, while OT used only constraints,

thereby simplifying matters (McMahon 2000). However, that time has passed. Modern OT seems to value itself in terms of its explanatory power primarily, not being a more elegant theory through the elimination of rules. OT now discards rules on the grounds that rules are more descriptive than explanatory.

This is important when considering the criticism that OT requires increasingly complex machinery to resolve common segmental effects. The matter at hand is why the addition of extra machinery to the theory is a problem outside of Ockham's Razor or other principles of elegance themselves. Certainly, all things being equal, a simpler theory is better. But this presumes that all things are equal in this debate, which they do not seem to be: as indicated above, OT's focus on constraints is intended to make the theory primarily explanatory, in contrast to Generative Phonology being primarily descriptive with its rules. If the extra machinery provides better explanatory power, then it cannot be something which is in principle inferior to the simple theory. Now, of course, particular mechanisms may be bad: and it may be the case that all the proposed machinery for OT will turn out to be poorly grounded, or produce unacceptable pathologies, or otherwise turn out to be bad. But that is a different matter from the addition of extra machinery in principle. If the extra machinery is bad on its own merits, then it should be rejected primarily because it does not work, not because it is less elegant. Conversely, if it works, and by using that machinery we as phonologists are better able to analyze and understand the nature of sound change than we could using rules-based Generative Phonology, then we ought to accept the complexification of the theory as all linguists have done when faced with similar situations.

Consider the parallel development of Generative Syntax: the old Government-and-Binding model became increasingly complex as it sought to explain more and more phenomena

(Hornstein et al. 2005). These expansions became increasingly burdensome, but the alternative of returning to the models which preceded Government-and-Binding was not taken, as the burden was a worthwhile price to pay for the increased explanatory power. The ultimate ending of that story is also worth noting here, as the increasingly complex Government-and-Binding theory did not last forever, but in the 1990s was collapsed into the modern Minimalist Syntax model. All the extra machinery, though worth accepting over its predecessor, was not worth keeping forever. The solution to its weight and complexity was, however, to look beneath it to seek out the underlying truths which it has revealed (*Ibid*).

This is very much so what Optimality Theorists should expect and be prepared for in the coming years with OT. Many mechanisms have been proposed to fix the various limitations and problems of OT, and most advanced OT work today operates with the use of some combination of this machinery, whether through the use of a derived theory such as Stratal OT or Maximum Entropy (Goldwater & Johnson 2003; Kiparsky 2000), or simply through the addition of assumptions and new kinds of constraints to what is otherwise an ostensibly conventional Parallel OT analysis. We should therefore expect that, if constraint-based phonology is in general superior in explanatory power to its rules-based predecessor, then we shall soon as a field need to reflect and condense down all the myriad models and proposals into a single, more coherent model which seeks to unite the various advantages of OT's successors, and, more to the point, creates a unified underlying system which can, without the need for excess machinery, explain the various phenomena which we have to this point dealt with piecemeal with bespoke exceptions.

Putting Parallel OT aside, the explanation and analysis of segmental effects is very much so what FGHS is intended to provide for. By explicitly integrating feature geometry into a serial OT

environment, FGHS is much better equipped than Parallel OT to handle segmental alternations. This is not to say that FGHS has yet been fully tested; the theory is young, and requires further work before it can be unambiguously leveled as a solution to this problem. Nonetheless, there is strong potential here for a solution to be found to this criticism.

The Argument for Prosody Alone seems to ultimately be an extension of the above: McMahon argues that OT is bad at explaining segmental effects, but has a strong track record of explaining prosodic effects, and consequently we should divide phonological labour between segmental rules and prosodic OT. The simplest answer to this would be to point to the great wealth of segmental work done in OT in the twenty-four years since the publication of McMahon (2000).

The Argument from Opacity is a solid critique: opacity has been widely acknowledged as a weak point in OT from early on, and it continues to be an issue the field wrestles with. Certainly, Parallel OT is essentially incapable of analyzing opacity on its own, requiring various other mechanisms to solve the issue. As discussed in Section 2.5, the ability of Harmonic Serialism to account for opacity remains somewhat controversial. Some authors have shown that HS can indeed model opaque interactions with certain data, while others have argued that it is unable in principle to handle such data due to its focus on harmonic improvement. Variant theories such as Stratal OT or OT-CC have, however, proven quite effective at solving opacity. However, this problem is not as devastating to the cause of OT as it may seem: it operates on the assumption that all opacity is purely phonological in nature. This assumption is notably not held by other theories of linguistics, most notably Minimalist Syntax and Distributed Morphology.

At least some opacity should be solvable by attributing it not to productive, synchronic phonology, but to morpheme selection. That is, opacity can to some degree be understood as the

ossification into the lexicon of once-transparent sound changes. The alternation continues to show evidence in speech, but is no longer the result of direct phonological operation, being rather baked into the lexical entries themselves. This explanation seems unlikely to be able to satisfactorily explain all instances of opacity, if for no other reason than that there do seem to be at least a few cases of productive opacity, which of course could not be explained in this manner (McCarthy 2007a). Nonetheless, it is something worth considering in this context. Cases of productive opacity constitute a vital and fascinating component of the debate on diachronic OT, but must for now be put aside for future research. It is simply too large a question to be dealt with in the scope of this dissertation. For now, it is sufficient to note that this remains a widely accepted issue, and that there do exist potential solutions of sufficient plausibility that opacity alone should not disqualify OT or HS as diachronic models.

Contending with the Argument from Inability, that is, from the inability of OT to, even in principle, explain every sound change, requires a more round-about approach than the arguments above. There is something of an interesting contradiction in McMahon's (2000) argument which bears discussion. While discussing the evolution of language, McMahon (2000:163) cites Richard Dawkins in support of the proposal that whenever a structure is found in an extant creature which seems too complex to have developed by chance, it must be assumed, without any direct evidence, that each necessary intermediate step is in fact advantageous over its predecessor. That is, having just part of the structure must be superior to having none of it, axiomatically and without any actual evidence. This is invoked as part of a broader argument as to the evolutionary infeasibility of OT, advancing the position that OT's insistence on innateness renders it impossible in a neo-Darwinian context.

The key element here is the belief that unobserved intermediate steps must be assumed as a matter of faith. The validity of this position in terms of biology is not at issue here; but when extended into historical linguistics, this undermines a key element of McMahon's argument against OT. One of her points is that there are many changes which OT cannot explain in a single tableau, and therefore we should find OT inferior to rules-based Generative Phonology. The issue here is that she never once discusses the possibility that the changes which have been put forward to challenge OT are not single-step changes. As will be shown in Chapter 6, through the example of the RUKI Sound Law, there is plenty of potential for telescoped changes: sound changes which are the result of multiple independent changes which are erased or obscured from direct evidence, leaving behind strange and even seemingly unnatural reflexes. OT as a theory is concerned with the synchronic mapping of the input to the output, not the diachronic development of a proto-form to its distant reflex. This is not to say that OT cannot derive diachronic effects; rather, it is to say that where OT analyzes diachronic data, it must do so in a temporally displaced synchrony. It is not fair to permit OT only a single derivation and then claim it has failed because it did not produce an input-output mapping which no speaker ever actually derived, when the equivalent rules-based analysis may well require, and use, multiple rules to explain the same process.

The contradiction here is of course that OT is not permitted this rather logical concession. In fact, McMahon omits to even broach the topic; based on the discourse provide in the text, it would seem that there is some reason for not extending this principle to diachronic OT which is so powerful and so obvious that it need not be mentioned. But in the absence of such a principle being explained, it is very strange that we must fault OT for something which we must accept for

evolutionary biology. On this ground it seems that we can dismiss this argument against diachronic OT.

The Argument from Language-Specific Phenomena seems to be somewhat missing the design of OT. McMahon argues that by making constraints universal, OT becomes incapable of resolving phonological phenomena which is considered language-specific. This seems to ignore that the whole point of OT, which is that universal tendencies align in certain ways to produce specific outputs. This is in fact a point McMahon touches on when comparing OT and Evolutionary Biology, that universal rules produce specific effects. However, she seeks to lay down an exception, claiming that these universal rules only operate on a certain scale: to borrow her example, the universal principles of biology can determine whether a species develops horns, but it is only historical accident whether they develop one horn or two (McMahon 2000).

This argument seems strong, until one delves into the details. Fascinatingly, the argument and its hidden problems almost look like a parallel to the differences between OT and HS. In McMahon's example, the presence of horns is ultimately treated as a binary: either the mutation which added a horn is good or bad: if good then add, if bad then not. That is, this is treated, though perhaps not necessarily conceived, as an act of global harmonic improvement: the intermediate steps are assumed to be good and can be ignored. This, however, does not seem to align with a deeper assessment of how horn development would proceed. Rather, it would be more like HS: each element of horn development would have to be independently improving in its own step, or generation, in order to advance to the next stage. If one subspecies has two horns while another has one, then the presence of two horns must have been harmonically improving in some way, no matter how small or transient, in order to win out at the relevant stage of development. Now, it could be that the benefit was only salient for a single generation, after

which it was simply something inherited. This is no contradiction: rather, it is a parallel to the embedding of sound changes into the lexicon. Once a sound change is ossified, all future sound changes must work from it as a baseline, rather than competing with it as an equal. The underlying representation is not subject to the same concerns of universal markedness to which alternations must submit. Rather, it is what it is, especially if one adopts the Richness of the Base and holds that there are no restrictions on the shape of the input. However, before it becomes ossified into the UR, it must have won at least one derivation in the grammar of at least one speaker: that is, it must once have been the optimal choice for at least one situation, after which it could spread out, perhaps achieving an effect outsized to its inherent quality. It is therefore not at all a strong argument to claim that OT should not be able to model language-particular data through the application of universal principles. In the end, this argument holds that linguistics alone should act unlike any other science, in that the particular should be held to be specifically not the result of a confluence of the universals. Thus, we can safely dismiss this criticism as well.

The last argument to be considered in this section is best described as the Chicken-or-Egg Argument, which holds that OT is trapped in a paradox: regarding sound changes, do constraint reranks trigger the change, or does the change happen independently and trigger a constraint rerank? According to OT's principles, constraint reranking should be the trigger for sound changes, but there does not seem to be any real motive for these reranks. McMahon argues that in practice, OT constraint reranks seem to be more responses to independent changes in the phonetics or phonology of words, which drive speakers to rebuild their constraint rankings.

There is a question which might be asked in response to this challenge: why does it need to be one or the other? The criticism presumes that all phonological changes must be either the result of phonetics and acquisition, or of grammar-internal phonological processes. This

presumption does not seem to hold. Language is acquired anew each generation, rather than being strictly passed from mind to mind (McCarthy 2007a). New speakers do not necessarily have the same underlying forms as their predecessors; rather, they must each generate a fresh lexicon based on the ambient linguistic data being fed into the principles of Universal Grammar. Surely it is no betrayal of phonology to say that some speakers will phonetically reanalyze some of the sounds they hear, and thereby impose a change on the phonology. This is, indeed, how we discuss the phonemicization of formerly allophonic forms, that a sound which was once merely allophonic is reassessed by learners as something independent, and thereby added to the phonemic inventory (Martinet 1951). This has significant phonological effects, such as allowing that segment to spread out into new environments. The constraints would then be ranked such that this form is permissible, in the same way that all constraints are ranked in order to permit the perceived language to be produced.

However, with a new constraint ranking comes further changes, both actual and potential. Old processes can now interact with the new ranking; some of them may drop off, while new alternations may now result due to the shifting in the preferences of EVAL. An allophonic segment reanalyzed as phonemic can now change further under the pressure of the general ranking. There is also nothing stopping the constraints from simply reranking independent of the phonetic shifts. As will be shown in Chapter 6, if [sʲ] is reanalyzed as [ç], it can then be pressured by a raising of *ç to become [ʂ]. Phonetics, acquisition, and phonology all have their role to play, and we need not value one higher than the other.

Overall, the above demonstrates that while McMahon (2000) is certainly a formidable critique of OT, especially in its earlier forms, it is not as cutting a deathblow as it may initially seem. When distilled down to the essential arguments, it can be seen that there are strong

responses available to the work. Some have resulted from further development in the model, with holes in the theory being patched or improved upon. Others, however, are the result of the arguments themselves being based on shakier logic than is initially apparent. Either way, McMahon (2000) should not be taken as a full refutation of OT-based models as viable diachronic models.

4.2.2 McMahon 2003

McMahon (2003) advances a tightly defined, technical argument against OT, with an eye both to diachronic and synchronic uses of the theory. She takes as her data a phenomenon in West Saxon called Palatal Diphthongization. This process saw non-high-front vowels diphthongize when they followed a palatal segment. This is a very strange phonological alternation, which McMahon is upfront about admitting: in fact, that is her very point. Palatal Diphthongization is generally held to not actually be a phonological alternation: rather, it is an orthographic convention adopted by the West Saxons, and the West Saxons alone (McMahon 2003). McMahon's argument is that despite West Saxon Palatal Diphthongization not being a real phonological change, OT can still provide an analysis of it. Therefore, she argues, OT is at best no better than rules-based phonology in terms of predicting all and only those languages and alternations which exist, but in losing its advantages becomes less viable than the old generative phonology.

This dissertation, of course, disagrees with this assertion. The argument which McMahon advances is flawed, though it should be noted here and now that its flaws would not necessarily have been as obvious at the time it was published: constraints of the kind which will be critiqued below were more common in the early days of OT. However, those errors have been largely

excised from OT, and therefore it is fair to criticize them when dealing with the question of whether OT as a modern phonological model is a legitimate option for diachronic study.

The analysis on which McMahon's (2003) argument is based is not directly provided anywhere in the work. Rather, the constraints are provided and defined, and the construction of the actual tableau is left as an exercise for the reader. Such construction has been done here for the purpose of critique. To be clear, this is a Parallel OT analysis, not an HS one of any kind. The constraint definitions have been collected below, with two of them converted from formal definitions into prose for reader convenience.

- (86) DIPHTHONG BACKNESS⁷: the first element in a diphthong must be [-back], and the second element must be [+back]
 (87) DIPHTHONG HEIGHT HARMONY⁸: elements of a diphthong must agree in height
 (88) *PAL: no mid-front vowels after palatal consonants
 (89) PAL: nonhigh-front vowels following a palatal must be diphthongs
 (90) V≈[+high]: vowels prefer to be high (cited from Archangeli & Suzuki 1997)
 (91) DISTANCE: composed of two constraint families, MAINTAIN CONTRAST and MINIMAL DISTANCE (MINDIST), the latter "requiring a minimal auditory distance between contrasting forms" (Miglio 1998:8)

With these constraints, we can construct the following Parallel OT tableau:

(92) Palatal Diphthongization

ŷæran	DIPHBACK	DIPHHEIGHTHAR	*PAL	PAL	V≈[+high]	MINDIST	FAITH
a. ŷæran				*!	*		
→ b. ŷæaran					*	*	*
c. ŷaæran	*!				*	*	*
d. ŷiæran	*!	*			?	*	*
e. ŷæiran	*!	*			?	*	*
f. ŷæuran		*!			*	*	*

As can be seen above, it is possible to construct a formal analysis based on McMahon's argument such that OT can produce Palatal Diphthongization. However, there are problems

⁷ This definition is paraphrased from the formal definition and prose description provided by McMahon (2003)

⁸ This definition is paraphrased from the formal definition and prose description provided by McMahon (2003)

below the surface for this argument which make the formal analysis less ironclad than it might appear. There are two grounds on which it can be criticized: the first, that it contains at least one badly-defined constraint, PAL; and the second, that this constraint, key to the analysis, has no clear justification even if it were to be properly defined.

As to the definition: PAL is defined in (10) above. This definition is unusual as OT constraints go: a study of McCarthy (2008)'s sample list of constraints will give nothing that has a shape like this. Rather, PAL is defined like a pre-OT rule: it provides an environment in which an input must be transformed into a particular output. That is to say, PAL's definition could be written as $V_{[-high, -back]} \rightarrow D_{[-anterior, +distributed]}$. This undermines both the spirit and the function of OT, as it encodes the output into the constraint itself. PAL should be instead formulated in a manner like this:

- (93) PAL: assign a violation mark for every sequence of a palatal consonant followed by a nonhigh-front monophthong

Now, this constraint provides the same ban on palatal-monophthong sequences which the original definition required, but no longer provides a *fiat* required output. In this scenario, the changes made are unlikely to change the formal analysis shown above. Thus, attention must be turned to the second matter.

McMahon omits discussion of the fact that OT is not itself a theory of constraints, but of computation. Furthermore, OT has no native theory of CON; rather, a theory of CON must be brought to it, similar to how OT has no feature theory but needs one to be inserted by researchers. That a constraint can be proposed and used to produce an unattested output is nothing new or outrageous: pathologies are well-known as a problem in OT. This is why in addition to theories about how EVAL and GEN work in OT, researchers must be careful in the construction of theories about CON. In OT, just because a constraint can be formulated doesn't

mean it should be automatically accepted: rather, as per McCarthy (2008), every constraint proposed must have some sort of justification. These justifications come in two broad categories, with the best constraints drawing on both: functional and formal. PAL does not clearly fit into any extant constraint family or archetype to any meaningful degree, and thus does not seem to have strong formal backing. Certainly, it is not a necessary member of any known constraint family, and thus claiming a place for it on formal grounds seems weak.

This leaves the functional explanation. Here it could be argued that PAL is required on the grounds that there is an observed pattern of banning monophthongs after palatal consonants. Such an argument could work until one considers that the data which would be used to justify this claim is held by McMahon herself (among many others) to be unreal. That is, McMahon's argument is that by using PAL, OT can analyze the non-existent Palatal Diphthongization change in West Saxon. However, PAL itself can only be justified on the grounds of observing PD in West Saxon. The basis of the constraint is thus hopelessly contradictory: PAL is necessary to analyze PD despite the latter's non-existence, but can only be justified if PD is something we hold to really exist.

It can therefore be seen that McMahon's (2003) argument is not as strong as it might seem. Rather than demonstrating a weakness of OT in regards to analyzing diachronic data relative to rules-based phonology, it functions more clearly as a warning against using *ad hoc* constraints in formal analysis. This is a well-understood risk when working with any variant of OT, and does not constitute a significant blow to its legitimacy as a phonological model, whether dealing with synchronic or diachronic data. Now, an argument could be advanced that the same restrictions existed for rules in generative phonology, and therefore, McMahon has still made her point. This does not hold true, due to the difference in the nature of rules and constraints. Rules remain

situation-specific descriptions of surface alternations: they make no predictions in and of themselves, and can be generated for any apparent pattern.

For an example, simply look at the very RUKI Sound Law this dissertation aims to analyze. This dissertation argues, as will be described in Chapter 6, that the RUKI Sound Law is not a single process, but the telescoped result of multiple independent changes. Yet while there has long been concern in rules-based phonological models about the RUKI Rule, it has still stood as a rule for quite some time. This rule persists because, while it is strange, it stands alone, and really does not have an effect on other analyses or the broader theory. In contrast, OT models cannot ever produce something so specific. Every constraint is held to be not only available to every language, but directly involved in the ranking of every language. OT, holding that constraints are part of UG, predicts that every constraint should be part of every language, and therefore disallows language-specific constraints. Furthermore, in OT outputs are the result not of singular rules, but of two or more constraints interacting.

Since any constraint can interact with any other constraint, any given constraint could be disproven by a pathology which would emerge in any language. Rules, in contrast, can in the utmost only be dismantled by demonstrations of their illegitimacy within the language they were proposed for. OT thus enforces a much higher standard of proof, in principle at least, on its constraints, in addition to those which were enforced on rules. Lastly, once accepted, constraints, being universal, makes predictions about human language as a whole, about what kinds of language can and cannot exist. Rules do not do the same, as they are language-specific.

The point of all this is to say that the constraint PAL is far more illegitimate in OT than its rule equivalent would be in generative phonology. Not only is PAL a bad constraint structurally for the reasons discussed above, but it is cross-linguistically bad. It not only would permit OT to

analyze a phonological pattern which is unreal, it would predict that similar effects should be available to other languages across the world, something which could happen, in theory, at any time in any place.

4.2.3 McMahon 2007

The core critique leveled in McMahon (2007) is that OT is simply not equipped to model chain shifts such as the Great Vowel Shift (GVS), nor its residue, referred to here as the synchronic Vowel Shift Rule (VSR). She contends that the opacity of these processes, particularly in the case of VSR, renders them incompatible with Parallel OT, and that furthermore OT is unable to analyze their morphophonological nature (McMahon 2007:343-344). She does admit that there have been some proposed Parallel OT analyses of the GVS itself, though she notes that almost none seem to exist for the synchronic VSR. The existing Parallel OT analyses are held to be less than fully legitimate, however, on the grounds that they introduce new machinery, new constraint types, or compromise the universality of constraints as a class.

This criticism will not be contested here, insofar as it refers specifically to Parallel OT being incapable of analyzing the GVS and its residue. However, some response will be given in regards to the use of constraint-based phonology in principle on these matters, and in regards to some of the principles underlying the criticisms given. It must be stated at the outset, however, that the discussion to follow is not intended to be a full exploration, and certainly not a full refutation, of McMahon (2007). That would require a much larger, more in-depth discussion on the GVS, which is beyond the scope of the current project. This dissertation intends to formulate and apply a model for a modern, diachronic-capable version of HS, and to specifically test it against, and thereby analyze, the RUKI Sound Law. The GVS is too broad and complex a process to be addressed in a subsection here, and will likely require further development of the theory than is

possible at the present time. Likewise, the synchronic VSR is a matter better saved for another time to be properly explored.

That said, the principles on which McMahon's criticisms here are based is worth examining. If nothing else, it must be shown that constraint-based models are not to be hereby inherently dismissed as useless for diachronic study. Not all of the criticisms levied here can be properly addressed given the constraints discussed above, however, and it is here admitted that some of the levied criticisms are to be taken very seriously as points on which constraint-based phonologies must either improve, or demonstrate a capacity for answering.

McMahon (2007) argues that VSR is both productive and opaque, which constitutes a significant problem for OT. After all, it is widely understood at this point that parallel OT is simply not properly equipped to analyze most, if not all, forms of opacity. Many of the variants of OT over the past twenty years have been focused on trying to resolve this issue, to varying degrees of success (McCarthy 2007a). This is a criticism which this present study will not contest. Opacity in general may be more explicable under FGHS than under Parallel OT, but for this FGHS would rely on the assumption that most opacity is not productive, but rather baked into the URs. That is, in FGHS most opacity would be conceived of as primarily lexical, rather than phonological *per se*. This is merely a proposal, of course, and one which must be properly tested and explored before it constitutes a proper refutation. For now, it merely stands as a possible solution, to show that the situation regarding opacity is not in principle entirely hopeless.

However, productive opacity defies even this possible explanation. If an alternation is productive, in OT terms it should be the emergent result of the synchronic constraint ranking. It should not, indeed cannot, be the result of phonologically ossified lexical entries. At the present

time, FGHS is unable to offer a refutation to this, and must concede that productive opacity is beyond its present capabilities. Hopefully future research will uncover some method, but present problems cannot be ignored on the grounds of uncertain future solutions. Thus, this point is functionally conceded at the present time.

One matter of particular interest is the assertion by McMahon (2007) that it is a problem for OT to introduce new machinery to deal with difficult data. Certainly, there is something to be said about avoiding the multiplication of extraneous mechanisms, but that does not mean that the addition of extra machinery in itself is bad: it is an admonition to exhaust the available tools first, and to carefully consider the grounds on which new theoretical machinery is based. After all, while theoretical elegance is something to be valued, it is not the be-all-end-all measure of a theory. It may, as has occurred many times in the long history of scientific advancement, be that the extra mechanisms will eventually grow too burdensome, and demand the simplification of the theory, but their existence does not invalidate the theory now, nor does it unmake the insights which the theory has brought. We discussed this above, in Section 4.2.1, in regards to the development of Government-and-Binding into Minimalism. There is no clear reason why we cannot simply undergo the same process in phonology as we did with syntax.

From a theoretical perspective, this criticism follows a running theme in McMahon's criticisms: she generally refuses to permit OT to expand beyond its original, or at least core, conception. When opacity turned out to be a problem for Parallel OT, researchers began to search out solutions, with varying degrees of success. Certainly, some of the proposed solutions were poor choices, or too complex to be particularly viable in the long run, such as Sympathy Theory (McCarthy 1999). But McMahon almost seems to disagree that it worthwhile was attempted at all. Consistently across McMahon (2000, 2007) she criticizes OT as becoming 'unnecessarily

complex' compared to rules-based generative phonology. This was somewhat fair in McMahon (2000), as at that time the greater simplicity of OT over rules-based phonology was a salient talking point. But that argument has largely been abandoned in modern OT discourse, and has been abandoned without consequence for any of the other advantages of OT-based models. Modern OT papers essentially never mention simplicity relative to rules-based Generative Phonology when discussing their findings or proposals for the model. Much more focus is placed on the devising and revising of constraints in order to account for strange phonological phenomena. Criticism of the expanded mechanisms as being failures in their purpose is thoroughly legitimate; likewise, criticism of the form of the solutions. But criticism of their existence in principle as somehow undermining OT, treating the need for new mechanisms with difficult data as a critical weak point in OT, is simply not the same. It stands as something out of date, an old criticism which no modern scholar seems concerned with.

Thus, we must conclude that McMahon (2007) does have some solid criticisms of OT as a model, but that not all the arguments therein are fatal, or even clearly relevant. The weakness of OT in regards to opacity is well-known, but is always fair as a criticism. In the long run, constraint-based models must either produce proper machinery for accounting for opacity, or phonological research must demonstrate the non-existence in principle of opacity. However, the argument that OT is flawed simply because new machinery is being generated for the purpose of resolving the first criticism is itself rather flawed. All scientific theories have the right, in principle, to address criticisms and provide solutions, even if that requires introducing new theoretical machinery or otherwise modifying the model.

Let us assume for a moment that productive opacity is uncontroversially real. Certainly, this is a major problem for Parallel OT, and in practice for many theories derived from it. But in

principle, a model with multi-step derivations, rather than a single fully parallel mapping, could be designed based on the underlying principles of OT to solve this problem. So long as one change can occur at a later stage in order to erase the context of an earlier change, then productive opacity can be solved. Whether the resulting model should be considered a variant of OT or to have instead invalidated OT as a model is something to be determined at such time as this model is put forward. The invalidation of OT, however, does not occur at the moment when some modification, whether grand or small, is put forward.

From this example we see the issue here. It is unfair to treat OT as something other than a normal scientific theory. Certainly, like all scientific theories, it can be proven wrong in the face of contradicting data. Similarly, it can be fundamentally broken through modifications, such that the assumptions inherent in the new machinery contradict the underlying assumptions of the model. But, like all scientific theories, OT has the right to be modified, to progress, and to adapt to new data and new circumstances. We cannot therefore dismiss constraint-based phonology as a model of diachronic data simply on the ground that it has adopted a variety of possible solutions in the form of new theoretical machinery.

Lest this section seem to be making a strawman, it is here reiterated that the inability of Parallel OT to account for opacity is a definite problem. However, opacity in general is a large and difficult matter which would be better served by a full discussion at another time, as solving it in principle in a constraint-based model is beyond the scope of this present dissertation. Some discussion, however, is both relevant and possible, and will be handled as part of the following section. Nonetheless, we should still in light of this be sufficiently confident in the value of constraint-based phonology as a model for diachronic change. It has notable limitations at present, but not all of the criticisms are nearly as fatal as some have held. We can therefore rest

somewhat safely in the knowledge of its success in synchronic data, and know that there is little reason to hold that it cannot in principle analyze historical data.

4.3 Diachrony and Harmonic Serialism

Having argued above that OT is in principle a viable model for diachronic change, albeit one which still has significant flaws, it is now time to turn to the more specific matter of diachronic Harmonic Serialism. Though it has been established that constraint-based models in and of themselves are not inherently incapable of analyzing diachronic data, it must still be asserted to what degree HS specifically is capable of such, and how diachrony would interact with the systems of HS. The answer is that HS is quite well-equipped, if still facing certain potential limitations inherent to any model which adopts the principle of harmonic improvement, that is, the problem of opacity.

Harmonic Serialism has a distinct advantage over OT as regards diachronic data: it is serial. Parallel OT, by its very nature, can only represent the input and the output, not any of the intervening steps: but diachronic phonology is essentially a long list of intermediate steps. HS, in contrast, is full capable of representing multiple layered operations in sequence, thereby capturing the effect of independent sound changes layering on top of each other over time. It should be noted, however, that HS does not represent the history in an unlimited manner. Especially when the considerations behind FGHS are accounted for, any form of diachronic HS must necessarily derive the output from a historically recent input, rather than from some ancient form. This is not really a radical idea, for no one seems to seriously argue that modern English speakers are deriving their words from Proto-Indo-European roots in the moment. It is nonetheless worth explicitly noting, as it leads into a useful advantage of HS over OT, and potentially over most rules-based phonology.

In order to function as a computational system, FGHS must be fed particular inputs in order to produce the attested output. This forces FGHS to make continual predictions about the nature of the input in each derivation, which in turn makes predictions about the development of language. For diachronic analysis, HS must make a prediction about the specific nature of the input the speaker is using. This is a claim about when diachronic change becomes baked into the lexicon, and ceases to be productive. These predictions change naturally as the language moves forward, which directly parallels how language develops: speakers slowly add on new sound changes until the very lexical entry takes on a new shape.

This informs how HS may be able to resolve at least some of its opacity problem: by referring to the lexicon and the morphological processes at play. Phonology by its very nature deals with the outputs of morphology: it is only after lexical insertion has occurred that phonological processes begin their work. In cases of non-productive opacity, it could be held that the opacity is the result of the morphology selecting lexical items which have already integrated sound changes, rather than those sound changes being applied by the phonology in the synchronic grammar.

All linguistic theories ultimately admit to the existence of something like the classical linguistic concept of the Lexicon (Fabregas & Scalise 2012). This implies that the lexical form of a word exists independently of, and prior to, the phonology itself. It must of course pass through the phonology before it can be phonetically pronounced, and when speech is heard it must pass through the phonology again before it can be lexically interpreted. For production, which is what most historical phonology is really discussing, this means that the initial state of the lexical form is decided prior to the phonology. In Distributed Morphology, the lexical form of each morpheme is selected from its paradigm prior to reaching the phonological interface. This implies that to

some degree, differences in phonological material are the result not of synchronic phonological operations, but of old changes which have become integrated into the shape of the morpheme itself. This allows for once-productive rules to continue to show evidence despite no longer being the direct result of the synchronic constraint ranking.

This leads into an important component of diachronic FGHS, since it directly concerns an important issue for any form of diachronic OT: ‘illusory’, or telescoped, changes. There are changes which are often expressed as a single rule which were not in fact a single-step change (Blevins 2004; Fallon 2002; Hock 1991; Jeffers & Lehiste 1979). Rather, the rule simply captures the beginning and end of a longer process of smaller changes, each of which came in its own time. These processes, summarized as a blanket rule which can cover a process which took centuries to fully develop, can be very difficult for OT models, including FGHS. Many of them make little sense in featural or markedness terms, and may even seem to be unnatural. This is not a sign of weakness in OT models, but rather a warning against treating these summarizing rules as hard fact: they are descriptions of the reflexes of ancient roots, nothing more. FGHS is very well-equipped to decompose these rules, and to analyze when the intermediate stages became ossified into the lexicon, rather than being derived on the spot. The very fact that OT-based models have trouble with these changes could well prove to be an asset, since it means that OT is predicting the non-existence of changes which, upon deeper investigation did not actually happen. Indeed, if we were to find a diachronic shift which does not make sense in terms of a single-step change, then OT-based models, especially FGHS, would naturally predict that it must be a telescoped change, and require the analyst to decompose the shift into more fine-grain constituents.

Something that must always be remembered is that all sound changes were once synchronic: each change was the result of real speakers making changes to their linguistic inheritance, and then in turn passing their modified grammar and lexicon onto the next generation. The analysis of sound changes in an OT environment must therefore examine these changes not as historical artifacts, but as synchronic alternations which just happen to take place in the distant past.

FGHS must have at least some explanation of the relationship between constraint reranking and phonetic shifts. Diachronic FGHS contends that the question of whether reranks or phonetic shifts come first is a false dilemma: it can be either, depending on circumstances. There is no reason to believe that a phonetic change cannot result in reanalysis by language learners, which consequently causes a different ranking to emerge. Likewise, there is no reason to believe that once a constraint is reranked, phonetic changes cannot ensue. Each instance should be assessed in its own turn, on a change-by-change basis.

With that matter resolved, the discussion can now turn to the details of how constraint reranking and phonetic shifts are to be modeled in FGHS. Constraint reranking can generally be conceived as a generational phenomenon, not a strictly synchronic one: that is, constraints rarely re-rank (without significant effort or pressure) in adult speakers, and it is children who do most of the constraint reranking. Setting aside for the moment theories of variable rankings (as that is a distinct matter from the kind of permanent constraint reranks being discussed for diachronic purposes), generally, it should not take place in the middle of a synchronic derivation. Rather, reranks should occur in-between derivations. These reranks should be justifiable in terms of the linguistic environment (presumed or attested) of the learner. At the present time FGHS has not adopted any particular theory of phonological acquisition, and thus has little to directly say on

the details of intergenerational constraint reranking. Further research is required in order to fully develop a principled theory of this.

The matter of phonetic shifts requires a different tact. The first question which must be asked here is what is meant by ‘phonetic shifts’. To a certain extent, FGHS contends that phonetic changes are not a concern for phonological theories. Rather, they exist outside of the phonological sphere. They can be a result of changes in the phonetic manifestation of the same underlying phonological features. Such changes would be the product of changes in the interface between phonology and phonetics, rather than the result of a particular rule. They might also be the result of an underlying representation which has been constructed in a way inconsistent with how older speakers understand the relevant morpheme.

A very important component of diachronic FGHS is lexical reanalysis: that is, the acquisition of an incorrect lexical entry by a language learner. As will be seen in Chapter 6, there are times when mechanically speaking, there is no feasible way to explain how a diachronic change has progressed using the most recent output. In these instances, if there are solid grounds by which a reanalysis can be justified, then one should be used. This would be something like, as will be seen below in Chapter 6, taking a palatalized dental fricative and reanalyzing it as a fully palatal fricative. This is a logical misinterpretation for a learner to make, and one which need never quite pass through the phonology itself. Certainly, phonology would play a role, as the learner attempts to map the acoustic input to some abstract form. But that decision is not being made as a result of the original speaker’s phonological knowledge, but rather a decision in a still-learning, still-developing grammar as to what shall be stored in the lexical entry. Reanalysis in FGHS is described as a lexical effect on these grounds, that it represents a change in the lexical entries which provide inputs, rather than something which was produced by the phonology itself.

While the admission of these changes into the theory may at first seem to be a betrayal of the very purpose of phonology, as it opens the door for every change to be handwaved as reanalysis, rendering phonology largely irrelevant, this is not so. This kind of change has been long acknowledged, under the name of analogy. Analogical change was always an alteration of the lexical form without direct reference to regular phonological processes. Lexical reanalysis in FGHS simply takes this further and holds that during acquisition, learners can reinterpret phonological stimuli into a different, but notably related, form. It must further be emphasized that the use of reanalysis in FGHS does not in any way claim to be a change made without reference to phonological knowledge. Rather, it is a change made with reference to language learner knowledge. The assumption is that reanalysis in this sense happens with children who are still acquiring adult language. They would have access both to whatever inherited linguistic knowledge they possess, and whatever specific details of their language have been acquired at the relevant point in time. Where there is a lack of knowledge is specifically in regards to the structure under threat of reanalysis. The result of reanalysis should be explicable either in terms of facts about the phonological system the speaker has to that point acquired, or in terms of typological universals.

4.4 Conclusion

This chapter has been focused on two topics: the defense of constraint-based phonology as a model for diachronic change; and the outlining of how FGHS adapts to diachronic analysis, particularly as regards the matter of opacity. The first has been achieved to a satisfactory degree. Parallel OT itself still has many problems with diachrony, and while FGHS addresses a number of these issues, productive opacity remains a problem for any system based on harmonic improvement. However, it has been demonstrated that many of the arguments against OT-based

models are much less solid than they initially appeared, especially in light of how the field has advanced. It can thus be said that OT-based models, speaking here in particular of FGHS, can be treated as legitimate options for diachronic analysis. However, just because they are legitimate does not make them superior to the existing Generative Phonology approach; it merely means they are allowed to compete. To make a proper argument for constraint-based diachronic linguistics, some particular strengths must be demonstrated. This will be done across Chapters 6 and 7, showing how an FGHS analysis works and discussing its implications, strengths, and weaknesses. However, before that, we must first take one last detour to discuss the data being assessed here: the RUKI Sound Law.

5. The RUKI Sound Law

5.1 Introduction

This chapter is the final theoretical detour before the analysis proper. This can be understood as an expanded data section of a normal phonology paper, covering the available RUKI data. The chapter will review the extant analyses of RUKI, in particular that of Allen (1973), which this dissertation largely follows. This chapter will also outline the reasons why, upon review of the research on RUKI and analysis of the data, Allen (1973) constitutes the best basis for a theoretical phonology approach to RUKI. As well, this chapter will discuss the analysis of Longerich (1998) and examine the differences between phonetic and phonological understandings of sound change. The bulk of this chapter will be found in Section 5.4, which provides a simple statistical analysis of the RUKI environments. Something which does not seem to have been done to this point is a comprehensive analysis of all the segments which can possibly appear before [s] and [ʃ] in Sanskrit. This dissertation holds that much of the confusing nature of RUKI can be attributed to an over-focus on traditional phonological environments, that is, an assessment of the segments which condition the change: the oddity of the RUKI set, however, may be resulting as much from the segments which do not appear before it as those which do. While the data analysis given here does not cover the actual totality of these words, it does work through a large number of them to provide statistically relevant conclusions, drawing data from MacDonell (1893). The ultimate finding of this chapter will be to say that the RUKI Sound Law is best understood as the accidentally visible reflexes of a theoretically broad-reaching process of place-assimilation.

5.2 A Brief History of RUKI

The earliest modern analysis of RUKI can be found in Whitney (1889), the text which in some ways forms even the basis of this present dissertation. Being primarily a Neogrammarian text, and beyond that a text concerned with the translation of Sanskrit after the manner of Latin or Greek, it provides a relatively short, functional explanation of RUKI. No significant attempt is made to explain why the RUKI set exists, or how it triggered /s/-retraction. Rather, there is an explanation of the environments in which the RUKI Sound Law applies. Notably, it provides as explicit something which many later analyses leave as assumption: the explanation that several sets of segments neutralize to the RUKI set when before /s/. That is, it discusses, albeit briefly, the fact that of all the front vowels, only /i/ ever appears before /s/; likewise, of the back vowels, only /u/; of the velars, only /k/. This fact seems to have been largely either ignored or assumed by the later analyses which drew on Whitney, or the chain of sources which followed him, for their data. The data analysis in Section 5.4 shows that such an assertion is not unambiguously correct, as there are instances of both [s] and [ʃ] occurring after [e] and [o], though they do not constitute a large portion of the data set. Nonetheless, it is relevant to note that while not generally directly mentioned, both [e] and [o] can be considered RUKI segments.

Other accounts of the RUKI Sound Law were given over the following decades, such as Martinet (1951) discussed in Section 2.6. While interesting in their own right, they do not directly bear on this present analysis except insofar as has already been discussed in Section 2.2, while covering Allen's (1973) discourse on them.

Zwicky (1970) stands as the key turning point in the analysis of RUKI. He provides, in a mere handful of pages, an analysis of RUKI which establishes, using the most advanced methods of his day, a natural class which can define the RUKI set. In the article he gives two different

natural classes, each based on a different feature system. For that of Jakobson & Halle (1956), he gives the class of [α consonantal, α compact]. For that of *Sound Pattern of English* (Chomsky & Halle 1968) he proposes [-anterior, -low], though he does not go into any particular detail about the nature of that definition of the class. However, in accomplishing this, Zwicky does not declare the matter solved, nor does he even seem to take any pride in making so significant a step. Rather, he reflects on the systems which allowed this class to be defined. In this reflection, Zwicky expresses significant concern that, rather than seeing the ability to group RUKI as a set as a strength of the system, it should be considered a weakness, a flaw resulting from too powerful a model. It should be noted that Zwicky does go on to acknowledge that the set he uses for RUKI, while it is technically valid in the system of Jakobson & Halle (1956), does not follow the pattern for any other set which had to that point been acknowledged. As he notes, natural classes in this system generally related features of the same type. Meanwhile, his definition for RUKI involved two types: [compact] is a ‘cavity’ feature, while ‘consonantal’ is a manner feature. Thus, while the Jakobson & Halle (1956) feature system does allow him to create the set, he was the first to use that particular combination of kinds of features, which he feels implies that the set is not as natural as the system might suggest.

Allen (1973) can in some ways be seen as an expansion of Zwicky (1970), taking Zwicky’s concern over the ability of a phonological system to group RUKI as a natural class to the next logical step: denial that RUKI is a set. In precise detail, Allen (1973) goes through several possible explanations of RUKI as a single process, and demonstrates the holes in those theories. As this was covered in Sections 2.2 and 2.6, it does not need to be repeated here.

Having dismissed the existing attempts to analyze RUKI as a single operation, Allen (1973) take a radical step: he argues that RUKI does not act like a set and cannot be grouped as a set, on

the surprisingly sensible grounds that it is not a set. Rather, since Sanskrit inherited only a single fricative from PIE, that sole fricative underwent a very natural process of place-assimilation. When a language has only one fricative, frication can become the only salient feature. The segment thereby becomes very susceptible to place-assimilation. In modern terms, this can be understood as the segment being underspecified for PLACE, since only the feature [continuant] matters. Once this is acknowledged, the development of the RUKI Sound Law can be understood as a telescoping of a much more complex process of initially independent changes.

Each member of the RUKI set, [r u k i], would trigger place-assimilation in the following fricative, resulting in [ʃ x ç]. A later process would then trigger the neutralization of the three variants, reducing them to a single form. In the case of Sanskrit, likely under the influence of the Dravidian languages and their heavy use of retroflexes, the single form chosen was [ʃ], with [x ç] disappearing. With the non-retroflex variants having been eliminated, all evidence of the intermediate stages would likewise disappear, leaving the impression of a single operation which changed /s/ into [ʃ] in four very different environments. This, then, would be the source of RUKI's strange nature. The reason we could not properly group the set because it was not, in the end, a real natural class. It was the product of several interacting processes which ultimately gave the impression of a natural class which had not existed at any point in the actual development of Sanskrit. This follows on quite naturally from the concerns expressed in Zwicky (1970) that we should be wary of a feature theory which neatly provides a natural class for RUKI, and comes to the same conclusion as that paper, namely that we simply should not try to understand RUKI as a single set undergoing a single rule.

There do, however, exist other analyses in the context of relatively modern linguistics for RUKI. Vennemann (1974) is something of a direct response to Zwicky (1970), accepting

Zwicky's concern about the definition of RUKI as a true natural class, but taking the opposite track from Allen (1973). Where Allen (1973) followed Zwicky and dismantled the RUKI class, Vennemann (1974) argued for an expansion of our understanding of possible natural class types. Vennemann (1974) uses the RUKI Sound Law as the basis for arguing for the existence of a *relative acoustic* natural class, being a set of sounds with similar acoustic effects. He posited that [r u k i], as a set, all caused an acoustic distortion in following fricatives. This distortion would have similar characteristics to retroflexion, and consequently could lead to language learners reinterpreting the segments as full retroflexes, rather than distorted dental fricatives.

Vennemann (1974) would receive empirical validation in Longerich (1998), which expressly set out to assess his claims. The fuller implications of this analysis will be left for Section 5.3, but for now it suffices to say that Longerich (1998) could well provide a solid vindication of Vennemann's (1974) proposal. Whether the phonological field as a whole should therefore accept the concept of relative acoustic classes, or whether the proposal requires more research before being solidly acceptable, is a question outside the scope of this present dissertation. Something important to note here is the incorporation of reinterpretation into the diachronic process. Relative acoustic classes can, by their very nature, only have an effect on sound change through the acoustic perception of a listener. The speaker is unlikely to notice the distortion in his own production. If such is supposed to be the trigger, then it must be distortion perceived by a listener, who must then interpret the distortion as a native characteristic of the segment.

In the same timeframe as Longerich (1998), Hall (1997) put forward his analysis using more conventionally phonological tools. This analysis has been discussed already in Section 2.2 and does not need much reiterating here. The important takeaway is that Hall (1997) argues that the situational trigger for what we understand as the RUKI Sound Law was the emergence of an

alveolopalatal fricative emerging from the historical palatalized velar stop. He argued that at the time there were only two other fricatives in Sanskrit, being the dental and a palatoalveolar. Since no language ever contrasts alveolopalatals and palatoalveolars, Hall (1997) argued that the palatoalveolar fricative was retroflexed in order to maintain contrast against the new alveolopalatal. While this present dissertation will not focus much on this matter, it will be brought up when we come to the I analysis in Section 6.3.2, and the value of contrast maintenance in shaping the RUKI Sound Law will be brought up. However, as will be discussed then, the elaboration of a contrast maintenance system for FGHS is beyond the scope of this dissertation.

5.2.1 The Segmental Inventory of Sanskrit

This section is intended to provide the clear phonological context in which the RUKI Sound Law operated. The inventory given here is adapted from Müller (1879), which gives an early system of transliterating Sanskrit into English, and information provided in Whitney (1884). I have adapted this system into modern IPA here for modern reference. Note that *Sacred Books of the East* covers more than just Sanskrit, and so not all the segments it provides transliterations for were actually part of Sanskrit itself.

The format used below is based on the structure of the modern IPA, but with small revisions intended to suit it better to this particular language. Most notably, aspirated stops have been entered in their own row, as opposed to being included with the unaspirated stops.

Table 2: Sanskrit Consonantal Inventory

	Labial	Dental	Retroflex	Palatal	Velar	Glottal
Stop	p b	t d	ʈ ɖ	c ɟ	k ɡ	
Aspirated Stops	p ^h b ^h	t ^h d ^h	ʈ ^h ɖ ^h	c ^h ɟ ^h	k ^h ɡ ^h	
Fricatives		s	ʂ	ç		h
Nasals	m	n	ɳ	ɲ	ŋ	
Approximants	v/w	l	r (ɽ)	j		

Some segments could not be properly represented in the chart above and are therefore explained here. First, there is the Visarga, an [h] which is derived from final [s r] (Whitney 1884). Since it does not seem to show any particular interaction with the RUKI Sound Law, it will be treated as a phonetic [h] just like the regular glottal fricative shown in the chart above. Sanskrit also has a place-variable nasal known as the Anusvara, which is assumed here to be a placeless [N].

All of the approximants shown here had a syllabic variant which is not enumerated here as it does not seem to matter in regards to the RUKI Sound Law. Nonetheless, for purposes of completeness it is mentioned here.

Something important to note is that there are four fricatives, five if we count the Visarga as something separate. As discussed in Section 5.2 and Sections 2.2 and 2.6 above, the analysis of Allen (1973) on which this dissertation is based requires that there be only one fricative in the language so as to justify wide-ranging place-assimilation. Thus, we must here point out that of the four primary fricatives, one is itself the RUKI reflex, and thus obviously would not have existed prior to the application of the Sound Law. The palatal fricative does not seem to come from the same source as the RUKI reflex, and seems to be a later development. Thus, at the early

stage when the RUKI Sound Law happened, there was only one fricative in place, save possibly for [h], which if it were in play at that time must not have been particularly relevant.

Next we will describe the Sanskrit vowel inventory, drawn from the same sources as above.

Table 3: Vowel Inventory of Sanskrit

i i:		u u:
e ai		o au
	a a:	

As we can note here, Sanskrit has a single low vowel (which simply participates in the length distinction seen across all the vowel spaces save for the mid vowels, which contrast a monophthong with a diphthong). The traditional description of the RUKI Sound Law varies somewhat in whether the mid vowels are considered to trigger it, or if they instead neutralize to high vowels before *s. Either way, we can see that RUKI is triggered by all vowels save for the sole low one.

5.3 Acoustics, Phonology, and Diachrony

Something which deserves a more particular focus is the analysis of RUKI by Longerich (1998). This Master's Thesis stands as a significant component of the RUKI literature, being seemingly the first attempt to test RUKI using modern methods and technologies. It stands out from previous attempts to analyze RUKI, which had been essentially theoretical in nature, focusing on feature definitions and other formal modes of analysis. Longerich (1998) instead turns to empirical data in an attempt to settle the debate. The short version, as this paper has already been discussed in Chapter 2, is that, using English speakers as a data source, Longerich (1998) found that indeed, the set of [r u k i] have distinct acoustic effects on following [s], being distortions which are not seen when compared to similar segments such as [l].

The Longerich (1998) analysis thus provides an excellent acoustic and phonetic explanation of RUKI. However, it remains something of an open question whether her analysis is satisfying from a phonological perspective. That is, the debate, especially in OT-based research, remains open as to whether or not the phonology has direct access to acoustic information. Now, it must be stated here that while FGHS holds that acoustics *per se* are not part of the phonological interface, the phonological component of language is absolutely affected by acoustics via lexical reanalysis. This does not, however, totally abdicate the responsibility to provide a phonological explanation for phonological problems: it is merely an acknowledgement that some changes happen outside the phonology, and in such cases the phonology must simply impose an order on it without having had a say in its development.

Longerich (1998) demonstrates a common acoustic effect of the RUKI set, albeit using English data which may not be wholly phonetically appropriate for dealing with a Sanskrit change. That is, when compared to a non-RUKI set of [l t p a ʌ ɔ], the RUKI segments caused “the presence of an initial noise frequency component below 3500Hz” (Longerich 1998). This is a strong finding in favour of the argument for relative acoustic classes. On the basis of this finding, she argues that the output of the RUKI Sound Law was probably something like /ʃ/ initially, with the daughter-languages later shifting it to their various reflexes based on their various needs.

Nonetheless, these findings are not necessarily the final word in regards to the phonological problem. From the perspective of theoretical phonology, the selection of [ʃ] in Sanskrit (or [x] in Slavic, etc.) must be the work of the phonology, rather than the acoustic character of these sounds. The acoustics could absolutely trigger reanalysis of *s into some other fricative, as Longerich (1998) demonstrated. Something her analysis does not neatly account for is the fact

that the various RUKI reflexes across the Satem languages are drawn from the set of fricatives which would result from simple place-assimilation by one of the RUKI members (Allen 1973). This clearly implies the involvement of purely phonological machinery, for the selection of phonemes and allophones is the defined domain of phonology.

This would seem to be an acceptable model for structuring the relationship between acoustic data and the purely mental processes of phonology. In such a system, the acoustics provide information which must be processed down to units of meaning, and, importantly, provide the data on which language learners construct their acoustic definitions for various phonemes and allophones. Through this acquisition, acoustic data can trigger reanalysis between generations, which leads to the learners acquiring a different underlying representation from their parents. This causes changes which the phonology must deal with, regularize, and process, but which were not in themselves of phonological origin.

5.4 A Statistical Assessment of RUKI

The key trouble in regards to analyzing the RUKI Sound Law, as discussed above, is that the conditioning environment, of preceding [r u k i], does not form a natural class in traditional terms. If we put aside the *relative acoustic* natural class proposed by Vennemann (1974) and supported by Longerich (1998), then we are left with a difficult question indeed. There is, however, another option not presently discussed in the literature: that, from a logical perspective, the RUKI set is an accident, or to put it another way, that RUKI forms not a natural class, but what might be called an ‘accidental class’.

The proposal here is straightforward: as noted by both Zwicky (1970) and Allen (1973) attempts to define RUKI as a class according to phonological characteristics have routinely encountered troubles where they have not outright failed. Nonetheless, there must be something

common across them in order to explain why they pattern together with respect to the RUKI Sound Law. What I propose is that phonologists have, entirely reasonably, been looking at the issue from the wrong angle: that the RUKI set is united not by their internal characteristics, but by their external distribution. That is, that the RUKI set can be defined as the set of segments which could both precede /s/ and were able to leave a visible sign of assimilation.

Consider the analysis of Allen (1973), which in summary noted that when a language has only one fricative, said fricative will be very flexible in its place of articulation. It will commonly assimilate to a surrounding place in order to facilitate easier pronunciation, since frication is the only salient feature. This indeed forms the basis of Allen's (1973) analysis of RUKI as separate changes which were later unified, the analysis on which this present study is built. If we accept this position, then it stands to reason that the single fricative, *s, of Indo-Aryan would regularly engage in place-assimilation in Sanskrit. This variably assimilated fricative would seem to have originally passed by unnoticed by speakers until some later point, at which time the many variants were neutralized into a single allophone, which itself then later phonemicized.

Now this analysis falls immediately under a major criticism: if it were true, how would it explain the selection of [r u k i] alone as the triggers for the change? Surely therefore [ʃ], or other identifiable reflexes, should be widely seen in other environments, as the result of other assimilations. The answer to this forms the basis of my proposed 'accidental class': that the criticism is entirely valid in theory, but not particularly relevant to the data in fact.

Thus far in the literature, the discussion has focused on where [s] and [ʃ] appear. None that I have found yet, however, discusses the environments where neither appear. These non-RUKI environments reveal a surprising result: that the non-RUKI environments are irrelevant to the RUKI Sound Law. I do not mean that they reveal no interesting information, but rather that they

reveal interesting information in the absence they show. A sample of over 3000 Sanskrit words, discussed in more detail below, shows a staggering lack of [s ʃ] tokens which do not immediately follow segments from one of four categories: dental sounds; placeless sounds; RUKI sounds; and labial sounds. Now, this may at first seem like a strange way of categorizing the data, but it follows a certain very relevant logic.

If we assume for a moment that *s was subject to broad place-assimilation based on the preceding segment, then one of the first things that would be observed is that any segment which shared a place of articulation with the default place of *s would leave no evidence of any assimilation. A placeless underlying /S/ would simply assimilate to dental [s], and an underlyingly dental fricative would give absolutely no sign of any change, even if its place were deleted, since it would be assimilated back to the default it would have used anyways. A similar result would be found for any preceding segment which itself lacked place: either the pair of them would simply have to assimilate to something even earlier in the phonological string, or they would need to have the default place inserted directly. Regardless, both dental and placeless segments would therefore leave no visible evidence of assimilation.

In contrast the RUKI segments would of course leave evidence: the very evidence that has so far been the subject of all debate around the RUKI Sound Law. That is, we would expect that if *s were to undergo assimilation according to its preceding segment, that we would not find [s] after the RUKI segments following the sound change. This is therefore perfectly in line with all expectations and not worthy of further discussion at this present juncture.

The interesting part of this list is the labials, as Sanskrit has no labial fricative. This implies one of two scenarios: either there is an accidental gap, and it just so happened that Sanskrit never had any words with labial fricatives; or there was some high-ranking constraint to the effect of

*LABIALfricative which banned such from ever emerging. Given that in OT-based models, we prefer to explain as much as possible through the ranking of constraints, the latter situation seems the more likely, and this would easily explain why labial segments would fit into the group of four listed above. It was simply the case that any /s/ which followed a labial segment would be prevented from assimilating at the first step, and therefore would not be in a position to participate in the later neutralization, remaining dental in both cases.

Fascinatingly, the data explained below will show that, statistically speaking, [s ʃ] only rarely following segments other than [a] and the RUKI Set. There are some here and there, but given the sample size, they are vanishingly rare. This is a surprising revelation, but one which is key to the discussion in this section. If it is the case, as the data will show, that [s ʃ] functionally never appeared after these other places, then analysis of RUKI does not need to account for their exclusion. Their exclusion would not need to be phonological in a traditional sense: there would need to be no explicit rule or constraint which banned them from participating. Via what looks to be an act of historical accident, they are already excluded by the happenstance of the distributional state of Sanskrit. It is a fair and intriguing question to ask why this distribution exists, but that is beyond the scope of the present study. What matters at the present is that this distribution does exist, and would therefore necessarily shape the progress of any historical change. Environments which do not exist do not participate in changes, no matter how much they would match its conditions if they did exist.

Thus why I have called the RUKI set an ‘accidental class’ here: because when considering the above, the RUKI set consists of the sounds which were allowed to cause visible assimilation and were in a position to actually do so. It is a result not of common features, but of common

distributional patterns which themselves seem, in the absence of further investigation, to be a mere historical accident.

5.4.1 Methodology

All data was collected from MacDonell (1893), specifically the Amazon.ca reprint. According to the dictionary's Preface, it was intended to fill a gap in the literary market at the time, as there was no in-print Sanskrit-English dictionary available for learners and scholars. It claims that by the time of its publication at least three other such dictionaries had been published, but that it stood out for having "nearly double as much material as any of the dictionaries in question" and was "the only one of the four, [*sic*] which is transliterated" (MacDonell 1893). A sample of 3523 tokens was collected from the dictionary by hand over a span of several months, all performed by the sole author of this dissertation. The tokens were collected in alphabetical order based on the structure of the dictionary, though it should be noted that all tokens were word-internal in the data analyzed below, and in consequence the bias towards earlier-in-alphabetical-order initial segments did not significantly impact the data. The only effect which this selection had was the exclusion of [s]-initial and [ʃ]-initial words. Since all words were analyzed in isolation and therefore without reference to any preceding words, a necessary limitation given that the source was a dictionary, fricative-initial words were not directly relevant to the discussion of preceding environments and would have been excluded regardless. Nonetheless, a short discussion of the raw word-counts of [s]-initial and [ʃ]-initial words in comparison to each other is given later in Section 5.4.3.1.

All data was stored in a single Excel file, a modified version of which is attached as Appendix A.⁹ Each word was entered into the data in two columns: the first contained the

⁹ Due to space limitations, the full document could not be included. Unnecessary columns were deleted, leaving only the transcriptions, segmental tallies, and the RUKI Exceptions column (which was renamed to 'EX'. All dental

transcription as given by MacDonell (1893), while the second contained a conversion of that transcription into modern IPA. Each word was entered on its own row, with both transcriptions being in the same row as each other. *The Sacred Books of the East, vol. 1* (Müller 1879) was used to provide definitions of the symbols used in MacDonell (1893) and to thereby convert it to IPA. Some minor differences exist between the original text and the Excel file as regards the MacDonell transcriptions, largely arising from the nature of modern typing. Stress markers, which showed no sign of impacting RUKI and which have not been referenced in any discussion of the Sound Law, were generally omitted. Similarly, for most of the data, diacritics were replaced with similar symbols, generally placed after the segment the diacritic had been on: <^>, as in <a^>, was used instead of <â>; <.>, as in <n.>, was used instead of <ñ>; and in some cases <'>, as in <a'>, was used instead of <á>. As well, throughout the MacDonell transcriptions in the Excel file, <:> often stands for <:>. All of this was done to increase the efficiency of data collection, as it reduced reliance on copy-pasting the relevant symbols into the Excel sheet, or the switching between a normal English keyboard set-up and a digital IPA keyboard. The use of these substitution symbols did not seem to impair the purpose of the transcriptions for this analysis. For the IPA transcriptions a digital IPA keyboard was used, and all relevant symbols and diacritics were used in their proper place, save that stress was never marked.

After being thus twice transcribed, each word was analysed for the number of [s ʃ] tokens it contained, and which segments preceded them. Every RUKI fricative token in a given word was counted and entered as a whole integer in the relevant column. Thus, for a word which had one [s] token, a '1' was entered in the [s] column, while a word with two [s] tokens would have a '2'

segments were combined into a single column labeled 'Dental', while all labials were collected into a single column marked 'Labial'. Some preceding environments had very low token counts, and so were grouped into the 'Other' column: [s ʃ ç ɖ #]. All other preceding environments kept their own columns. As well, some transcriptions were broke up into multiple lines within a single cell in order to accommodate the available space.

entered in the same column. The same procedure was followed for those segments which immediately preceded the RUKI fricatives: the number for each preceding segment was tallied and then entered as a whole integer into the relevant column. Thus, for a word which had three [s] tokens, two of which were preceded by [a] and one by [t], a '2' would be entered in the [a] column, and a '1' in the [t] column. Calculations entered into the Excel file automatically kept a running tally of every numeric column, providing instant total counts for [s] and [ʃ] tokens, and for how many times either of them were preceded by a given segment. At the end of the row each word was marked for any of the following which applied: the count of any exceptions to the RUKI rule it contained; and the count of how many times there was a following [r], as this environment should block the application of the RUKI Sound Law. Regular checks were performed to ensure that the number of RUKI fricatives in each row was equal to the count of preceding segments. This was done using an Excel SUM function to tally the total counts for every segmental-numeric column. These were then checked using Excel's 'Search' function to find any odd numbers, and to check any even number greater than 2, in order to ensure that no segments were either missed or double-counted.

The raw counts of preceding environments were automatically collected into a running calculation which grouped them into a series of categories: dentals; placeless; RUKI segments; labials; and 'other', which contained any preceding environment which did not fit the previous, but which had too few tokens to justify a separate line. The collection was performed by the Excel SUM function, set to automatically tally the total count in each column.

Dental segments included [d t l]. While [s] is technically also a dental segment, its low token count and direct involvement as the subject of the RUKI Sound Law led to it being counted

separate in a subcategory of ‘Other’ along with [ʃ]. Note that the ‘dental’ category did not include [n], for reasons discussed below.

Placeless segments included [h n N a]. The inclusion of [h N] in this category is obvious, but [n a] require some explanation. In the data, due to ambiguities surrounding the underlying nature of [n], the segment was treated as being underlyingly placeless, with its dental PLACE node added later in production. Importantly, nasals in general seemed to generally follow cross-linguistically common patterns of nasal place assimilation, making it very likely that the Sanskrit [n] is underlyingly more of an archiphoneme-like [N]. How the surface-dental [n] and the Anusvara would be distinguished in their underlying representations is not entirely clear. It could be that [n] had a CORONAL node while the Anusvara did not, or it could be that they were phonemically indistinct. Ultimately, their strict featural definition is a matter for a more dedicated study. What matters for the present purpose is that in regards to the potential assimilation of *s, these two segments would have the identical functional effect of not triggering visible assimilation. The dental [n] was therefore counted with [N] in a single column. [a] was the only low vowel, and therefore considered to not have an underlyingly PLACE node. This assumption neatly explains why it did not participate in the RUKI Sound Law, as it had no PLACE node to spread during any assimilation process. As will be discussed in Section 6.3.5, this assumption does not entirely hold up in practice, and we will ultimately adopt the view that Sanskrit [a] had a bare V-PLACE node. Nonetheless, as it acts like the other placeless segments, it will still be counted among them for the purpose of this analysis.

As regards the counting of preceding segments, the following logic was used. In most cases, each preceding segment received its own column, in which a value would be entered so long as it exceeded zero. Any line which did not include a token for a given column was left blank as a

convenience, as blanks were treated as zeroes by the calculations. Length distinctions for vowels were ignored, on two grounds: the first, that no discussion of RUKI has made reference to length as a factor; and the second, that there was no apparent pattern in the sample data of length having an effect. Therefore both long and short vowels of the same quality were grouped together. As well, the Anusvara, which is a Sanskrit phoneme defined as a placeless nasal distinct from the surface-dental nasal, was grouped with the said surface-dental nasal [n], as both would produce the same effect upon following *s. That is, the surface-dental [n], treated here as being underlyingly placeless, would fail to produce any visible assimilation. Lastly, the Visarga and regular [h] were grouped together, as the Visarga seems to just be a phonetic [h] and both would have the same effect upon following *s.

Tokens which displayed a violation of the RUKI Sound Law as traditionally defined were marked as ‘RUKI exceptions’, with a running tally kept as with all other data in the Excel file. An exception was defined as any occurrence of [s] following a RUKI segment, or [ʃ] appearing in any context other than following a RUKI segment.

An admitted limitation of the methodology in this study was the duplication of morphemes with morpheme-internal tokens. For logistical and definitional reasons, it was not possible for this study to omit duplication of morphemes which contained *s tokens inside them. The key issue comes from the fact that this study was analyzing words, and the definition of a ‘word’ can be a tricky affair. It was not clear, as someone who is not deeply immersed in Sanskrit as a language as opposed to a source of data, when a duplicate morpheme should be included because it forms part of a meaningfully different word rather than excluded because it does not. Thus, to ensure that the maximum quantity of data was accounted for, duplicate morphemes were considered to form new words when attached to roots which had not yet been processed. This

certainly increased the count of certain preceding environments, but given the disparity in results which will be seen in Section 5.4.2, it does not seem likely that this would substantively change the overall analysis of the data.

Relatedly, this data is limited due to the nature of the collection method. By using a dictionary there is a risk of the data being somewhat unmoored in time and possibly comparing forms which never existed contemporary to each other. In comparison, using actual Sanskrit texts as a source would ensure that we were examining a specific language at a specific point in time. Furthermore, since this study collected data in an alphabetical order, it is possible that certain sequences are overrepresented due to being frontloaded in the source. However, while these are limitations, they do not seem fatal to the purpose of the study. The dictionary, while not a perfect source, provided a clean and straightforward collection of data on which to build the following analysis. Fundamentally, this study is focused on trends rather than specific numbers. Based on the data collected, as will be shown below, there are significant asymmetries in the data. It is not at all clear that further data would undo these trends. Thus, the data as collected is nonetheless useful for the role which this study plays in the larger analysis: demonstrating that certain environments do not need to be excluded from triggering assimilation by the constraint ranking, since they are already effectively excluded by the lexicon.

5.4.2 Data

The data collected consists of 3260 Sanskrit words containing 3523 tokens of [s] and [ʂ]. Of these tokens, there were 1896 [s] tokens and 1627 [ʂ] tokens, meaning that [s] made up 53.82% of the assessed tokens, and [ʂ] 46.18%. As these numbers imply, several words contained multiple tokens of the fricatives in question, in various combinations. All the numbers which

follow are based on token counts, without further reference to raw word count except as specified.

Of these 3523 tokens, 423 were considered to be exceptions to the regular application of the RUKI rule, constituting 12% of the data.. It should be noted, however, that these exceptions concerned only the distribution of [s ṣ], and not that of historical *s. While these exceptions have their importance, they do not impact the overall discussion at hand, which concerns specifically the environments in which *s could appear in Sanskrit prior to the RUKI Sound Law. The claim of accidental class is, after all, predicated in the idea that prior to the onset of RUKI, *s was distributed so as to produce the RUKI Set by historical accident. The results of that rule are therefore less important than the environments in which its subject could be found.

A total of 9 instances of a following [r] seeming to prevent the application of RUKI were found in the sample, forming 0.25% of the data. Since so few tokens were found, /r/-blocking will be excluded from further discussion here on the grounds of a lack of meaningful evidence to analyse. Presumably more tokens could be found with further data, and especially with the use of sentential data not available in a dictionary. However, that must be left to future research.

The total set of tokens can be organized according to which segment preceded the fricative. These preceding environments have been grouped for the purposes of analysis, and are as shown below. All percentages have been rounded to two decimal places.¹⁰ Any data which is shown in a sublevel is considered to be part of the macro-category it is under. All percentages are out of the total set of tokens.

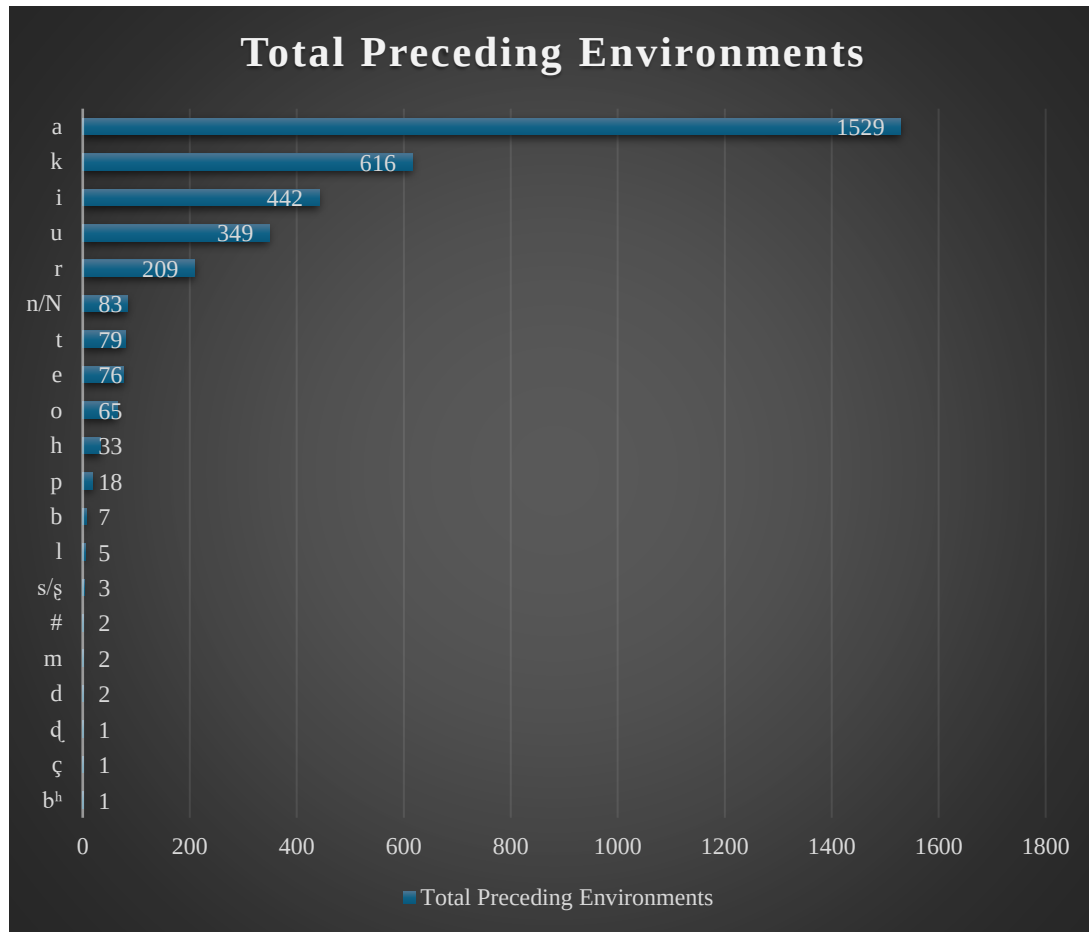
(94) Organized list of preceding environments of *s

¹⁰ Note that the percentage totals for the categories do not always quite equal the total of the percentage values given for specific segments. This is a function of rounding to two decimal places, as each percentage value given in this section was calculated independently. The category percentages can be taken as more accurate than the sum of segmental totals given here. See Appendix 1 for the full data.

1. RUKI set: 1757 tokens, 49.87%
 - a. [r]: 209 tokens, 5.93%
 - b. [u]: 349 tokens, 9.91%
 - c. [k]: 616 tokens, 17.49%
 - d. [i]: 442 tokens, 12.55%
 - e. [e]: 76 tokens, 2.16%
 - f. [o]: 65 tokens, 1.85%
2. Placeless/dental/labial: 1759 tokens, 49.93%
 - a. Placeless: 1645 tokens, 46.69%
 - i. [n N]: 83 tokens, 2.36%
 - ii. [h]: 33 tokens, 0.94%
 - iii. [a]: 1529 tokens, 43.40%
 - b. Dental: 86 tokens, 2.44%
 - i. [d]: 2 tokens, 0.06%
 - ii. [t]: 79 tokens, 2.24%
 - iii. [l]: 5 tokens, 0.14%
 - c. Labial: 28 tokens, 0.79%
 - i. [b^h]: 7 tokens, 0.20%
 - ii. [b]: 1 token, 0.03%
 - iii. [p]: 18 tokens, 0.51%
 - iv. [m]: 2 tokens, 0.06%
3. Other: 7 tokens, 0.20%
 - a. [ç]: 1 token, 0.03%
 - b. [s ʂ]: 3 tokens, 0.09%
 - c. [d]: 1 token, 0.03%
 - d. #: 2 tokens, 0.06%

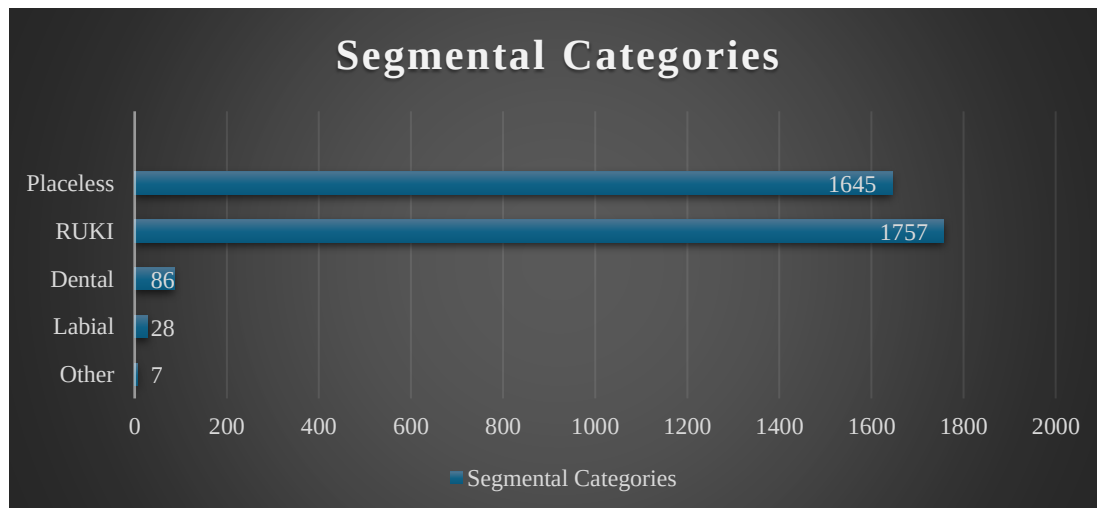
The above is given in the form of a list due to constraints of space: there are simply too many categories to provide a legible chart here. Thus, to make the numbers somewhat more understandable, a series of pie charts are provided below. The first simply covers the total data set. The design of the chart has been selected to maximize readability.

Table 4: *s distribution: total preceding segments



Next, we turn to compare the four broad categories shown in the list above.

Table 5: By Segmental Categories



These charts should give a clear sense of the distributional asymmetries in the RUKI data. For Table 4, we see that [a] constitutes almost half the total preceding environments, and is roughly 2.5 times the size of the next most common environment, [k]. For Table 5 we see that Placeless and RUKI preceding environments overwhelmingly dominate the chart, leaving only slivers for all other environments.

5.4.3 Discussion

From this data, several observations can be made immediately. The first is that while [s] was the more common of the two RUKI fricatives, it made up only slightly more than half the total tokens in question. The second is that there is a similar distribution of RUKI environments compared to non-RUKI environments, with RUKI segments making up 49.87% of the total preceding segments.

Digging into the finer details, the breakdown by particular preceding segments is quite striking. 43.40% of all tokens saw one of the fricatives preceded by [a], making it by far the single most common preceding environment in the entire data set. Indeed, its commonality accidentally inflates the importance of [h n N] due to falling into the same macro-category, as without [a] they only collectively comprise a mere 3.29% of the data. There are almost as many [a] tokens as there are total RUKI environment tokens, with [a] alone being 43.40% of the data compared to the 49.87% of the collective RUKI set.

Comparing [a] to the other non-RUKI environments and it quickly becomes apparent that there are clear distributional gaps for [s ʃ]. Other non-RUKI environments make up only 6.73% of the sample. Of this 6.73%, non-[a] placeless segments are the majority environment at 3.29%, followed by dental segments at 2.44%. This means that out of the 6.73% of non-[a], non-RUKI environments, 5.73% would be unable to trigger any visible assimilation. This leaves just 0.99%

of the data to fill the category of segments which are theoretically capable of causing observable assimilation. Of this 0.99%, 0.79% are labials, with 0.51% of that being [p]. This leaves just 0.20% of the overall dataset for the ‘Other’ category. We can therefore conclude that the non-labial, non-dental ‘Other’ segments are statistically irrelevant as preceding segments.

It must be made clear that the commonality of [a] as a preceding segment is not at all unexpected. That a vowel will precede a consonant is something quite normal across all languages. Rather, the emphasis here is not on how often [a] appears, but instead on how rarely anything else does. If we exclude [a], then *s only appeared after non-RUKI segments in 6.73% of assessed words. This is a strikingly low number when compared with how often it appears after RUKI segments. Even if we only compare consonants to consonants, [r k] are preceding environments for roughly 23.47% of the data in comparison. That is, *s in this data set appeared after RUKI consonants almost four times as often as it did for all other consonants combined. Now, it should be noted here that the [r] data may not be entirely accurate for this purpose, as there was a syllabic [r] in Sanskrit which is generally considered a vowel (Whitney 1884). However, the total [r] data in this study constitutes only 5.93% of the total data. Even if we removed it from consideration entirely here, [k] alone would stand at 17.49% against 6.73% for all non-RUKI consonants. We therefore see the striking asymmetry in the data, and from it can only conclude that many segments would not have participated in a general process of place-assimilation simply because those respective environments did not exist in any significant numbers.

5.4.3.1 [s]-initial and [ʃ]-initial words

In the discussion above, no direct reference has been made to findings in the word-initial environment. As noted above, this is because the source for the data, a dictionary, does not

provide preceding words for its entries, and so there is limited information to be gleaned from this. Nonetheless, it is worth briefly going over the numbers and what they say regarding this matter. It must be emphasized here that this subsection is not intended to provide any new revelations, as the data here certainly tells us nothing new. Rather, this digression here is simply intended to explain the raw findings from a major preceding environment which otherwise features very little in the primary analysis: word-initial position.

Now, as this section is a side topic from the main discourse, a different methodology will be used from the primary data analysis. Rather than counting every possible word, a method which counted every combination of root and affix which the dictionary provided, this section will only count dictionary headwords. That is, every word which gets its own entry in the dictionary is counted, even if there are multiple entries which look like they contain the same root morpheme. Variants within each entry, showing what would result from attaching different morphemes to the root, will not be counted. As will be shown, adding the extra polymorphemic words would not change the essential results, and so they were excluded.

The count of [ʃ]-initial words came to 31 entries. In terms of space, this came to about two-thirds of a page in the dictionary. The count of [s]-initial entries, in contrast, came to a total of 1929 entries across 51 pages. The first of those pages took up about a quarter of a page, having 3 entries, while the final page was likely about an eighth or less of a page, with 5 entries. The other 49 pages had an average of 35.4 entries per page. This gives a sense of just how asymmetrical these two groups are. The [ʃ]-initial words were able to fit 31 entries, with any given entry for either category potentially having one or dozens of variants listed within it. Meanwhile, there are not only roughly 62 times as many [s]-initial words, they on average would have about as many variants as the [ʃ]-initial words.

Overwhelmingly, therefore, more words begin with [s] than with [ʃ]. While this does not account for instances of RUKI which may have appeared contextually based on preceding words, it does strongly fall in line with what would be expected of [ʃ] as a phonemicized allophone: that it would be rare for it to appear word-initially, since it would need to either be consistently allophonically derived there, borrowed in from another language, or innovatively placed there in a novel word.

5.4.4 Analysis

The obvious conclusion to draw from this data is that there is an incredible bias in the data as regards the environments for *s. A mere 6.73% of tokens of *s do not come after either RUKI or placeless segments. Now, the data itself does not make clear why this is the case, and that in itself is certainly a tantalizing question. But it is ultimately secondary to the present discussion. Whatever is at the bottom of this discrepancy, whether it is truly historical accident, as this analysis will henceforth assume, or the result of some as-yet unclear restriction, what matters is that it exists. Overwhelming, *s in Sanskrit was distributed after either [a] or a RUKI segment.

This strongly supports the analysis of RUKI as an accidental class as opposed to a natural one. If *s was found relatively regularly after other segments, then the accidental class argument would quickly collapse. But that is not the case. Rather, *s overwhelmingly appears following either a RUKI segment or [a]. Of the other segments, most of them are [e o], which as has been noted throughout this dissertation could be considered RUKI segments themselves. The remaining few percent are overwhelmingly dental or labial. This asymmetry should strike us. We are not dealing here with a small difference, the indication that there may have been some small preference for *s to follow RUKI segments. Rather, there are entire categories of segments which were practically banned from preceding *s. Whatever the cause of this asymmetry,

whether it was truly just the happenstance of those word which happened to exist, or if it was the result of some more principled phonotactic constraint, the fact of the distribution is undeniable. It was simply not the case that *s appeared in meaningful numbers after non-RUKI, non-[a] segments. We are therefore left with a situation where those segments which could cause visible assimilation of *s and did so consists of practically just the RUKI set. The unassimilated [s] was overwhelmingly otherwise restricted to appearing only after [a], a segment which was not capable of causing visible assimilation in that fricative.

Now, the 0.99% of the data which comprises segments which could in theory cause visible assimilation of *s is worth some discussion. There are two key points to be made here regarding it. The first, though important, is little more than an observation of this category's size. Out of 3523 tokens, a mere 35 fit into this category. This alone speaks volumes to the distributional disparities which preceded the RUKI Sound Law. It is no wonder that none of these segments form part of the RUKI Set: they barely interacted with *s at all.

The second key point here is the breakdown of this already small category. Out of the 35 tokens here, 28 of them, 0.79% of the overall dataset, are labial segments. As noted above, the overall lack of a labial fricative of any sort in Sanskrit implies a high-ranking constraint to the effect of *LABIALFRICATIVE, which would have interfered with any attempt at assimilating *s in that environment.

The conclusions from this data are, therefore, quite overwhelming. An incredible 99.01% of the data fit neatly into the accidental class analysis. All these environments are either part of the RUKI Set, and therefore must have had *s following, or would be expected to not show any visible sign of assimilation regardless of whether a broad change operated on them or not. That there are exceptions on where [s] appears as opposed to [ʃ] is no particular problem to this

analysis, except insofar as all formal phonological analyses, whether constraint-based or rules-based, have problems with the residue of real-world sound changes. Fundamentally, phonology is concerned with systems of interaction, and the sociolinguistic factors which drive the spread of changes through a language, or fail to completely spread it, remain in the same place they always have: as their own discussion, apart from the formal analyses themselves. What matters for this present discussion is simply the distribution of *s and its reflexes. This distribution holds strong for the accidental class analysis.

The matter of whether the distribution of *s is accidental or systematic is fascinating but ultimately irrelevant to the present study. If it is accidental then there is simply no challenge to the current analysis, as the present claim is that RUKI emerged from accident. If it is the result of some underlying systematic ban, then it is also no challenge, though it is certainly a much more interesting topic for future research. Whatever system prevented *s from appearing outside the above-discussed contexts must necessarily predate the RUKI Sound Law itself, and therefore cannot be part of the Law. It would be like a region which was beset by floods. There may be good reasons why flood walls and dams had been erected in some places but not others, but those reasons themselves would not explain why some regions suffered more flood damage than others. Rather, it is the dams and walls themselves which would explain the relative damage. The situation here is similar: the reasons why *s had the distribution it did are important and worth discussing, but are not themselves the direct explanation of the pattern.

5.5 Future Research

Obviously, the data above, while substantial, is as of yet incomplete. Two major tasks remain in regards to this project. The first is to perform a more comprehensive analysis of [s]-initial and [ʃ]-initial words, with a particular eye towards why the [ʃ]-initial words exist at all, given the

origin of [ʃ]. The second outstanding task is to complete the overall analysis of the dictionary. The data as it stands is not yet complete, and while it seems very unlikely that further data would alter the trends discussed above, it is certainly worth investigating to be sure. As well, further quantity of data may shed light on some of the edge cases and rarities observed in the collected data. As it stands it is difficult to say much of interest about the interactions of [ʃ] with palatals, as the raw numbers available are so small. While this lack of data serves well in supporting the ‘accidental class’ analysis proposed here, it does mean that discussion of the palatal-*s interaction itself remains outside the realm of reasonable discussion. The same holds true for other preceding segments which were simply too rare in the data to support meaningful analysis beyond the fact of their rarity. Further data could either provide the sheer numbers required for analysis, thereby allowing further testing of the ‘accidental class’ analysis, or could prove still far too few. This latter outcome would be most fascinating in some ways, as it would strongly support the ‘accidental class’ analysis by unequivocally demonstrating the absence of *s from those environments.

5.6 Conclusion

Fundamentally, the RUKI Sound Law does not operate on a conventional natural class. Two options are therefore available: we must either accept the concept of a *relative acoustic* class as per Vennemann (1974) and Longerich (1998), or we must accept the concept of an *accidental* class as outlined above. Certainly, the accidental class analysis has clear accordance with the data, as a mere 0.99% of the sample does not fall into the category of either being attested as triggering RUKI, or being contextually unable to leave any evidence of place-assimilation. If there was general place-assimilation of the singular fricative *s, and that *s simply never appeared outside of these contexts, then the strange RUKI Set is exactly what we would expect

to see. The set of “those segments which could leave evidence of assimilation and were in a position to cause it” would fall directly to RUKI. This strongly demonstrates that it was distribution which made RUKI a set, rather than some elusive common feature. It was not the internal phonology, but rather the external lexicon which determined the path of RUKI in this sense. In the same way that loanwords are not subject to sound changes which occurred before they were borrowed, words and environments which did not exist in Sanskrit did not participate in the general process of place-assimilation that the RUKI Sound Law was derived from.

6. Analysis

6.1 Introduction

This section will focus on the analysis proper of the RUKI Sound Law, based on the Diachronic FGHS model which this dissertation has thus far been focused on explaining. This analysis follows the principles of (Allen 1973), arguing that the RUKI Law is in essence an illusion, being the levelling of multiple separate processes into a unified output. That is, as per Chapter 5, the RUKI set does not appear to be a natural class because, in fact, it is not one. Rather, it is an accidental class, wherein each member engaged in normal place-assimilation processes, the reflexes of which were later neutralized into a single, common output. As discussed in Chapter 5, there was a surprisingly small set of segments which ever actually appeared before /s/ in Sanskrit, which conveniently explains the lack of segments which engaged in the overall RUKI phenomenon. Important to the entire analysis is the fact that *s, being the only native fricative, would have been incredibly susceptible to place-assimilation. This is best represented by being underlyingly placeless, as that would allow simple constraint rankings such as HAVEPLACE >> DEP to drive the spreading of place. It must be noted here that the placeless /S/ would seem to be distinct from /h/, as /h/ did not participate in RUKI. Due to its necessity for other reasons, discussed below, it will be assumed that the difference between /S/ and /h/ in Sanskrit is that /S/ was specified for [-sonorant], while /h/ was not. Thus, /S/ functioned as the sole historical fricative phoneme, while /h/ filled other roles in the system.

As regards the members of the RUKI set, this analysis proposes four separate developments, listed below. Note that for reasons of phonetic accuracy, the retroflex [ɽ] symbol is used for the Sanskrit rhotic in this analysis, as opposed to the conventional <r>.

- (95) $\text{t}\underset{\text{R}}{\text{s}} \rightarrow \text{t}\underset{\text{R}}{\text{s}}$
 (96) $\text{u}\underset{\text{R}}{\text{s}} \rightarrow \text{u}\underset{\text{R}}{\text{s}}^{\text{V}} \rightarrow \text{ux} \rightarrow \text{u}\underset{\text{R}}{\text{s}}$
 (97) $\text{k}\underset{\text{R}}{\text{s}} \rightarrow \text{kx} \rightarrow \text{k}\underset{\text{R}}{\text{s}}$
 (98) $\text{i}\underset{\text{R}}{\text{s}} \rightarrow \text{i}\underset{\text{R}}{\text{s}}^{\text{j}} \rightarrow \text{i}\underset{\text{R}}{\text{ç}} \rightarrow \text{i}\underset{\text{R}}{\text{s}}$

In prose terms, the R component, being already retroflex, is easily explained in terms of regular place-assimilation: R spread its C-CORONAL node to the placeless fricative, naturally producing a retroflex fricative. The U component spreads a dorsal V-PLACE specified for [+back] which triggers secondary articulation on the fricative. The secondary articulation is reanalyzed as a primary articulation, after which it undergoes the insertion of a CORONAL node to shift to retroflex. The K component is initially simple place-assimilation like with R, which later undergoes neutralization to [ç] via an intermediate two-place segment. Lastly, the I component is similar to the U process in that it spreads its [-back] V-DORSAL node to the following fricative. This leads to reanalysis of a palatalized fricative into a fully palatal one, and a later neutralization process shifts it to being retroflex.

This chapter also demonstrates the importance of language acquisition to diachronic study, by showing how reanalysis can explain otherwise mechanically strange changes to phonological structure. At several stages in the /i/ and /u/ analyses reanalysis will be invoked to explain changes which are otherwise difficult to model in a Clements & Hume (1995) model of feature geometry. The implications of involving inter-generational reanalysis will be discussed in more detail in Chapter 7.

6.2 Constraints

The following constraints will be used in this analysis.

- (97) *SEGMENT: assign a violation mark for every instance of the noted segment
 (98) HAVEPLACE: assign a violation mark for every ROOT node which is not connected to a PLACE node

- (99) NO LINK: assign a violation mark for every association line which does not have a correspondent in the input
- (100) IDENT[distributed]: assign a violation mark for every [distributed] feature which has a specification which does not match its correspondent in the input
- (101) IDENT[anterior]: assign a violation mark for every [anterior] feature which has a specification which does not match its correspondent in the input
- (102) IDENT[back]: assign a violation mark for every [back] feature which has a specification which does not match its correspondent in the input
- (103) DEP: assign a violation mark for any entity in the output which does not have a correspondent in the input
- (104) MAX[C-Place]: assign a violation mark for every C-PLACE node in the input which does not have a correspondent in the output
- (105) MAX LINK: assign a violation mark for every association line in the input which does not have a correspondent in the output
- (106) *DOUBLE CONSONANTAL ARTICULATION (*DCA): assign a violation mark for every C-PLACE node which dominates more than one specified PLACE node

Some comments on the nature of these constraints are in order. The first note is also simplest, being that ‘*SEGMENT’ will not appear *per se* in the analyses to follow. Rather, there are a variety of constraints, each of which ban a specific segment, which will be used in their appropriate places. Since they all function the same, simply having different segmental targets, their definitions were condensed here for more convenient reading. The *SEGMENT constraints primarily exist to explain patterns of segmental inventory, and to show a language’s preferences when confronted with multiple possible segmental candidates. As with all constraints, they are of course not absolute, and a segment which is banned by a *SEGMENT constraint could potentially still surface. It is also possible, due to these ultimately being separate constraints which can be ranked relative to each other, for a derivation to serially satisfy these constraints one at a time, slowly shifting through several intermediate candidates before finally reaching the surface-attested output. Note that in this analysis, *SEGMENT targets specifically the segment it lists: a segment which has some modification, such as double articulation or secondary articulation, is not considered to violate the constraint.

The constraints HAVEPLACE and NOLINK are both relatively self-explanatory. HAVEPLACE requires all segments to have place nodes. More specifically, it requires that every ROOT node have an association line connecting it to some PLACE node. Note that it does not specify what kind of PLACE node: both V-PLACE and C-PLACE nodes can satisfy the constraint. Equally, it can be vacuously satisfied through ROOT-deletion. The constraint NOLINK is intended to prevent the shifting of nodes from one association to another, and to prevent shared nodes disconnecting from some of their associates. It is not *per se* violated by the deletion of nodes themselves, but more the deletion of the association of nodes which continue to exist in the candidate. So, for example, if there is a C-PLACE node which is shared by two ROOT nodes, and a candidate proposes that it only continue to be connected to a single ROOT node, then NOLINK would be violated.

MAXLINK can be considered the reverse of NOLINK: it serves the purpose of preventing established association lines from being deleted. It does not itself play much of a role in the procession of the analysis, but it brought up to show that it must be low-ranked for some of the following derivations to function.

IDENT[BACK], IDENT[ANTERIOR], AND IDENT[distributed] are all classic Ident constraints which do not particularly need explanation here. They functions the same as all other standard Ident constraints. In this analysis, it is used to explain various patterns in feature change preferences which will be explained as they become relevant.

Likewise, DEP is simply the same conventional DEP commonly used in OT models. Specifically, this analysis will use two primary DEP constraints: DEP[C-PLACE] and DEP[V-PLACE], which will be ranked separately from each other. This is necessary, as will be shown in

Section 6.3.5. MAX[C-Place] is the conventional MAX constraint, though in this analysis it is only used in regards to Place nodes.

Lastly, there is *DOUBLECONSONANTALARTICULATION, shortened to *DCA throughout. This constraint has both a broad and a specific role. Broadly, it represents the crosslinguistic trend against the use of doubly-articulated consonants. While [w] is relatively common, other double articulations are rather rare, which implies that there is some constraint which is violated by their existence. More specifically, *DCA here is used as part of the [k] and [u] analyses to help explain how dorsal fricatives following dorsal segments could become retroflex. The explanation which will be shown involves an intermediate period where the fricative is both velar and retroflex, allowing it to avoid censure by *x. *DCA will thereafter be used to justify the deletion of the original C-DORSAL node.

In the analyses to follow, there are broadly speaking two constraint rankings in use. The first represents the ranking for the earlier Sanskrit speakers who underwent the proposed general place-assimilation process. The second ranking represents a new ranking adopted by some later generation, wherein all fricatives except for [s ʂ] become banned.

(107) First Sanskrit Constraint ranking

HAVEPLACE>>DEP[V-PLACE], DEP[C-PLACE]>> NoLINK>>IDENT[back]>>
IDENT[anterior]>>IDENT[distributed]>>*ʂ, *sʲ, *sʷ, *DCA>>*ç, *x

Something important to note for the first ranking is that the relative ranking of *ʂ against *sʲ *sʷ is unknown, as they never interact in this analysis. Indeed, it is entirely possible for *ʂ to be ranked down with *ç and *x. However, it must be the case that *sʲ and *sʷ respectively outrank *ç and *x, and so the ranking above is given.

(108) Second Sanskrit Constraint Ranking

*ç, *x >> *s^j >> HAVEPLACE >> DEP[V-PLACE], DEP[C-PLACE] >> NoLINK >> IDENT[back] >> IDENT[anterior] >> IDENT[distributed] >> *ç, *s^j, *DCA, MAX[place] >> MAXLINK

In this ranking we see that *ç and *x become more highly ranked relative to the first ranking. This is what will drive the neutralization to [ç].

6.3 Proposed Analysis

The analysis will be broken up into four processes, as dictated both by the data, and by the requirements of the model. It should be noted that the ranking of the *Segment constraints is to some degree estimated rather than assured. Since they are concerned only with telescoped or invisible steps, it is difficult to know for sure where each one should sit in the overall ranking: that is, generally speaking, their exact position may vary by a few places without issue for the analysis. Note further that the following analysis assumes a high-ranking MAX[ROOT] constraint which prevents deletion from being a default solution.

6.3.1 The R analysis

The R components of RUKI is the simplest to analyze, being a straightforward case of PLACE-assimilation. Assuming that the driving constraint behind RUKI, HAVEPLACE, outranks DEP and NoLINK, then the analysis would go as follows:

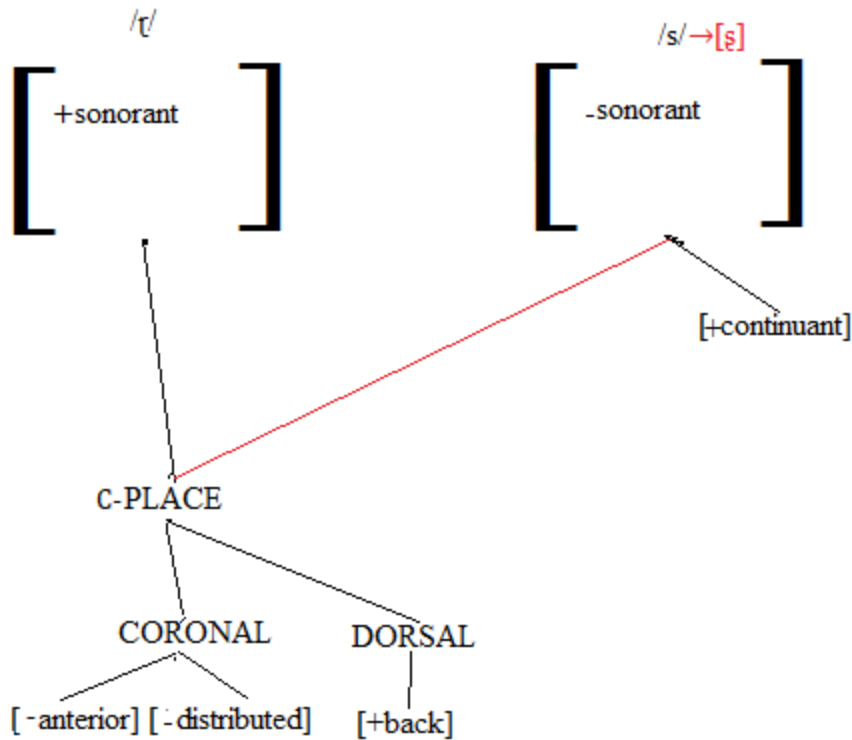
(109) Step 1: Retroflexion

/ɽS/	HAVEPLACE	DEP[C-PLACE]	NoLINK	*ç
a. ɽS	*!			
b. ɽɕ		*!		
→ c. ɽç			*	*

In Step 1 the underlying /S/ violates HAVEPLACE, as shown through Candidate (a). This necessitates the attachment of some PLACE node to /S/. Broadly speaking there are two options: either a PLACE node must be inserted, or an existing one must be borrowed. Candidate (b) represents the first option, here using a default dental C-PLACE, though any CORONAL node

would technically suffice. Since it violates DEP, it is eliminated in favour of Candidate (c). This candidate violates NO LINK and * $\text{\textsubscript{\$}}$, but since these are lower-ranked it wins out, resulting in the structure shown below.

Figure 19: Diagram of Step 1



Note that here we have defined [ɽ] with a Dorsal node bearing a [+back] specification. This is based on the arguments, discussed in Section 2.3, that retroflex segments should be considered coronals with a [+back] specification (Arsenault 2008, 2009; Hall 1997; Hamann 2002, 2003). While this does not play much role in the current analysis, it will become increasingly important throughout much of the remainder of this chapter.

(110) Step 2: Convergence

$\text{\textsubscript{\$}}$	HAVEPLACE	DEP[C-PLACE]	NO LINK	IDENT[distributed]	* $\text{\textsubscript{\$}}$
→ a. $\text{\textsubscript{\$}}$					
c. $\text{\textsubscript{\$}}$				*!	

In the second step there is no real room for further improvement. It is possible to change the [distributed] feature and make the fricative dental, but this provides no improvement due to Ident[distributed]. Thus, the derivation reaches convergence. The simplicity of the R-sequence is thereby seen, explained by the addition of a single association line. The other analyses, however, will require more complex solutions.

6.3.2 The U analysis

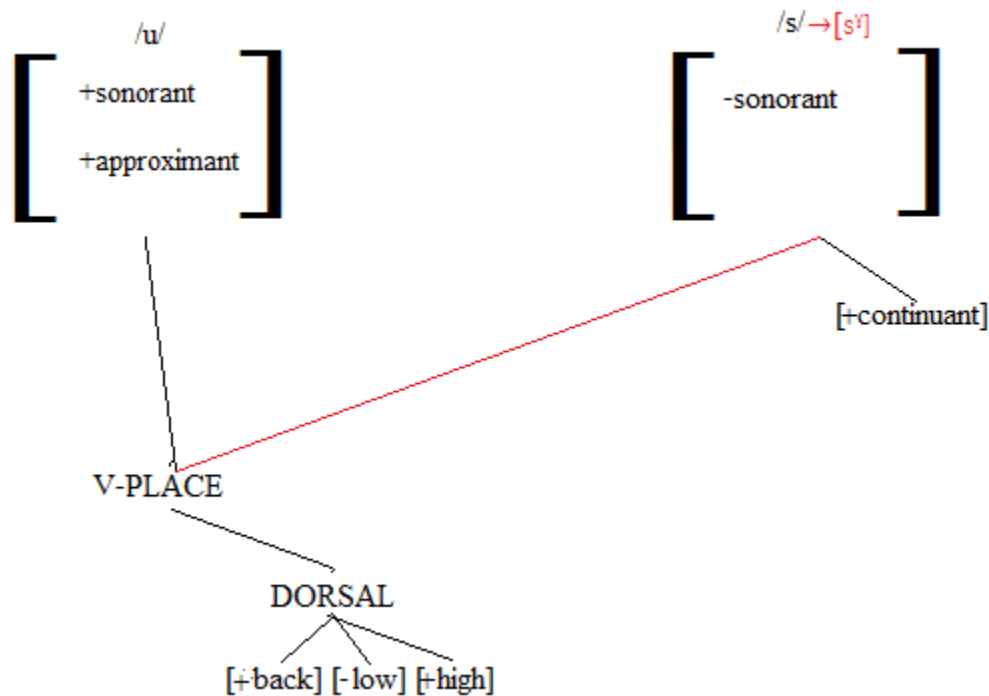
The U analysis will now follow, showing the use of intergenerational reanalysis in FGHS, though it starts in the same place as all the others, with a simple instance of place-assimilation.

(97) Step 1: Velarization

uS	HAVEPLACE	DEP[C-PLACE]	NO LINK	*X
a. uS	*!			
→ b. uS ^y			*	
c. uS		*!		

As with the R analysis, the initial step is simply an assimilation effect. Now, this is where the analysis begins to differ in form from R: the result here is not a fully-PLACE-assimilated segment, but a secondarily-articulated fricative. In fact, this segment, as indicated by its representation in the tableau, will have a dental C-PLACE node inserted prior to pronunciation. This does not violate DEP because it is not a phonological insertion: it is a product of the phonetics interface, as discussed in Chapter 3, and thus not subject to the constraint ranking. HAVEPLACE immediately eliminates the fully faithful candidate (a). Thus, like with R, the contest is between the insertion of some C-PLACE node, here assumed to be a default dental, and the spreading of a preceding PLACE node. Candidate (c) represents the insertion option, and is eliminated by DEP. This leaves Candidate (b). Note that Candidate (b), if immediately sent for pronunciation, would be pronounced as [isʲ] due to feature-filling rules defining /S/ as [s].

Figure 20: Diagram of Step 1

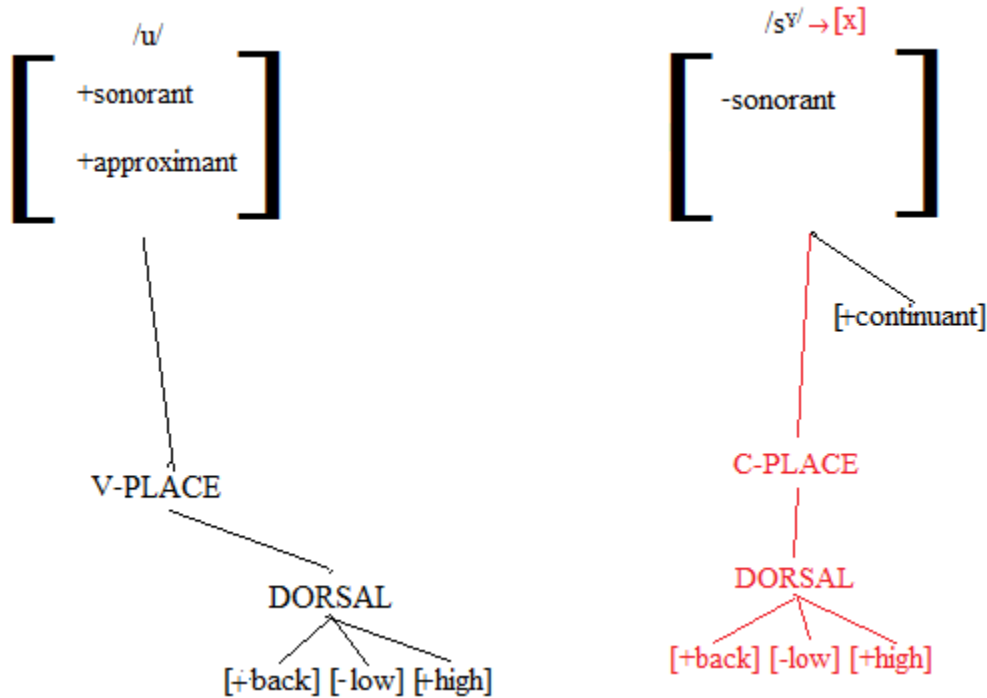


There must be a reanalysis stage wherein the link to the V-PLACE node is removed and an independent C-PLACE node is inserted into the fricative. This would result from learners misinterpreting the velarization on the fricative as indicative of primary PLACE, rather than a secondary characteristic. This is not itself a function of the regular phonology, but rather of the acquisitional phonology of a language learner. Phonological information would be applied in selecting a structure, but that information would be limited to whatever the learner in question had acquired by that point, in addition to whatever universal linguistic inheritance was available.

To be clear, reanalysis like this is not something that a speaker does: it is a way by which we describe language learners acquiring a different representation from adult speakers. It is in fact better to say that the fricative simply has a new velar C-PLACE node inserted, though this is not quite right either. Rather, the situation is best described as the learners constructing a fully palatal segment from an input which is itself merely palatalized. There is not, strictly speaking, a ‘change’ here: there are two different analyses of the same acoustic data, with the different

analyses being favoured by different groups of speakers. This results in a change between generations, but no individual speaker has made a change in terms of his or her own grammar.

Figure 21: Diagram of Reanalysis



Thus we come to the final stage, which begins with the reanalyzed fricative as a new underlying representation for a new generation. At this point we return to normal HS derivation, as the intergenerational reanalysis is finished.

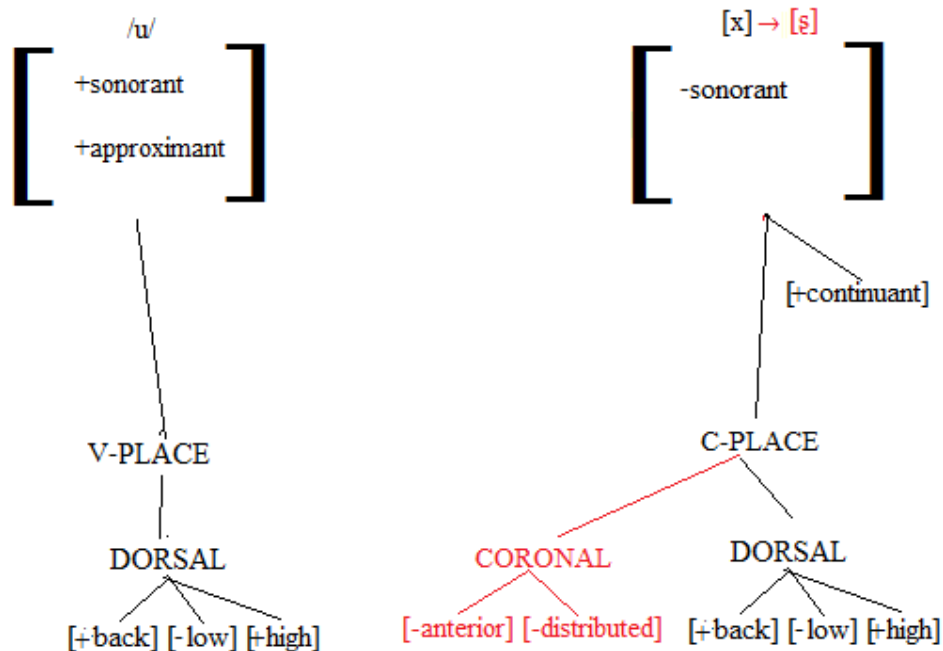
(98) Step 2: Retroflexion

ux	*x	HAVEPLACE	DEP[C-PLACE]	NO LINK	*DCA	*ʂ
a. ux	*!					
→ b. uʂ			*		*	
c. uS		*!				

With the reanalysis complete, we finally come to the retroflexion itself. With a ban on [x] emerging, there is a shift towards the retroflex via the insertion of a CORONAL C-PLACE. PLACE-deletion to [S] is blocked by HAVEPLACE, and so insertion of the new C-PLACE node is preferred. Due to the reanalysis, it is entirely possible to transition into a full retroflex in a single operation by simply inserting a CORONAL node specified for [-anterior, -distributed].

Now, the question of why a retroflex CORONAL node would be selected rather than a dental one is not entirely understood given the present model. There must be some system maintaining contrast between this fricative and the default dental [s], but how such a constraint would operate at this stage is unclear. It is likely from the typological research discussed in Chapter 2 that retroflex was selected in order to maintain contrast between the RUKI reflexes against the alveolopalatal reflex on the one hand, and the dental fricative on the other. Furthermore, for both this analysis and the follow U Analysis, it is rather likely that there is some constraint which would prefer retroflex to dental here, as retroflexes require a DORSAL node anyways, while a normal dental segment would not include one. Nonetheless, at present the development of a system of contrast maintenance constraints for FGHS is beyond the scope of this dissertation. Thus we come to the structure shown below.

Figure 22: Diagram of Step 2



The next step is convergence, as no further improvements can be made. The dental fricative would never be available as a candidate due to Gradualness, as a regular dental both does not

have a DORSAL node and is furthermore two Coronal features different from retroflex, thus leaving no further candidates which could provide harmonic improvement.

6.3.3 The K analysis

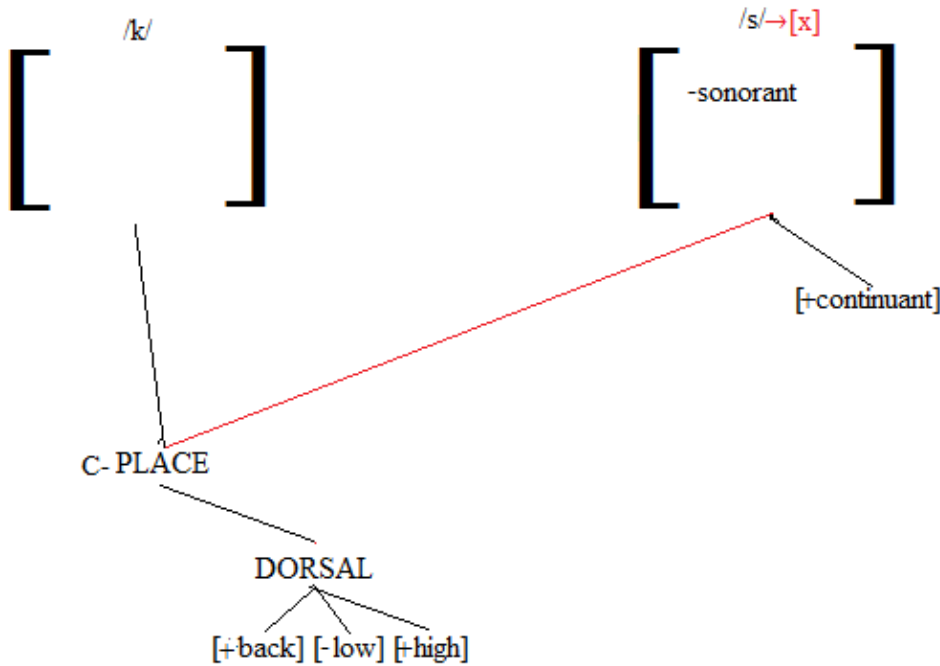
The analysis of the K requires us to again examine some of the finer points of our featural representation. Before we attend to those, however, we should first cover the first step.

(99) Step 1: Velarization

kS	HAVEPLACE	DEP[C-PLACE]	NOLINK	*DCA	*x
a. ks		*!			
→ b. kx			*		*
c. kS	*!				

This step represents the involvement of [k] in the general place-assimilation process which seems to have been the origin of the RUKI Sound Law. Once again, HAVEPLACE drives assimilation to the preceding segment, and DEP ensures that association to a pre-existing PLACE node is preferred over the insertion of a new one.

Figure 23: Diagram of Step 1



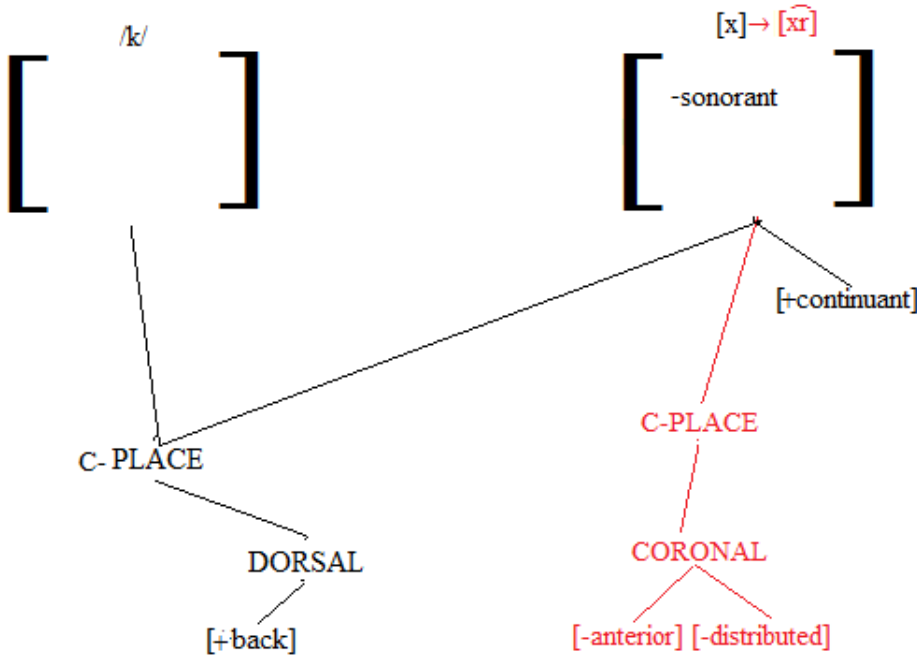
Thus we come again to a generational shift. Since we have no V-PLACE to be concerned with, we can skip over the reanalysis of featural representations, and proceed directly to the reranking of constraints. Like with the U analysis, neutralization is driven by the *x constraint, representing a ban on dorsal fricatives.

(100) Step 2: Retroflexion

kx	*x	HAVEPLACE	DEP[C-PLACE]	NoLINK	*DCA	*ξ
a. kx	*!					
→ b. kxr			*		*	
c. CS		*!*				
d. kS		*!		*		

Thus, the second step results from a ban on [x], now reranked between generations to outrank DEP, which now necessitates further change. The solution is to insert a new place node, such that the segment will no longer technically qualify as [x]. The resulting segment has a single ROOT node which connects to two C-PLACE nodes, and is represented by the symbol $[\widehat{xr}]$. This is represented in Figure 25 below.

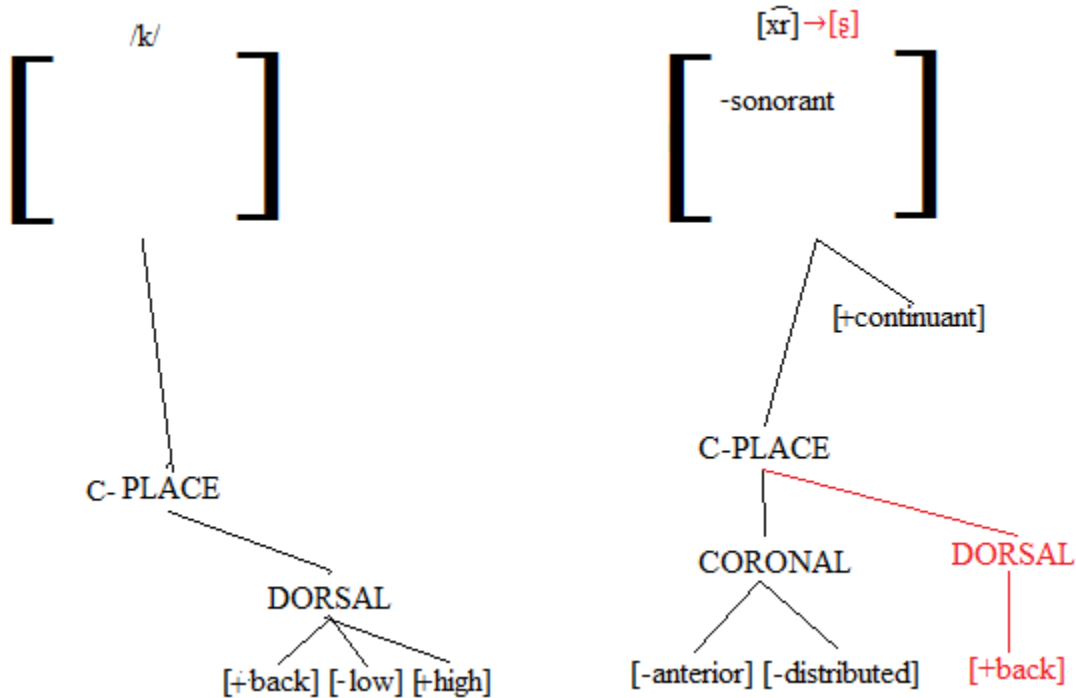
Figure 24: Diagram of Step 2



Given the assumptions at play in the current model, there are two ways we can understand this segment. The first would be to assume that we must treat this as a doubly-articulated consonant, as it has two C-PLACE nodes. In this analysis, assuming that double articulation is neither typologically common nor particularly desired in this analysis, we would next need to find a way to delink these two segments while maintaining the [+back] specification on the fricative. The alternative would be to interpret this segment as functionally indistinguishable from a regular retroflex, as it shows a single ROOT node which links to both a DORSAL node and a CORONAL one, with the necessary feature specifications for the retroflex place of articulation.

This second analysis is certainly a bit strange, as it does not provide a good reason for these two C-PLACE nodes to not collapse into one, save for the fact that we know the [k] did not become retroflex itself. However, we do have access to a tool which could resolve the matter. If we follow this assumption that $[\widehat{xr}]$ is functionally indistinct from $[\xi]$, then we could expect reanalysis to solve this particular problem. That is, we would predict a first generation which reached convergence after the step above, and thereby produced a fricative which linked to two separate C-PLACEs, and then some later generation which reanalyzed the fricative as an organic retroflex, without any link to the preceding [k]. This would leave us with a final structure as seen below, with a [k] followed by a standalone, fully retroflex $[\xi]$ as seen in Figure 25 below.

Figure 25: Diagram of Reanalysis



There would be no further steps, as there is no further need for any changes. Thus, we can now turn to the most complicated of the analyses.

6.3.4 The I analysis

The I analysis brings us to the close of the RUKI analyses proper. As with the entire set, it begins with PLACE-assimilation, but now must contend with explaining why this assimilation eventually resulted in retroflexion.

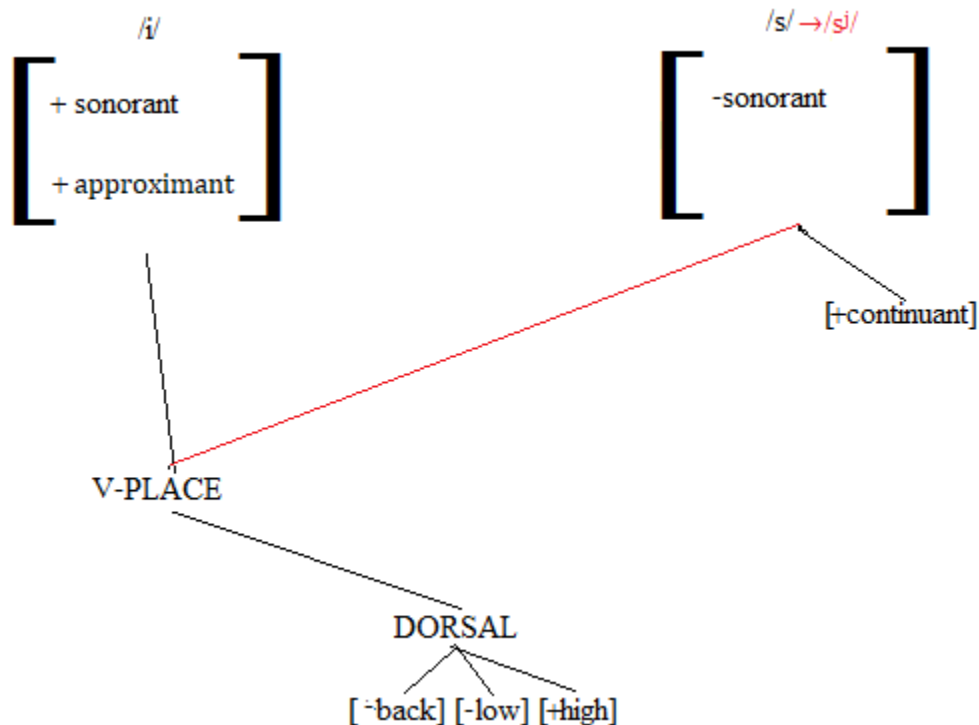
(101) Step 1: Palatalization

/iS/	HAVEPLACE	DEP[C-PLACE]	NO LINK	* _S ^j
a. iS	*!			
b. i _S		*!		
→ c. i _S ^j			*	*

At the first step, the vocalic DORSAL node spreads to the placeless non-sonorant fricative, which results in the phonetics interface later inserting a dental C-PLACE node. This leads to a

palatalized dental fricative being pronounced. The fully faithful Candidate (a) violates HAVEPLACE and is immediately eliminated.

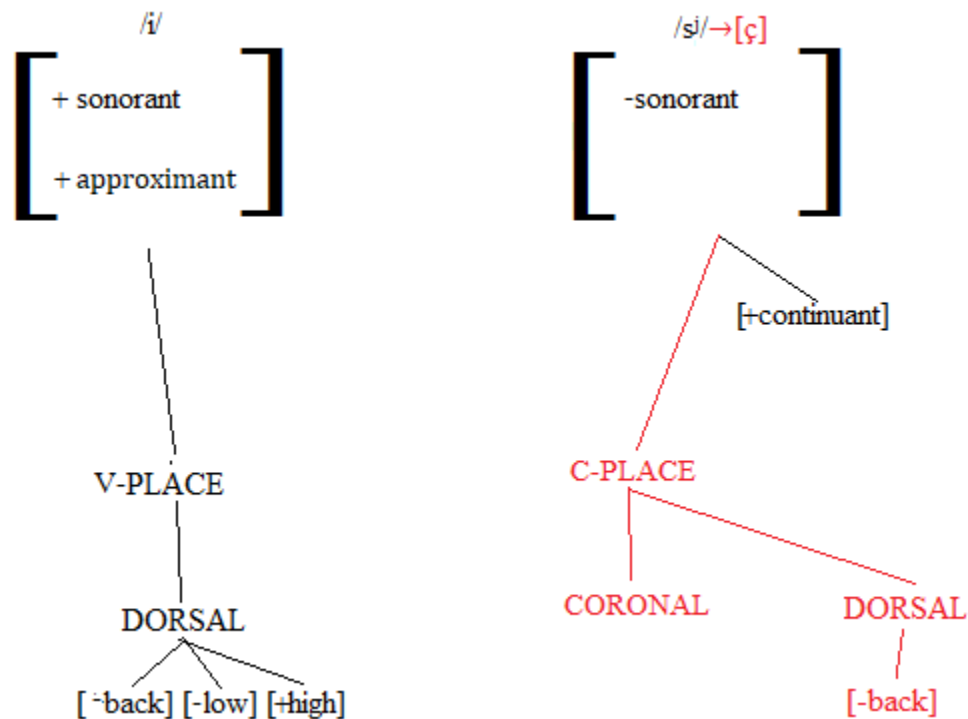
Figure 26: Diagram of Step 1



Whichever depiction the reader prefers, one fact remains consistent between: association of a ROOT node to a V-PLACE node should result in vocalization. Here, however, it does not. The answer to this problem is the $[- \text{sonorant}]$ feature specified on the fricative. In addition to delineating this segment from $/h/$, as discussed in Section 6.1, this feature specification prevents vocalization. A non-sonorant vowel is a contradiction in terms, since a vowel is the most sonorant segment type. Thus, $[- \text{sonorant}]$ here prevents vocalization. Phonetically, it requires the insertion of a C-PLACE node, presumably dental, in order to resolve the contradiction and output an articulatorily possible segment. This results in a dental fricative with a secondary palatal articulation. While this can seem strange, it is what FGHS proposes is by and large happening in most phonological derivations: that underspecified segments are manipulated in

regards to contrastive or otherwise relevant features during the phonology, with predictable features being later inserted to fill out a coherent pronunciation. At this stage, this segment is the best possible candidate to resolve the constraint ranking, and so it is kept. This leads us into the next stage: reanalysis.

Figure 27: Diagram of Reanalysis



That said, the important factor here is that the fricative receives its own organic C-PLACE node. This is key to the following step, as otherwise the derivation cannot produce the attested RUKI output: [iɕ]. Either there would be no further modification to the fricative, or change to the PLACE node would cause the /i/ to change along with the fricative. As has been noted several times in this dissertation, most clearly in Section 3.5.2, when a node is shared, changes to the shared node will result in changes to both associated segments. Thus, a change of the fricative to retroflex would necessarily require the [i] to also become retroflex, which is obviously not what happened. By reanalyzing the fricative, that unattested joint fate can be averted, and the derivation allowed to proceed along historically attested lines.

With that said, we must now discuss what exactly the product of this reanalysis would look like in terms of featural representation. Our first instinct could be to simply use a CORONAL node defined for [-anterior, +distributed]. This follows from the feature definition given in Hall (2007) and provides a neat basis for further development of the analysis. However, Hamann (2002, 2003) and Arsenault (2008) both argue in favour of palatals also being defined with a [back] feature, though they differ in exactly how to represent this. Given the feature theory which we have adopted for this present dissertation, the most logical solution would be to follow the precedent set by the retroflex representation given in Section 6.3.1, and give palatal consonants a CORONAL node specified for [-anterior, +distributed] with an additional DORSAL node specified for [-back].

This, however, leads into a problem: such a definition puts two steps of separation between palatals and retroflexes, as they differ both in [distributed] and [back], both of which need in principle to be change to transition from one place of articulation to the other. This would require two steps in order to make the change. Furthermore, recall Hamann (2003), which argued that retroflexes generally cannot be palatalized, as their characteristics are exclusive to each other. However, while palatalized retroflexes do not seem to endure for any significant length of time, it is notable that they can engage with palatalization as a process at all. This implies the possibility of an intermediate stage of something like a palatalized retroflex, which thereafter will almost always lose the following step to a harmonically superior candidate only made available at that time. Thus, we shall solve our problem through Gradualness rather than through featural definition.

Note that we have here underspecified the features of the CORONAL node. This underspecification is key to how the derivation will proceed. It derives from the fact that Sanskrit

at this time would only have two primary places of articulation which shared both a CORONAL and DORSAL place: retroflex and palatal. Thus, simply having both nodes would be enough to contrast them against just about any other place of articulation. To differentiate between each other, they would need to either specify [distributed] or [back]. Either feature would accomplish the same purpose: [back] has been chosen here to emphasize the initial agreement between the fricative and its preceding vowel.

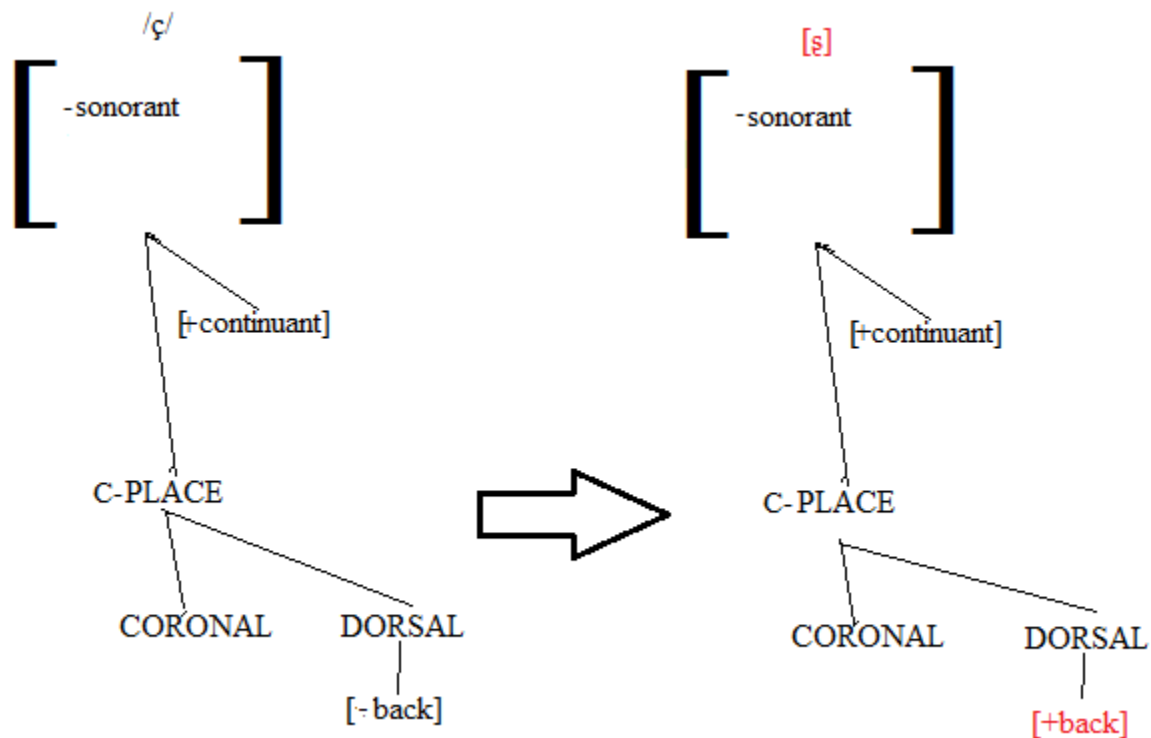
Thus, now that the fricative has been reanalyzed, the stage is set for a future change. The following change may have occurred in the same generation as Step 2, or it may come from a later generation. Lacking extant records from so far back in history, it is difficult, if not practically impossible, to know. Nonetheless, we can assert that some new generation acquired not merely a different featural representation for post-[i] *s, but also a new constraint ranking. For whatever reason, the non-[s], non-[ʂ] fricatives became banned, leading to the diverse reflexes of *s neutralizing to a single output. This is represented here with the constraint *ç. As discussed in Hall (1997) and Hamann (2003), the retroflexion of this segment was likely caused by contrast maintenance systems accounting for the emergence of [ɕ] in Sanskrit. As the elaboration of contrast maintenance constraints for FGHS is beyond the scope of this dissertation, the segmental ban used here stands in place of such constraints. It will also be noted here that [ɕ] must have differed from [ç] sufficiently that it did not trigger violations of *ç. The details of such differences, however, are better left for a time when FGHS contrast maintenance constraints can be worked out, as that is where the crux of the matter will be found.

(102) Step 3: Beginning of Retroflexion

iç	*ç	IDENT[back]	*ʂ
→ a. iʂ		*	*
a. iç	*!		

Once the reanalysis has been accomplished, then the retroflexion can ensue. A ban on the palatal fricative] would drive the segment towards an end goal of [ʂ] as an output. So long as *ç outranks IDENT[back], then a shift towards [+back] will be preferred as a solution. Given how few features we have defined [ç] with, there are very few viable candidates allowed by Gradualness at this step. The dental fricative [ʃ] is not available here for this reason, as dentals lack DORSAL nodes and thus would be at least two operations away. Thus we have a change within a single step from palatal to retroflex.

Figure 28: Diagram of Step 3



The following step would simply be convergence. Thus, we come to the end of the I derivation.

6.3.5 The A analysis

The analysis to follow is not part of the RUKI Sound Law itself. Indeed, it will not be much of a change at all. Rather, it is intended to show how underlyingly placeless segments fit into the

analysis given above. It is in this analysis that the constraint DEP[V-PLACE] will finally play a role.

Here the underlying form of the vowel [a] is represented as /A/. This is intended to indicate that it is underlyingly placeless. The place-having version of the vowel is represented by the usual [a]. This placelessness, however, brings up an important point in regards to the featural space of Sanskrit. It was discussed above that both [S] and [h] fill very similar roles in the system, being placeless and [+continuant]. There, a difference was made by specifying [S] for [-sonorant], while leaving [h] without a specification for [sonorant] at all. This difference would be negated in the pronunciation, but during the feature-filling stage, the lack of a [-sonorant] feature would lead to the application of the [h]-filling rule rather than the [s]-filling rule. Now, a vowel without a V-PLACE node must also be defined in such a way that the phonetic feature-filling rules can identify it as different from [h]. Thus, we need at least one feature in which it can differ from [h]. Since both vowels and [h] are [-consonantal], and we cannot specify [h] as [-sonorant] without abandoning its contrast with [S], the only solution is to specify [A] as [+sonorant] (Hall 2007). Thus, [A] will not be misidentified with [h] during feature filling.

(103) Step 1: Dental Insertion

/AS/	DEP[V-PLACE]	HAVEPLACE	DEPP[C-PLACE]	NO LINK
a. AS		**!		
b. aS	*!	*		
→ c. As		*	*	

In this single step of the derivation, HAVEPLACE requires that PLACE nodes be attached to the two placeless segments. Since DEP [V-PLACE] outranks HAVEPLACE, insertion of a V-PLACE is not a viable option. Thus, keeping the A placeless is simply the best option, and the derivation moves on to the next matter. The /S/ is of course also violating HAVEPLACE, and the derivation must at least attempt to solve it, as seen in the tableau above. This is where the relative

ranking of HAVEPLACE and Dep[C-PLACE] becomes key, as due to the higher ranking of HAVEPLACE, insertion of a C-PLACE node is a possibility. In the RUKI analyses, this was always harmonically bounded by a spreading solution, since DEP[C-PLACE] outranks NOLINK. Here, however, there is no possible target for a place-linking operation, and it is thus not a possible operation at this step. Thus, we are left with two options: either we select Candidate (a), in which neither segment receives a place node, or we must favour Candidate (c) and insert a dental C-PLACE node for /S/.¹¹ Since Candidate (a) violates HAVEPLACE twice, it is eliminated in favour of Candidate (c). It should be noted here that in practical terms, Candidates (a) and (c) are indistinct: both would end up being pronounced the same way after phonetic feature-filling. Thus, this analysis poses no direct problem for the RUKI analysis presented in the preceding sections.

This does, however, lead us into a new problem: why does [A] not itself not follow the pattern of [S] and simply link back to the place of a preceding segment? If the current analysis of RUKI is to hold, then there must be some explanation for this. Ultimately, there are only two clear solutions at this present time. The first is to assume that there is some constraint which prevents [A] from assimilating during the productive phonology, leaving it to be filled in by the feature-filling rules. This is a possible solution, but the nature of that constraint is unclear, and so we cannot at present go much further with this option.

The second solution requires us to give up the assumption that [A] is totally placeless. It must still be the most heavily underspecified vowel, but it cannot be totally without a PLACE node. This is all told a rather reasonable development based on the assumption of Clements & Hume (1995). There, the consonant-vowel distinction is defined not so much as a [consonantal] feature]

¹¹ The details of why dental over another are not mechanically important to discuss here, as we have thus far already assumed dental to be the default coronal place in Sanskrit.

but by whether the ROOT node connects to a V-PLACE or C-PLACE node. Thus, we should not in the end really expect any vowel to be truly placeless, as to be a vowel at all it must have at least a V-PLACE node, and would therefore be better represented by [a].

If there is a V-PLACE node in play, then we must assume that, all things being equal, it will act like the V-PLACE nodes of /i u/ and spread to the following placeless segment. That is, given the nature of constraints, we cannot create a constraint which bans the spreading of a V-PLACE which would not block the other spreading patterns, as we only have the V-PLACE to target and it is common to all the vowels. Thus, if we want to hold onto this whole analysis, we must find something which is not equal. The most logical option here is to say that [a] is specified for [+low]. This gives it something which can be targeted by a constraint such that its spreading would be banned. A simple ban on [+low] secondary articulation would solve the problem then and there.

6.4 Conclusion

The RUKI problem, though complex, is fully explicable under FGHS. It requires the use of many of FGHS' theoretical tools, such as intermediate segments and the effects of shared PLACE nodes, but nonetheless is solvable. FGHS thus agrees on some level with the assessment of Allen (1973) that RUKI is actually four separate changes, later neutralized to a single output. This process was obscured by the telescoping effect of the neutralization, as by reducing four separate developments to a single output, the impression was given that a single unified process had been at work. It differs, however, in that while Allen firmly treats each RUKI trigger as being part of an independent change, the FGHS analysis treats it as a general process of place-assimilation in which there were only four triggers which produced observable effects. This arguably returns it to being a single change, though not in the manner of earlier analyses like

Zwicky (1970), or Vennemann (1974). Rather, it groups RUKI not through any common featural characteristics, but rather through the accident of the distribution of *s. Thus, we can conceive of the RUKI Set as an ‘accidental class’, a concept which will be further explored in the following chapter. This analysis shows the importance in diachronic linguistics of remembering that, strictly speaking, language changes very little: each generation simply acquires a slightly different grammar. The role of reanalysis via learning errors is here shown to be quite important, as it makes possible the UI components of the RUKI Sound Law.

There remain some outstanding questions, most pointedly that of why a retroflex node is selected for insertion when neutralizing [x] rather than a presumably default dental node. The intuitive answer is that there is some sort of contrast maintenance going on which prevents the altered fricatives from merging with the default fricative. However, the matter of how that works mechanically is an open question. FGHS has not at the present time adopted a theory of contrast maintenance, and so that must be left for future research.

7. Discussion

7.1 Introduction

This chapter has a simple purpose, no matter how complex the chapter itself may become: to discuss the analysis presented in Chapter 6. This will be a comprehensive discussion, covering not only the analysis itself, and its implications for our understanding of the RUKI Sound Law, but the broader implications for phonological theory and diachronic linguistics. This includes discussion on both the analysis of the RUKI Sound Law, and how it relates to the Sanskrit data analysis from Chapter 5.

Section 7.2 will be the Discussion Proper, covering the analysis itself and what it can directly tell us about FGHS, phonology, historical linguistics, and the integration of constraint-based phonology, feature geometry, and diachrony into a single model. Section 7.3 discusses FGHS and its comparison to OT, examining the two as models for synchronic and diachronic phonology. Section 7.4 covers avenues for future research resulting from this present study, both in terms of the RUKI Sound Law itself and the fields of phonology and historical linguistics generally. Section 7.5 concludes.

7.2 Discussion

The analysis presented in Chapter 6 covered the core of the RUKI Sound Law, that is, the problem of the RUKI set. It described how a common phonological process, that of simple place-assimilation based on the preceding segment, could result in so strange a set of triggers. It did so by breaking down the RUKI Sound Law into two broad phases: the initial place-assimilation, and then the neutralization to [ɕ]. By decomposing the change like this, the analysis avoided any need for complex theoretical machinery in service of explaining the change. Both place-assimilation and phonemic neutralization are common enough as operations: it is only the

confluence of them in so restricted an environment as we find for RUKI which causes the whole process to appear far more complicated. There is certainly complexity in the analysis, but it is more a function of independently-necessary expansions of the assumptions of HS than it is actually new theoretical machinery.

This decomposition into multiple operations is a quintessential characteristic of HS, though here it was not the letter but the spirit of HS which was most important. The decomposition into two stages is more than simply ordering one operation after another: this could be done in any derivational phonological theory. Rather, the most relevant decomposition is the very treatment of the different operations as being independent changes at different stages of the language: that is, that RUKI is not a single process, to be explained in a single derivation. It is the integration of historical linguistics and language acquisition which proved here decisive. Diachronic change occurs, of course, across the span of history: that is, it occurs across the span of generations, each of which must independently acquire language on its own. This leads to something of a ‘reset’ in terms of the underlying representation being used. A conventional HS analysis, like with most phonological theories, will take a single UR at the beginning, and derive all further changes from it. The form will be modified throughout the derivation, but fundamentally there remains an unbroken chain of intermediate forms between the UR and the eventual surface representation. Consequently, each change must be explicable in purely phonological terms, whether that be by rules (as in generative phonology) or by constraint interaction (as in HS).

The FGHS analysis provided in Chapter 6 breaks somewhat from this tradition. For each of the UI analyses there is a “reanalysis” step which, rather than referring to conventional phonological operations, instead makes recourse to misinterpretation in acquisition. Each of these sees the replacement of a secondarily articulated fricative with a fully place-assimilated

fricative. This step is a necessary consequence of the FGHS model and its adoption of the Clements & Hume (1995) feature geometry. A V-Place node should cause either vocalization or secondary articulation: it cannot simply allow a segment to remain consonantal without interference from a C-Place node. The solution to this problem is the reanalysis step.

Thus, there are essentially two models of diachronic development seen in the analysis: the consonantal model, and the vocalic model. This distinction is a function of the split between C-PLACE and V-PLACE adopted here. For [r k], the process is, in this context, relatively straightforward. The [r] simply triggers normal consonantal place assimilation and requires no further discussion. For [k] the matter requires some more discussion. The phonological alternations at play here are surprisingly simple, consisting only of the initial assimilation and later the insertion of a single C-PLACE node with a dependant CORONAL node. As per Hamann (2003), retroflex segments can generally be understood to have both CORONAL and DORSAL places of articulation, and thus the change from [x] to [ʂ] is largely as simple as adding this CORONAL node. If any further change is required, it would seem better explained by reanalysis from a fricative which links to two C-PLACE nodes to an organically retroflex fricative.

For [u i], it is simply impossible for a consonantal segment to fully place-assimilate to them while remaining consonantal, since full place-assimilation would necessitate the acceptance of the V-PLACE as its sole place, which would render the segment no longer a consonant. Thus the need for reanalysis after the initial place-spreading, so that C-PLACE nodes can be inserted. These C-PLACE nodes then participate in the remainder of the RUKI Sound Law, leaving the V-PLACE nodes untouched. The reanalysis serves also to mark the beginning of phonemicization, as the segments are no longer secondarily-articulated variants of underlying [s], which would be rederived each time the word is produced, but rather independently stored segments. The

speakers may or may not have retained an understanding of the connection between [s] and its reflexes, a good question which must be answered in some future research. But either way the change in underlying lexical representation marks out an important stage in the diachronic development. We will expand further on the topic of reanalysis in FGHS, but for the moment it must be put aside to discuss the rest of the I and U analyses.

The U analysis is rather pleasingly straightforward. After reanalysis, it is as simple as adding a relevant CORONAL node to change from velar to retroflex. This fits in well with the patterns described in Hamann (2003) concerning the common patterning of back vowels and retroflex consonants.

The I analysis is similarly simple. By underspecifying the features of the Coronal node, retroflexes are made to be only a single operation apart from each other. This makes a surprisingly degree of sense, as Hamann (2003) notes that intermediate forms between these two places rarely, if ever, occur. If we required two steps to get from palatals to retroflexes, we would expect to see palatalized retroflexes more often. We do not observe this, and so we would expect the alternation between them to be a single operation in an HS-based model. That is to say, the oddity here is not that palatals and retroflexes can somewhat easily alternate with each other, but rather that we find a retroflex after a front vowel. Further discussion of that point is better left to a future project which can elaborate a proper system of contrast maintenance constraints for FGHS whereby we can explain the underlying pressures to keep [ç] and [ɕ] distinct.

Returning at last to the topic of reanalysis, its use in the U, K, and I analyses would seem like a worrying complication of the theory simply to resolve the complexities of RUKI, were there not independent reason to believe in the necessity of inserting a new PLACE node in an FGHS context. As discussed in Section 3.5.2, Catalan shows a situation in which regular PLACE-first

deletion is prevented by the fact that two ROOT nodes share the same PLACE node. The logic of that analysis more or less applies here. Changes made to a shared PLACE node necessarily cause both segments to change: if a shared PLACE node changes from [+anterior] to [-anterior], then both of the segments sharing that node would now be [-anterior]. The corollary of this is that if one of those segments becomes [-anterior] while the other does not, then they must no longer share a PLACE node. Since this is required independently for FGHS, its use alongside reanalysis seems to be no significant cost to the system. There is therefore no concern in using this mechanism for RUKI.

The matter of transitioning from a secondarily articulated consonant to full place-assimilation provides grounds for some interesting discussion. This analysis has treated [sʲ] and [ç] as meaningfully distinct segments, based on their differing featural representations. However, while this is certainly the path which the analysis necessitates, it may somewhat overstate the changes which occurred. Noting that the relevant acoustic research has not yet been performed for this specific hypothesis, it is entirely possible that these segments are phonetically indistinct, despite being phonologically different. That is, we must consider the possibility that multiple representations could map to the same phonetic product, or near as makes no difference. This, indeed, is similar to the basis of Longerich's (1998) thesis on the RUKI Sound Law. In her research, Longerich found that the RUKI segments produced in [s] significant acoustic distortion, which she argued formed the basis for Sanskrit reanalysis of those segments. That is to say, different segments with different phonological featural representations, being various distorted [s] tokens and [ʃ], could be phonetically realized in such a way that they were effectively indistinct.

This being the case, it is quite logical to assume that these two segments may be so acoustically similar as to not constitute separate phonemes in the mind of a language learner. This is the basis on which reanalysis is proposed here. Given a certain acoustic input, a language learner must create a mapping between it and some featural representation which can then be stored in the lexicon. If there are two possible structures for the same output, then when presented without any clear evidence for one of them, the most logical solution is to pick the simpler form. This requires less storage for the lexical form, and fits in with the general trend for language acquisition to be as much about carving off unnecessary information and forms, so as to winnow down to what is needed, as it is about ‘acquiring’ particular forms.

Now, the very use of reanalysis in the RUKI analysis deserves further discussion. It does not seem to be a conventional inclusion, certainly not in an OT context. Usually, analyses of change pass all changes to phonological content through the phonological matrix, as of course makes perfect sense. And certainly, this should be the bias and tendency: to seek out a phonological explanation for changes to the phonology first. However, to structurally deny the possibility of other components of language altering the phonological content is rather limiting. Language acquisition occurs every generation, and every language learner starts not with their parents’ grammar, but the Universal Grammar (Isac & Reiss 2013; Ringe & Eska 2013). Each person must take the raw material of their genetic inheritance, and make from it a grammar and lexicon which permits comprehensible communication with peers. This marks out an important factor in any discussion of language change, one which is not always seen in otherwise parallel historical developments. Political systems are handed off wholesale, and must be changed directly from their old form. Language acquisition does not function like this, and it is in acquisition where most sound changes develop. Language acquisition has no constitutions or judiciaries. Each

speaker is like the king of a new realm, who must make a whole new set of laws suited to the circumstances at hand.

Sound changes of course are governed by regular laws and processes; otherwise the Neogrammarians could never have enjoyed as much success as they did. Nonetheless, it must be acknowledged that every lexicon is built afresh by independent learners making the best they can of what they hear, passing through their inherited systems of language acquisition. It is therefore completely possible for learners to incorrectly analyze ambient speech, misreading the implications of the acoustic ranges they hear and thereby assigning a different, though of course related, structure to the lexical representation. All of this can happen without ever passing the change through phonological review, so long as the phonetics matrix has already made the decision. When the phonology is still developing, it is heavily dependent on the phonetics to inform its ranking. It is only as the mass of phonetic details is analyzed by the learner that phonological rules are established. This therefore leaves plenty of room for those learners to make changes to a language without those changes being subject to a conventional phonological rule, being rather subject to whatever systems are used to select between two possible forms in acquisition.

The analysis thus provided is certainly complex, though that would seem fitting for so vexing a change as the RUKI Sound Law. Nonetheless it does seem to hold up, providing a natural explanation of how a single broader process, being place-assimilation, could become telescoped into a strange and seemingly unnatural pattern. It requires no *ad hoc* theoretical machinery developed solely to explain RUKI. It certainly takes full advantage of the rules and systems of FGHS, but that does not seem a particularly egregious sin for a computational system. After all, the whole point of such a system is to provide rules for explaining phonological alternations.

A very important component of the analysis is in what is not being analyzed: that is, the environments which do not exist. As has been repeatedly discussed throughout this dissertation, much ink has been spent trying to determine how RUKI could be grouped as a natural class, or if it should be grouped at all. Across all that research, one possibility does not seem to have played any significant role: that RUKI is not a natural class, but an arbitrary one. That is, RUKI is simply the set of non-dental sounds which could actually appear before [s], and therefore were the only sounds available to trigger place-assimilation. This should not be construed as a surrendering over to the idea that some things are historically contingent and therefore cannot be explained. Rather, it is an acknowledgement that every language exists in a certain form at a certain time, as a result of earlier changes. Thus sound changes come to each language in a particular context, reacting to that context, and leaving a new context for future changes.

This hypothesis has been demonstrated above in Chapter 5. As it turns out, from a sample of 3523 tokens, a mere 0.99% were neither RUKI segments, dentals, or placeless. The overwhelming evidence from this data is that the RUKI Set is a result of distributional accident rather than traditional notions of natural classes. It is no contradiction of the concept of natural classes, but rather a supplement, an acknowledgement that phonology exists not only in theory but also in the real minds of real speakers. Phonology is a set of universal principles which interact with many sets of particular speakers and particular languages. We should therefore expect that from time to time that very particularity will produce peculiar environments. The absence of a certain phonetic sequence which might have otherwise existed is a thing which is in itself sometimes strange, but in general is commonly found. English lacks any **bn* sequences, and would therefore never expect to find [b] in a set of segments that could trigger some change in following [n]. The same principle applies here.

This is why the analysis in Chapter 6 does not provide a principled explanation of why other segments did not participate in RUKI, nor does it give any particularly strong reason as to why the RUKI set is as it is. It simply does not need to give such an answer. The analysis explains how the RUKI set as the RUKI set could result in [s] and nothing more. Placeless and dental segments, as discussed in Chapter 5, would not have been able to leave any evidence of assimilation, regardless of whether they participated in the broad change or not. It is most likely that they did, given the nature of *s, but since dentals would assimilate a by-default dental segment back to its default state, and placeless segments by definition have no PLACE node to spread, they do not need to be directly analyzed. The lack of analysis is itself sufficient for them.

To elaborate a bit more on the segments identified as ‘placeless’, we observed in Section 6.3.5 that [a] cannot be truly considered placeless. It acts sufficiently similarly to a truly placeless segment in regards to the RUKI Sound Law that it can be fairly grouped with them, but we were forced to operational reasons to specify it with a V-PLACE node and a [+low] feature. This was because [a] does not as a rule attach to the place node of preceding segments. Thus, it is worth noting that the [N] segment does in fact undergo assimilation, as we would expect of a placeless segment. The interaction of [h] with other segments is not a focus of this dissertation and thus is left to be discussed at another time.

The other segments are not analyzed for the simple reason that they barely occur in the data. Those other segments may be subject to convenient principled exceptions which explain why they did not participate, though given the history of RUKI analysis this seems rather unlikely. Indeed, it would seem most likely that, given the constraint ranking in Chapter 6, they should have also participated in the assimilation. That they did not is a result of distributional patterns,

not a precise constraint ranking by which [r u k i] were permitted to cause assimilation while other segments were not.

Thus, the discussion turns again to the concept of an accidental class. This concept having been introduced and explained in detail in Chapter 5, the topic will here be relatively brief. An ‘accidental class’, as proposed here, is a set of sounds which are united not by any qualities of the segments themselves, but rather as an accident of distribution at a particular time. They are not sounds which naturally pattern together, though parts of the set may do so. They cannot be united by common features, whether articulatory or acoustic. Rather, they are simply a subset of sounds which could potentially have engaged in some process, and were the only ones which were in a practical position to do so. The larger set alluded to here would presumably form a natural class of some sort, whether broad or specific. It also may not be, as with the RUKI Sound Law itself, purely a result of segmental distribution. Now, whenever a distribution exists such that it so dramatically effects the output of a process to the point that an accidental class must be proposed, the question should always be asked as to why that distribution exists. It is not necessary to answer that during the explanation of the process itself, since the process would be ignorant of any such distribution and simply active in its available contexts. Nonetheless, it is a question that must be asked, and should in principle be eventually answered. It may be that in the end the explanation of the distribution must fall back on pure accident, that the distribution simply is what it is without any rhyme or reason. It may also be that there is some definable phonotactic constraint which prevents certain segmental sequences such that certain segments which could in principle have engaged in the change did not. There could be some other, more detailed, more principled explanation. Whatever the case, while it does not need to be explained

in the course of explaining the process itself, it should eventually be discussed, as this will in itself add to the general pursuit of the knowledge of human language.

Thus we come to the final point of this section. Mechanisms have been employed, and an argument made for FGHS as a particular model, this is true, and not one word of it is at present retracted. But this model is not the only focus of this dissertation. The analysis of the RUKI Sound Law should stand or fall somewhat on its own. That is, the argument that RUKI is not a single rule, but a telescoping of at least two separate changes, the shape of which was determined not so much by phonologically-defined natural classes but rather by the accident of segmental distribution. From a historical linguistics point of view, the exact means by which the analysis was computationally supported are less important than the statistical evidence in favour of the concept of the accidental class. Similarly, while the details of the FGHS analysis may change in the years to come, as new solutions are found for problems seen here, what will remain is the assertion that between generations, there can be changes in language which affect the phonology but are not derived directly from it. Most importantly, this refers to the reanalysis of secondarily-articulated segments into ones which take their primary place from what had been a secondary articulation. Lastly, turning back somewhat more to the mechanical side, this analysis shows that it is possible in principle to use FGHS to analyze diachronic data. Whether the particular analysis presented here is ultimately accepted as correct or not, what remains is that the model was able to put forward as earnest an attempt as the rules of generative phonology.

7.3 FGHS vs. OT

For the theoretical phonologists reading this dissertation, this section will perhaps be the most interesting. Having outlined and applied FGHS, it must now be compared to OT. If nothing else, the comparison is a longstanding tradition of HS literature: there is almost always a pressure

to demonstrate how HS is not only equal to OT, but superior, how it better captures the data and provides better generalizations. Thus, for the next section our attention will turn to this comparison, primarily focusing on the big-picture differences between FGHS and OT in regards to both the analysis of the RUKI Sound Law in itself, and the use of constraint-based models for diachronic work generally.

No small intention in this work has been to legitimize the use of constraint-based models in diachronic analysis. Much of Chapter 4 was dedicated to arguing against the general criticisms laid against OT and its variants. But countering criticisms is one thing: it is another to demonstrate that constraint-based phonology is not merely ‘not incapable’ of analyzing historical changes, but in fact actively useful as a tool in that endeavour. The success of FGHS in analyzing RUKI, a problem which has endured for over a century, should be a strong argument in favour of constraint-based phonology. Certainly, this is not a vindication of Parallel OT itself. It is not clear how classic OT would have been able to properly analyze the RUKI Sound Law. The limitation is not that it is necessarily impossible to create an OT analysis which could cover similar ground to that which was here covered by FGHS. Rather, it is somewhat a matter of what such an OT analysis would even begin to look like. There is no individual step which has been done in this analysis which could not in principle be modeled in OT. However, at some point we would need to start making recourse to multiple OT tableaux which span across multiple generations. This is not something that OT was really designed to do, and so it is unclear what shape that final analysis would ultimately take. Contrast that to the serial-derivational analysis used in this present dissertation, which very clearly predicted a minimum number of generations required for the change. This allows FGHS to predict when one derivation ends and the next begins: if reanalysis has occurred, then we predict that regular phonological processes have run their

course and reached an endpoint. Further phonological development will have to be put off until the reanalyzed representation is available to act at the input for a new derivation.

Yet serial-derivation was not the only difference here, and this dissertation does not directly discuss conventional HS. Indeed, many modifications have been required for the theory to be made ready for the task to which it was set here. However, many of those changes were independently required to properly fill out the assumptions of HS itself, as discussed in Chapter 3. The structure of FGHS stands as an important development for HS whether or not it becomes adopted for broader historical use. This ought to, therefore, stand as a strong argument for the usefulness of constraint-based phonology for diachronic study, as by independently expanding out the theory it has become more capable of handling diachronic changes.

Having been expanded to take direct account of the feature geometry, FGHS is better equipped to explain feature changes in phonological data than basic HS. To this point, a form of Clements (1985), or Clements & Hume (1995), feature geometry has been tacitly assumed, as discussed in Chapter 3. The reasons enumerated there for the adoption of feature geometry will not be reiterated here, but they are nonetheless important to this discussion. HS requires some sort of feature geometry to properly act out its basic assumptions, most particularly Gradualness and two-step deletion. Now that this has been done, it is prepared to delve into the details of how this adoption bears on the comparison of FGHS and OT.

First, to simply get it out of the way: FGHS inherits all of the advantages and disadvantages of HS in comparison to OT. FGHS, while complexly outlined in this dissertation, is not so much an independent entity as it is an expansion and reformation of HS. It is, in essence, what happens when Gradualness is taken seriously and worked out into a principled system. This is not to say that Gradualness has not been taken seriously prior to now: simply that to this point, no one

seems to have sat down to try and work out the full implications of its adoption. Therefore, every argument for the superiority of HS over Parallel OT automatically applies to FGHS and does not need to be specifically mentioned here. Such arguments have been made, both for and against HS, in other works which have given them better elaboration and focus than there is space for here. Those arguments shall thus be left to their respective places, and the remainder of this section will largely assume that the arguments in favour of HS hold so that we can discuss the shape and implications of the model as proposed. Some points may be worth reiterating, if FGHS sheds new light or provides a firmer understanding of the extant advantages. But in general, the following discussion will focus primarily on what the adoption of feature geometry adds to the discourse.

The clearest advantage diachronic FGHS offers over Parallel OT is that it naturally makes predictions about the incorporation of sound changes into the lexicon. Whether as a result of acoustic reanalysis, lexical analogy, or regular sound laws, FGHS must make firm statements about the nature of the underlying representation in every derivation. Furthermore, as seen across much of the analysis in Chapter 6, it must make specific claims about when the UR changes during a broader period of phonological development. That is, FGHS marks out a clear delineation between what is diachronic, being those things which have become baked into the UR, and what is synchronic, those things still being productively derived in the active grammar. Otherwise, it will make wrong predictions. OT makes no such predictions: it produces single-step alternations with an often unclear provenance as to how far back in diachrony the lexical entry reaches. OT tacitly requires the changing of inputs between generations in order to properly structure an accurate constraint ranking. However, it is quite easy, given the theoretical structure of OT, to construct a ranking which encapsulates several generations of smaller changes,

brushing over the fact that no actual speaker experienced a change from Form A to Form D. This has always been the classic disadvantage of OT relative to HS, and its claim to superiority over rules-based phonology: that by applying all changes in parallel, the ordering of operations becomes irrelevant. This allows for multiple rules to be coalesced into a single underlying principle, but loses the ability to account for when the order of operations has an impact on the shape of the output.

Relative to rules-based phonology, parallelism allowed for an easy solution to the problem of phonological ‘conspiracies’, by uniting rules which could not otherwise be unified. The advantages and disadvantages of parallelism over rules-based derivations are a debate which need not be rehashed here: enough ink has been spilled by better hands on that topic. What is important here is that, as noted often in this present study, diachronic linguistic development does not work this way. Historical linguists do not, as a rule, assume that modern English speakers are deriving their speech from Proto-Germanic, let alone something so ancient as Proto-Indo-European. But this is what the use of telescoping rankings in OT tacitly implies should be the case. OT must make a fundamentally arbitrary assumption of which input a speaker is actually using, since it is possible to make rankings which apply in parallel change which in reality occurred across multiple generations. Certainly, OT would never do something so outrageous as derive a modern English word directly by one step from Proto-Indo-European. But this extreme example serves primarily to cast a light on the issue of deciding which version of Modern English should be assumed when selecting an input.

In contrast, FGHS is afforded little such wiggle room, if any, in regards to selecting inputs. Given the need for precise knowledge of the feature-geometric structure, and the need to explain every change in sequence, it cannot telescope stages of linguistic development. Certainly, an

FGHS derivation can stretch across multiple generations: this has been done in the this present study of the RUKI Sound Law. But it did not do so by tacitly treating RUKI as a one-step change, a thing which occurred entirely within a single generation. Rather, it proposed that at least two generations were required: the first to apply place-assimilation to *s, and a second to reanalyze the assimilated reflexes of *s into new fricatives, whereafter some generation after the first, which could in practice have been quite distant in time, neutralized then all into [ʃ]. Now, FGHS does not claim to effortlessly predict exactly how many generations are involved: such a prediction is beyond the scope of phonological theory itself. That is fundamentally a question of history and society rather than language itself, as it is quite possible for a language to sit at a certain stage of its development for an arbitrarily long time before it finally carries out any particular change. Nonetheless, FGHS can predict, in regards to a particular series of changes, how many stages the language went through.

FGHS must theorize a particular input, Form A, which is proposed to be in use by the speech community at a particular time. This forms the basis of the analysis. It must then propose a ranking which would trigger some change to Form B. It can then continue to define the ranking such that Form C would emerge, and so on. This can all then represent then-synchronic phonological activity. However, there will eventually come one of two stages, should the changes continue to layer for long enough: either there is a change which cannot be accounted for by regular FGHS feature changes, or there is a change which would require a new ranking. If reanalysis is required, then FGHS predicts that this change occurred in a later generation than the previous changes: that they have some other underlying form in their lexicon than their predecessors did. If the change necessitates a change in the constraint ranking, this then also implies a new generation. This does not, however, necessarily imply a new underlying form. It

can be possible to change a ranking and derive the new output from the same old input. This is the basis of all proposals for variable rankings on constraint-based models. If this is the case, then all is well: we have a new generation with a new output, but the old input remains the same. However, it is possible for a new constraint ranking to prevent the attested sequence of operations by which the output has hitherto been derived from its input, in such a way as to prevent the new output from possibly being derived from the old input. In such a case, FGHS requires that a new input be proposed, one which is built from the old input but no longer formally derived from it. One of the old outputs, which were in their time derived from the old input, must be selected and installed as the input for a new generation which can no longer reverse-engineer the old input.

Such predictions are generally not found in classic OT, since it often brushes over the details of featural structure and operational sequencing which underlies these predictions. This may or may not be all well and good if we are only concerned with synchronic data. But history simply does not operate in parallel, but rather in sequence. Each generation is derived from the last, and do not exist in parallel. Thus, FGHS seems better suited to handling diachronic data than is Parallel OT.

This also implies a more general superiority of FGHS over Parallel OT, for the simple reason that synchronic data is not the whole scope of phonology. To its credit, Parallel OT is well suited for handling many changes, even historical ones, by projecting backwards to treat them as they were when they were synchronic. After all, every diachronic change was once synchronic. But as discussed above, this is not the same as analyzing the change as diachronic, that is, as something which occurred both within and across generations.

Interestingly, this advantage which FGHS holds over Parallel OT is also one it holds over rules-based phonology. Now, rules-based phonology is superior to Parallel OT for analyzing diachronic pattern in that it acknowledges clearly the individual changes which occurred to derive the modern form from its ancient ancestor. However, where rules-based phonology comes up short in this regard relative to FGHS is in the distinguishing of diachronic and synchronic processes. Rules-Based Phonology certainly can list out every operation in its proper order, but it has no principled means by which to predict when the underlying forms change. Rather, with a sufficient rich list of rules, you could easily give a derivation for a modern English word and how it, step-by-step, was derived from an ancient Proto-Indo-European word. At no point in this sequence, however, would you be able to predict when speakers ceased deriving from the PIE original and began to use a later form as their input. This is the very thing which FGHS adds: that it predicts when what was once a derived form becomes lexicalized and forms a new input from which further changes are derived.

This touches on a recurrent theme in this present study: the nature of diachronic change. The traditional treatment is to tacitly speak as though languages are entities in themselves, which grow and change like any living thing, and which humans then access by some unexplained magic. This is not of course what any linguist actually believes, but it is implicit in the ways we talk about historical changes. It is just like how people talk about countries as living things which change and grow, rather than as the constructs of human effort that they really are. But when we assume that language is a genetic inheritance, that UG causes each generation to reinvent language with each generation, we cannot continue to treat language in this manner (Isac & Reiss 2013; Ringe & Eska 2013). We must firmly remember that for every speaker, language is a new discovery, a magical and wonderful thing acquired fresh in the days of our youth. Speakers of all

ages engage in regular phonology, the allophonic variation of speech according to our understanding of the phonological rules. But diachronic change is a thing which primarily manifests in that juncture between the old and the young, when aged and veteran speakers pass on what they have learned, not through teaching, but through the example of use, to the fresh-faced youngsters, to make of what they will.

Now, a potential weakness must be here acknowledged. Much has been made here of how FGHS predicts when new generations will begin to use a new input. This is a strong prediction to make, and one which has a clear potential issue. Such a prediction necessarily also predicts which sound changes are still productive and which are not: for any alternation which is derivable from the current constraint ranking will be productive. That is, after all, the nature of constraint-based phonology, to say that the changes we observe are those which the constraint ranking demands. But the corollary of this is that any change which is found to be productive must be derived from the current constraint ranking. This means that if there is a process which is attested as productive, but is not explained by a coherent constraint ranking, then the proposed ranking must be wrong. For FGHS, that means that if it predicts that an input change has occurred which necessitates the neutering of an allophonic change, and then that change is found to apply to new forms as well as old, then at minimum the constraint ranking is wrong. If no alternative constraint ranking can be found which should account for this contradiction, then it would be a terrible, possibly fatal blow, to FGHS in its current form.

The discussion above made much of the manner in which FGHS deals with sound changes over time. It uses both the conventionally-understood system of constraint reranking, as well as accepting that some changes are lexical-acquisitional. It is this latter point that bears on phonological analogy, as they would seem to be describing almost the same matter. Now, what

was discussed above was focused on phonemic changes: that during acquisition, learners could derive an alternate phonemic structure based on positing an alternative underlying structure which was capable of producing the same acoustic product to which they were exposed during acquisition. That is, it was focused still on systematic changes according to unambiguously universal principles. Analogy is rather the idiosyncratic change of a single form for reasons which cannot be explained via reference to the sound patterns of a language. Yet FGHS, by accepting that some changes are fundamentally lexical alterations driven more by acquisition rather than actual phonological operation, should be able to better accept these changes. Certainly, there is nothing which stops Parallel OT from using an analogically altered input. But there is equally nothing by which Parallel OT could give an explanation of why the input was altered. FGHS does not claim to give a derivation for such a change, but it explicitly puts forward a theoretical explanation of why the change happened. While small, this is nonetheless a valuable advantage of FGHS over Parallel OT.

7.3.1 Rules vs. Serial-Derivational Constraints

This short subsection is intended to cover a question which, while not identical to the above, follows from a similar comparison. The section above essentially dismissed any real comparison between FGHS and rules-based Generative Phonology. This was done in order to focus the discussion on the comparison between FGHS and OT, to follow in the above-mentioned, longstanding tradition of such comparisons in HS research. However, this dissertation is not intended to only speak to Optimality Theorists, but to all modern phonologists and historical linguists. Therefore, this subsection will now turn to a somewhat general discussion of FGHS, or more accurately constraint-based phonologies, and rules-based phonologies.

At this present time, all phonologists are well aware that, despite the problems regarding conspiracies which helped drive the introduction of OT in the first place, rules-based phonologies are simply better than constraint-based phonologies at describing phonological processes. A rule is the researcher's first instinct when trying to describe an alternation, not a constraint ranking. Rules can easily describe operational interactions simply by ordering the rules so that the overridden process occurs first, and the overriding one is second. However, it is not descriptive power which drove the shift to OT. Rather, modern Optimality Theorists, regardless of their specific preferred model, are far more concerned with the explanatory power of a model. Explanation is what drives OT research as much as the ability to model a change. The purpose of an OT derivation is to explain the change, rather than simply describe it. This is why long, at times complicated rankings of often conflicting constraints are made, so that through their interaction we can create an explanation of why the output is the best possible option for the speaker.

This is ultimately where a comparison between FGHS and rules-based phonology is to be made. FGHS, as far as OT variants go, is much closer to the rules-based side of phonology. It uses a multistep derivational structure, and is very focused on featural representations in order to produce an accurate derivation. However, it remains a constraint-based model, and that brings with it certain limitations and benefits. Like all constraint-based models, it is forced to describe every phonological phenomenon through constraint interaction. This can lead to needing relatively complicated tableaux to describe alternations which in rules-based phonologies could be easily described in a single rule to the format of $X \rightarrow Y/Z_$. However, because it must provide constraint interactions for every alternation, it retains from OT the greater explanatory power.

FGHS may, as an example, require three derivational steps and a constraint ranking of $A \gg B \gg C$ to describe the same phenomenon that Rules-Based Phonology may have handled with a simple $X \rightarrow Y/Z_$ rule, but nonetheless FGHS in its complexity better shows by the alternation occurs. Indeed, it may even imply that the single rule is not actually accurate. The use of Gradualness, inherited directly from HS, implies a potentially greater limitation than do the rule-writing conventions of Generative Phonology. This is not to say that Generative Phonology considered any possible rule to be a good or legitimate rule, but rather than HS, and through it FGHS, has a strongly principled limitation. It cannot perform more than one operation at a time, and through this is forced to very strictly define what is and is not an operation. All of this leads towards a system that is more tightly focused on explaining why a given alternation happens, even if it makes the mere description of that process more cumbersome.

As was noted in the section above, there is another advantage of the constraint-based FGHS over rules-based Generative Phonology. Previously it was mentioned that rules-based phonology can be easily used, in principle, to create an unbroken chain of rules deriving a modern English word from its Proto-Indo-European antecedent. This chain in itself is no bad thing, and indeed shows just how far modern historical linguistic research has come. The problem here, however, is that at no point does the rule-list give any indication of when the actual input form changed. As all phonologists are aware, it is possible to apply multiple rules to a single input, which implies that you can have the same input across several stages of a language's development. However, since we know that modern words are not synchronically derived from ancient ones, but rather from more recent reflexes of those ancient forms, we must also assume that at some point learners cease to acquire the old form and instead acquire some new form from which further development is then made. Rules-based phonology gives us no clear answers on this, but

FGHS does. This was discussed in relation to OT, but it applies equally well in comparison with any rules-based phonology.

The nature of serial-derivational constraint-based phonology is such that eventually a hard line must be drawn and a proposal made for when the input itself changes. Otherwise no relevant constraints can be reranked, as they would instead be altering the derivation from the ancient input, which may well not be a possible input for the attested output. In contrast, the application of each rule is an independent matter, making changes to the output of the previous rule. Now, on the surface this sounds not dissimilar from what HS does: in HS, each step save the first gets its input from the output of the previous step. However, importantly, at each step the constraint ranking remains the same¹². This is very different from the independent application of rules. We must recall that what rules do in Generative Phonology is in OT-based models the result of constraint interactions. The constancy of the constraint ranking means that their interactions will remain the same unless some force alters their ranking. A change in the initial input will certainly lead to a different output, as the constancy of the interactions means that a different input, which will therefore be subject to different priorities in those interactions, will produce a different output. To change the interactions, we must ultimately change the ranking. But in changing the interactions, we can no longer reliably derive the forms which we did previously, because they relied on those interactions.

Thus, the only solution is to eventually change the initial input. This could occur often, or could be relatively rare, a thing which only occurs every few generations, at least for any given word. Its relative commonality or rarity is ultimately irrelevant. What matters is that the change

¹² For the purpose of this discussion, we assume a model which does not allow variably ranked constraints. Their inclusion does not substantively change the overall point here. It would simply require that we acknowledge the constraint ranking to remain generally consistent, save for select exceptions.

must occur, and in any diachronic analysis it must be explicit. The theory itself makes predictions as to the minimum set of input changes, as it will be marked by those times when it becomes impossible to correctly derive the attested output from the old input.

7.4 Future Research

While this dissertation has covered a lot of ground, there remains much work to be done regarding the integration of HS, feature geometry, and diachronic linguistics. Likewise, there is yet more work to be done in untangling the whole of the RUKI Sound Law. These outstanding questions and threads will now be briefly discussed, outlining where future projects would be beneficial to the field.

The RUKI Sound Law is, as has been noted elsewhere, more than just a strange instance of a non-natural class of sounds triggering a change: it is also the subject of certain odd restrictions. Where /r/ followed *s, the application of RUKI was blocked. As well, the RUKI Law generally seems to only apply once in a word. Neither of these problems have been tackled in this present study, but both warrant some further comment.

The R-blocking process seems, on a surface assessment, most likely to be an instance of dissimilation: Sanskrit, it would seem, will not suffer so many retroflex sounds in a row, and so blocks the retroflexion of /s/ in that environment. This explanation leads to two points. The first is that as of yet, there is no established analysis for dissimilation in FGHS. This is left to future research to work out, as assimilation is significantly more straightforward to explain. Moving beyond the narrow terms of FGHS, the second point is that if R-blocking is simply a blocking of retroflexion when there is a following /r/, it does not properly explain why the blockage would have occurred where the change was conditioned by IUK. After all, if the motivation is to prevent too many retroflex sounds from being adjacent to each other, then such a process should

not have been triggered by the palatalization or velarization of the fricative. Furthermore, it seems somewhat odd to argue that two adjacent retroflexes are acceptable so long as the sequence is [rʂ], but is unacceptable if [ʂr]. This could imply that the R-blocking did not in fact prevent the assimilation of the fricative, but was a later process which undid RUKI wherever /r/ followed. There remains the matter of why following /r/ would trigger this, however, and thus further research into this matter is required. It would also be useful to investigate the data and see if [r] also de-retroflexed other segments. If that were to be the case, then it would point towards a more general underlying ban on having a retroflex segment immediately precede a retroflex sonorant.

The claimed single application of RUKI per word, a pattern so important it helped form the basis for Lexical Phonology, is another conundrum which must eventually be solved (Kiparsky 1982b). It has at first glance the appearance of a classic HS product: the operation must apply each time independently, and after its first application no longer meaningfully improves on the constraint ranking. At the present time, however, it is quite unclear why this would be so. On the other hand, Kiparsky's (1982b) analysis strongly argues it is sort of morpho-phonological restriction, given that it does apply on the word level, implying an interaction with the morphological interface. If this is the case, then the solution is quite beyond the scope of this present study: it would require a fuller development of a theory of morpho-phonological interaction in FGHS. It is further complicated by the fact that HS has no built-in system for accounting for effects at morphological boundaries in the manner of Stratal OT. Such development is likely to be necessary in the future, certainly if this is what is happening to RUKI, but is far too great an undertaking to be worked out presently. Rather, it demands a dedicated study to properly solve.

Of particular interest is the potential for integrating Contrastive Hierarchy Theory (Dresher 2009) into FGHS. It provides a more detailed system of explaining feature contrasts than traditional feature geometry, and it has interesting parallels with the heavily underspecified feature geometry used in FGHS. Contrastive Hierarchy Theory articulates a principled structure for determining which features are phonologically active, that is, which features are able to have an effect on the phonology. This could help solve the traditional problems constraint-based models face when trying to explain phenomena such as the Great Vowel Shift in English. By combining cyclic development with the restructuring of the contrastive hierarchy, explanation could be provided for the ‘knock-on’ effects observed in vowel shifts, whereby certain changes happen not because of phonological environment, but in response to changes in the contrast system. The spirit of such a system fits in well with FGHS treating some changes as the result of lexical changes rather than direct phonological change. Lexical changes are not the same thing as changes in the contrastive hierarchy of course, but both point towards the capacity to change phonological forms without the use of conventional phonological operations. Investigating the potential integration of Contrastive Hierarchy Theory into FGHS is therefore a high priority for the theory.

Such integration would relieve FGHS of one of its more apparent weaknesses, which is its presently agnostic theory of underspecification. At present, underspecification in FGHS is somewhat *ad hoc*, simply leaving in features which are relevant to the analysis and omitting those which are not. The integration of CHT would alleviate this issue, without resorting to committing to something like Radical Underspecification. Instead, the contrastive hierarchy would naturally explain which features are active and which are not.

A notable question in this regard is how such an integration would take place. Broadly speaking there are two options: either there should be Contrastive Hierarchy Constraints, or the Contrastive Hierarchy should exist prior to the Constraint Hierarchy. The latter hypothesis is at present more preferable, pending research into what specific Contrastive Hierarchy constraints could be formulated, as Contrastive Hierarchy is language-specific, while OT constraints are generally held to be language-universal. It furthermore makes intuitive sense that the Contrastive Hierarchy would exist prior to the constraint ranking, as it has a similar relationship to derivation as the lexicon does: it feeds content into the derivation, but does not itself perform derivation. The Contrastive Hierarchy does not seem an appropriate addition to the Lexicon directly: rather it should function as a Lexico-phonological interface, transferring data between the two stages of language. The Contrastive Hierarchy, like the lexicon, becomes subject to change as a result of derivational processes, and then in turn alters the inputs for derivations. A vowel is changed by regular phonological derivation, and in response the other vowels are shifted so as to maintain contrast in a new system. This allows the constraint set to remain language-universal while still integrating the strengths of Contrastive Hierarchy.

It would also require complexifying the conception of underspecified features into two categories: Enhancement Features and truly underspecified features. The former would be available to enhance phonetic contrast without having any contrastive value, while the latter would be truly absent from the segment until absolutely needed. However, while this would increase the complexity of the model, it would be a fair price if it solves the current underspecification question and increases the explanatory power of FGHS.

On a related matter, something worth investigating at a later date is the present claim of FGHS that underspecified features are inserted by phonetic rules after the phonology is

concluded. As we often acknowledge, though do not always explicitly integrate into formal phonological theories, the actual instantiation of segments can vary within a variety of bounds. Free variation is the most obvious occurrence of this, in which feature values can vary without having any effect on meaning. Further consideration of this would ultimately have to await the integration of CHT, as without such a system there is too much potential for pathologies.

On a similar topic of further developing FGHS as a model, this dissertation does show quite clearly the need for an elaborated system of contrast maintenance constraints. The RUKI analysis given here relies on the existence of a contrast maintenance system to explain why so many disparate segments would be driven into a single phoneme, and to explain why the alveolopalatal fricative would not have engaged in the same shift. Such a system is beyond the scope of this present dissertation, but must eventually be dealt with as part of working out FGHS specifically, and HS generally, as a model.

We must now discuss, if somewhat briefly, one of the major findings of this dissertation. A core concept in the final analysis of RUKI herein proposed is the concept of an accidental class, being a set of unrelated sounds which are united by a common distribution and therefore are able to exclusively participate in a phonological process which is itself strictly more general. This concept is quite out of the ordinary for a phonological analysis, and as of yet has only been applied to the RUKI Sound Law for which it was developed. Now, the very nature of the proposal implies that such sets should be very rare, as otherwise we would not be able to so clearly find evidence of the power of natural classes. Nonetheless, if accidental classes are truly a part of human language, then they should be found in other contexts. Therefore, it is important for future research to scour the Earth and discover if any other such accidental classes exist, so as to substantiate its use.

It should also be emphasized here that the concept of an accidental class is one used cautiously and only in the face of strong data. As a concept, accidental classes are potentially very powerful things, able to brush over potentially any oddity in a data set. This, however, would be an abuse of the concept. Accidental classes are proposed as a potential explanation for data sets which are not merely difficult, but have no ‘natural’ solution via appeal to feature classes.

Lastly, the most important topic for future research in regards to FGHS is to apply it to more data. It has begun by tackling a very hard change, but if it is to prove itself as a theory then it must be shown capable of handling many more, both those which are difficult and those which are easy. It would be a terrible blow if FGHS could not handle simple changes. And difficult changes may well necessitate further revision of the theory, so as to account for strange new circumstances.

7.5 Conclusion

Fundamentally, the discussion of the RUKI Sound Law here presents two major conclusions. The first is that by integrating feature geometry, it is possible to use a Harmonic Serialism ranking to explain the RUKI Sound Law as it has been observed. Such an analysis provides an explanation for why four so disparate sounds would result in the same output, by including reference to intergenerational reanalysis and giving a proposal for a neutralization process. On this basis this present study has established a modified version of HS which is both better suited to handle diachronic data, and more completely works out the foundational assumptions of the model. The second is that the quest to define the RUKI set in terms of its members has been misguided. Rather than there being some secret commonality across the RUKI Set, it is the facts of Sanskrit phonological distribution themselves which explain the pattern. By arguing, with the

backing of the strong data discussed in Chapter 5, that RUKI is simply the result of a general place-assimilation process shaped by the historical accident of *s distribution, this present study shows that historical sound changes can be shaped by more than just pure operations. It shows that phonological distribution and the nature of the lexicon as it exists are just as important as operations and feature definitions when explaining phonological problems.

8. Conclusion

Thus we come to the end of this present study. This dissertation set out with the goal of analyzing the RUKI Sound Law by using modern methods, and in doing so provide a model which could reunite Optimality Theory, Feature Geometry, and Diachronic Linguistics. The result is the Feature-Geometric Harmonic Serialism analysis of the RUKI Sound Law presented in Chapter 6.

The dissertation started by laying the groundwork by establishing a basic framework for each of the fields involved in the study: Feature Geometry, Optimality Theory, and Historical Linguistics. Feature Geometry and Optimality Theory were then reintegrated as Feature-Geometric Harmonic Serialism, a serial-derivational version of OT which is explicitly sensitive to the feature geometry of its segments. Doing this required the model to explicitly define an input so that its features could be manipulated during the derivation. It also required the adoption of some form of underspecification, as full specification proved unworkably cumbersome, as shown with the alternative Nodal Faithfulness model. The usefulness and validity of FGHS was demonstrated with a series of analyses focusing on lenition processes, using data from Latin, Serbian, and Chilean Spanish, and one on nasal assimilation in Catalan.

Having established FGHS, the discussion then turned to its application to historical data. Chapter 4 discussed the potential issues with and benefits of applying constraint-based models to diachronic data. HS in particular was advanced as a natural fit, FGHS even more so, because it inherently made predictions about when speakers adopted a new underlying representation. Since FGHS requires explicit knowledge of the input to function properly, it must be careful in checking when a new input is being used by a new generation. As was noted then, no modern speaker of English derives words directly from Proto-Indo-European. Rather, we use much more

recent data as the basis for our lexical entries. Therefore, there must come a point at which the UR being adopted by new speakers is no longer the UR used by older speakers. This is what FGHS makes predictions about: whenever a change must occur which would trigger a ranking paradox in order to derive it from the input, then a later form can be identified as having become the new UR. This is something which was noted to be an advantage over traditional rules-based models, as a list of ordered rules cannot naturally predict when speakers would adopt a new UR. Rather, lists of rules if anything predict that each speaker of English is deriving directly from Proto-Indo-European, albeit by a ludicrously long derivation. As we can agree such a thing is absurd, the advantage must be given to FGHS.

Chapter 4 also discussed criticisms of using OT as a historical model. These criticisms were largely argued against by various means, though some were acknowledged as sound. Most importantly, it was argued that there is no principled reason to hold that constraint-based models are inherently incapable of analyzing diachronic data. It was also conceded that many OT-based models, including HS, have problems analyzing instances of opacity, a weakness which must be properly addressed if we are to fully transition into the use of constraint-based diachronic models. The discussion then turned to how FGHS specifically avoids most of the issues which affect diachronic OT. By showing the places where FGHS improved on OT, while acknowledging that it inherits the limitations of classic HS regarding opacity, the dissertation asserted that FGHS was a legitimate option for diachronic phonology. It also noted that FGHS, by predicting when inputs changed across generations, could possibly resolve the HS opacity problem, though only so long as there are no productive opaque processes.

The dissertation then turned to discuss the RUKI Sound Law in detail. There was an expanded discussion of the various solutions which have been proposed over the past century,

with a particular focus on the analyses of Zwicky (1970), Allen (1973), and Vennemann (1974). This dissertation most strongly followed after Allen (1973) and Zwicky (1970), disagreeing with the view that RUKI could be understood as any coherent natural class. Following from Allen (1973), this dissertation asserted that RUKI is best treated as multiple changes which were later neutralized. More specifically, this dissertation argued that, since there was only a single fricative *s in Sanskrit prior to RUKI, this fricative was subject to place-assimilating allophony in all positions it appeared. These place-assimilated allophones were the subjects of that later neutralization, with [ʃ] being favoured as the output. The outstanding question then, of course, is why RUKI is not observed after other segments.

The solution to this was found in an analysis of 3523 Sanskrit tokens of either [s] or [ʃ]. In this data, it was found that 99.01% of [s ʃ] tokens appeared after dentals, placeless segments, or RUKI segments. Other segments preceded the fricatives a mere 0.99% of the time. This result strongly supported the hypothesis that the RUKI Set is not, in fact, any sort of natural class. It is rather what was termed an ‘accidental class’, a set of segments united not by any featural or acoustic characteristics, but simply by the accident of distribution. The RUKI Sound Law does not need to explain why only [r u k i] triggered the change, and why other seemingly logical segments did not. The fact of the matter is that [r u k i] were really the only segments which both could cause visible assimilation and were in positions which allowed them to interact with *s. However, it was noted that further research should be done to determine whether the distribution of *s itself is truly just an accident, or if it derives from some other principle.

This distributional explanation formed the basis for the formal analysis. Chapter 6 provided this, showing FGHS analyses for each of the RUKI segments. The constraint rankings correctly predicted the attested output, but were notably of such a kind that they would also predict similar

changes for nearly any non-dental segment which preceded *s. This is indeed the contention of the dissertation: that any segment with a non-dental place could have participated in RUKI, but did not simply because practically nothing but the RUKI segments were in position to alter *s.

This led into the discussion, which explained the implications of the analysis in particular and FGHS as a whole. It argued that the FGHS RUKI analysis is strong evidence of the validity of FGHS as a model for diachronic change. From this central point, it further argued for the advantages of FGHS over both OT and rules-based phonology. Potential avenues for further research were discussed, with particular attention paid to places where FGHS requires further development.

FGHS is put forward here as an avenue for a reintegration of some of the different streams of phonological research which have emerged since the introduction of Optimality Theory in the 1990s. Each of these streams has produced excellent work and important discoveries in this time. This dissertation shows what can be accomplished when they are all brought back together, providing a new analysis of an old problem, being the RUKI Sound Law. FGHS restores the embedding of historical development which could be found in rules-based phonology, while also making explicit predictions about the change in underlying representations across generations. We have also put forward the concept of an ‘accidental class’, emphasizing the importance of the lexicon in explaining sound changes. Words which do not exist to not participate in sound changes, and environments which never instantiate in a lexicon do not need to be defined out of the set of triggering environments. These findings point towards the need to restore some of the importance of underlying representations in phonological study, so that we can better understand how the speech of our ancestors has come down to the speech of today.

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Appendix A: The RUKI Data

Dictionary Transcription	IPA Transcription	[s]?	[ʃ]?	r_?	u_?	k_?	i_?	e_?	o_?	n_?	a_?	h_?	Labial	Dental	Other	EX
Sum Totals	3523	1896	1627	209	349	616	442	76	65	83	1529	33	28	86	7	423
Percentages (%)		53.82	46.18	5.93	9.91	17.49	12.55	2.16	1.85	2.36	43.40	0.94	0.79	2.44	0.20	12
ámsa	ansa	1								1						
amsa-kûta	ansaku:ta	1								1						
amsa-prishatha	ansapriṣaṭṭha	1	1				1			1						
ámsa-tra	ansatra	1								1						
amsa-phalaka	ansa-p ^h alaka	1								1						
amsa-la	ansala	1								1						
amsa-vartin	ansavartin	1								1						
amsa-vivartin	ansavivartin	1								1						
amsa-vyâpin	ansavja:pin	1								1						
ámh-as	anhas	1									1					
á-kanishtha	akaniṣṭha		1				1									
akali-prasara	akaliprasara	1									1					
a-kasmât	akasma:t	1									1					
akasmâd-âgantu	akasma:d a:gantu	1									1					
a-kâma-tas	aka:matas	1									1					
akâla-kusuma	aka:lakusuma	1			1											1
a-kâla-kshepam	aka:lakṣepam		1			1										
a-kâla-saha	aka:lasaha	1									1					
a-kutas	akutas	1									1					
a-kutsita	akutsita	1												1		
a-kusumita	akusumita	1			1											1
a-krita-lakshana	akritalakṣana		1			1										
a-krita-srana	akritasrana	1									1					

[illegible]

[illegible]

[illegible]

aṅka-lakshana	aṅkalakṣaṇa		1			1									
āṅk-as	aṅkas	1								1					
aṅkasâsya	aṅkasa:sja	2								2					
aṅga-yashti	aṅgajaṣṭi		1							1					1
aṅga-rakshaka	aṅgarakṣaka		1			1									
aṅga-rakshâ	aṅgarakṣa:		1			1									
aṅga-samskâra	aṅgasanska:ra	2				1				1					
aṅga-sam-â-khyâyam	aṅgasam a:k ^h ja:jam	1								1					
aṅga-sparsa	aṅgasparça	1								1					
aṅgû-shtha	aṅguṣṭ ^h a		1		1										
aṅgushtha-ya	aṅguṣṭ ^h aja		1		1										
aṅgushtha-parvan	aṅguṣṭ ^h aparvan		1		1										
âka-sam-ud	akasamud	1								1					
âka-sam	akasam	1								1					
a-kshur-vishaya	acakṣurviṣaja		2			1	1								
a-kashus	acakṣus	1	1			1				1					1
akarama-vayas	acaramavajas	1								1					
a-kikitsaniyâ	akikitsanija:	1											1		
akira-bhâs	acirab ^h a:s	1								1					
akira-rokis	acirarocis	1					1								1
akira-amsu	aciransu	1								1					
a-ketâs	acetas	1								1					
akeshta	aceṣṭa		1					1							
aga-gala-stana	ajagalastana	1								1					
â-gasra	agasra	1								1					
a-gâta-paksha	aga:tapakṣa		1			1									
a-gâta-ragas	aga:tarajas	1								1					
a-gigîsha	ajagi:ṣa		1				1								
a-gugupsita	ajugupsita	1										1			

a-gahal-lakshanâ	aḡahallak:ṣaṇa		1			1										
á-gushta	aḡuṣṭa		1		1											
á-gñâta-vâsa	aḡna:tava:sa	1								1						
á-gñâsa-tas	aḡna:satas	1								1						
á-gñâs	aḡna:s	1								1						
a-gyeshthá	aḡjeṣṭha		1					1								
aṅgvriksha	aṅḡvrikṣa		1			1										
aṅg-as	aṅḡas	1								1						
aṅgah-savá	aṅḡahsava	1									1					
atta-hâsa	a:ṭṭa:ha:sa	1								1						
án-ishtha	a:ṇiṣṭha		1				1									
án-îyas	ani:jas	1								1						
a-tattva-tas	atattvatas	1								1						
a-tapas	atapas	1								1						
a-tamisra	atamisra	1					1									
á-tas	atas	1								1						
ati-kashtha	atikaṣṭha:		1							1						1
ati-krishna	atikriṣṇa		1				1									
ati-garîyas	atigari:jas	1								1						
ati-kirasya	aticirasja	1								1						
ati-kkhandas	aticc ^h andas	1								1						
ati-tapasvin	atitapasvin	1								1						
ati-titîrshu	atititi:ṣu		1				1									
ati-trishnâ	atitriṣṇa:		1				1									
ati-trishna	atitriṣṇa		1				1									
ati-tegas	atitejas	1								1						
atithi-satkâra	atit ^h satka:ra	1					1									1
ati-durdharsha	atidurdarṣa		1	1												
ati-durmanas	atidurmanas	1								1						

[illegible]

ati-vimanas	ativimanas	1								1					
ati-vishama	ativişama		1				1								
ati-vistara	ativistara	1					1								1
ati-tas	atitas	1								1					
ati-vistâra	ativista:ra	1					1								1
ati-vistîrna	ativisti:rṇa	1					1								1
ati-visârin	ativisa:rin	1					1								1
ati-vrışti	ativręti		1	1											
ati-vaishamya	ativaişamja		1				1								
ati- vaikakshanya	ativaicakşanja		1			1									
ati-vyasana	ativjasana	1								1					
ati-vyasanin	ativjasanin	1								1					
ati-sastra	atiçastra	1								1					
ati-slishṭa	atiçlişṭa		1				1								
ati-shkând	atişkand		1				1								
â-tişṭhat	atişṭhat		1				1								
ati-sakti	atisakti	1					1								1
ati-sakhi	atisak ^{hi}	1					1								1
ati-samkata	atisaNkaṭa	1					1								1
ati-samkruddha	atisaNkrudd ^{ha}	1					1								1
ati-samkshepa	atisaNkşepa	1	1			1	1								1
ati-samkaya	atisaNcaja	1					1								1
ati-samrambha	atisaNramb ^{ha}	1					1								1
ati-satvaram	atisatvaram	1					1								1
ati-sa-daya	atisadaja	1					1								1
ati-sadrisa	atisadriça	1					1								1
ati-sam-tata	atisaNtata	1					1								1
ati-sam-dheya	atisaNd ^{he} ja	1					1								1
ati-samnidhâna	atisaNnid ^{ha} :na	1					1								1

ati-samartha	atisamart ^h a	1				1									1
ati-samîpa	atisami:pa	1				1									1
ati-sambhorga	atisaNb ^h oga	1				1									1
ati-sambhrama	atisaNb ^h rama	1				1									1
ati-sarasa	atisarasa	1				1									1
ati-sarga	atisarga	1				1									1
ati-sarpaṇa	atisarpaṇa	1				1									1
ati-sarva	atisarva	1				1									1
ati-saviṣaṅkam	atisaviṣaṅkam	1				1									1
ati-sahasâ	atisahasa:	2				1				1					1
ati-sâmvatsara	atisam:Nvatsara	2				1							1		1
ati-sâdhvasa	atisa:d ^h vasa	2				1				1					1
ati-sândra	atisa:ndra	1				1									1
ati-sâyam	atisa:jam	1				1									1
ati-sâra	atisa:ra	1				1									1
ati-sâhasa	atisa:hasa	1				1									1
ati-sitaāṅga- vihamga	atisitaāṅga vihaNga	1				1									1
ati-sukha	atisuk ^h a	1				1									1
ati-subhaga	atisub ^h aga	1				1									1
ati-surabhi	atisurab ^h i	1				1									1
ati-sulabha	atisulab ^h a	1				1									1
ati-su-vṛtta	atisuvṛtta	1				1									1
ati-sûkshma	atisu:kṣma	1	1			1	1								1
âti-sṛishti	atisrṣṭi	1	1	1		1									1
ati-sauganya	atisaujanja	1				1									1
ati-sauhitya	atisauhitja	1				1									1
ati-sneha	atisneha	1				1									1
ati-svalpa	atisvalpa	1				1									1
ati-svastha	atisvast ^h a	2				1				1					1

ati-harshula	atiharṣula		1	1												
ati-hasita	atihāsita	1									1					
ati-hrishṭa	atihṛṣṭa		1	1												
atī-kāsa	atī:ka:sa	1									1					
a-tīkshṇa	atī:kṣṇa		1			1										
a-tushāra-kara	atuṣa:rakara		1		1											
a-tushta	atuṣṭa		1		1											
a-tushti	atuṣṭi		1		1											
a-trishṇa	atrṣṇa		1	1												
atīashṭi	atīaṣṭi		1								1					1
atiasita	atiasita	1									1					
atī-āyus	atīa:jus	1			1											1
atīāsaṅga	atīa:saṅga	1									1					
atīāsanna	atīa:sanna	1									1					
atīuṣhṇa	atīuṣṇa		1		1											
atīūrgasvala	atīu:rjasvala	1									1					
atīautsukya	atīautsukja	1											1			
a-trasta	atrasta	1									1					
atra-stha	atrast ^h a	1									1					
a-trāsita	atra:sita	1									1					
a-tri-varsha	atrivarṣa		1	1												
atharva-aṅgiras	at ^h arvaṅgiras	1									1					
a-dakshina	adakṣiṇa		1			1										
a-dakshinā	adakṣiṇa		1			1										
a-d-ās	adas	1									1					
a-dākshinya	ada:kṣiṇja		1			1										
a-dāsa	ada:sa	1									1					
á-dits-at	aditsat	1											1			
a-dit-su	aditsu	1											1			
á-sattva	asattva	1									1					

á-sûtra	asu:tra	1									1					
a-vishaya	aviṣaja		1				1									
a-dushta	aduṣṭa		1		1											
a-dûra-tas	adu:ratas	1									1					
a-dûra-stha	adu:rast ^h a	1									1					
a-dushprâpa	aduṣpra:pa		1		1											
a-dushâna	aduṣa:na		1		1											
a-dûsh-ita	adu:ṣita		1		1											
a-driṣhta	adrṣṭa		1				1									
a-purusha	apuruṣa		1		1											
a-para-sâmarthya	apara sa:marth ^h ja	1									1					
a-driṣhti-dâna	adrṣṭida:na		1	1												
a-deva-gushta	adevaṣṭa		1		1											
a-des-a-stha	adeṣast ^h a	1									1					
a-dosha	adoṣa		1						1							
ad-bhis	adb ^h is	1					1									1
ad-bhyas	adb ^h jas	1									1					
adya-divasa	adjadivasa	1									1					
a-dvi-varsha	advivarṣa		1	1												
a-dvesha-râgin	adveṣara:gin		1					1								
a-dveshtri	adveṣṭr		1					1								
adha-keshta	ad ^h aceṣṭa		1					1								
adharaoshtha	ad ^h araoṣṭ ^h a		1						1							
a-dharmishtha	ad ^h armiṣṭ ^h a		1					1								
a-dharshana	ad ^h aṣaṇa		1	1												
a-dharshanîya	ad ^h aṣaṇi:ja		1	1												
adhás	ad ^h as	1									1					
adhas-tala	ad ^h astala	1									1					
adhás-tât	ad ^h asta:t	1									1					

adhah-stha	ad ^h aHst ^h a	1									1					
a-dhârâ-varsha	ad ^h a:ra:varṣa		1	1												
adhika-vayas	ad ^h ikavajas	1									1					
adhi-kashta	ad ^h ikaṣṭa		1								1					1
adhi-kshepa	ad ^h ikṣepa		1			1										
adhi-purusha	ad ^h ipuruṣa		1		1											
adhi-paurusha	ad ^h ipauruṣa		1		1											
adhi-bubhû-shu	ad ^h ibub ^h u:ṣu		1		1											
adhi-rukma- mandira- gavâksham	ad ^h irukmaman diragava:kṣam		1			1										
adhi-vakshas	ad ^h ivakṣas	1	1			1					1					
adhi-varkas	ad ^h ivarcas	1									1					
adhi-vasati	ad ^h ivasati	1									1					
adhi-vâsa	ad ^h iva:sa	1									1					
adhi-shâvana	ad ^h iṣavaṇa		1				1									
adhi-shthâ-tri	ad ^h iṣṭ ^h a:tr		1				1									
adhi-shthana	ad ^h iṣṭ ^h ana		1				1									
adhi-shthita	ad ^h iṣṭ ^h ita		1				1									
adhi-senâpati	ad ^h isena:pati	1					1									1
adhi-hasti	ad ^h ihasti	1									1					
adhîraaksha	ad ^h iraakṣa		1			1										
adhî-vâsâ	ad ^h i:va:sa	1									1					
â-drishṭa	adrṣṭa		1	1												
â-drishya	adrṣja		1	1												
adho-kshâ	ad ^h okṣa		1			1										
adho-ksha-ga	ad ^h okṣaja		1			1										
adho-drishṭi	ad ^h odrṣṭi		1	1												
adhovekshin	ad ^h ovekṣin		1			1										
adhiamsa	ad ^h iaNsa	1									1					

adhiaksha	ad ^{hi} akṣa		1			1										
adhiadhikshepa	ad ^{hi} ad ^{hi} ikṣepa		1			1										
adhiayana-sampradâna	ad ^{hi} ajana samprada:na	1								1						
adhiava-sâna	ad ^{hi} iavasa:na	1								1						
adhiava-sâjita	ad ^{hi} iavasa:jita	1								1						
adhiava-sâjin	ad ^{hi} iavasa:jin	1								1						
adhiava-sita	ad ^{hi} iavasita	1								1						
adhiâsa	ad ^{hi} iasa	1								1						
adhiâs-ita	ad ^{hi} iasita	1								1						
adhiâs-itavya	ad ^{hi} iasitavja	1								1						
adhiâs-in	ad ^{hi} iasin	1								1						
adhiuras	ad ^{hi} iuras	1								1						
adhiushita	ad ^{hi} iuṣita		1		1											
adhieshana	ad ^{hi} ieṣaṇa		1					1								
anu-sam	anusam	1			1											1
an-akshara	anakṣara		1			1										
an-ati-trasnu	anatitrasnu	1								1						
an-anu-tishth-at	ananuṣṭ ^{hi} at		1				1									
an-anushthâtri	ananuṣṭ ^{hi} a:tr		1		1											
an-anushthâna	ananuṣṭ ^{hi} a:na		1		1											
an-anu-samdhâna	ananusaNḍ ^{hi} a:na	1			1											1
an-anusarana	ananusaraṇa	1			1											1
ananta-si ^{hi} ra	anantasi:ra	1								1						
an-antika-stha	anantikast ^{hi} a	1								1						
ananya-drishṭi	ananjadṛṣṭi		1	1												
ananya-na ^{hi} ri-sa ^{hi} ma ^{hi}	ananja narisama	1					1									1
ananya-manas	ananjamas	1								1						
ananya-ma ^{hi} nasa	ananja ma:nasa	1								1						

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anu-sva [^] ra	anusva:ra	1			1											1
anu-rikshara'	anurkṣara		1			1										
anu-ri-naakartos	anurṇaakartos	1						1								1
a'n-samhita	ansa ^N hita	1							1							
a'n-abhi-samsana	anab ^h iṣa ^N sana	1							1							
an-tva-sas	antvaṣas	1								1						
an-tva-sam-sayaukkhedin	antvasa ^N ṣajaucc ^h edin	1								1						
an-tva-samstha [^] na	antva ^{saNst^ha:na}	2							1	1						
an-tva-san.khya	antvasaṅk ^h ja	1								1						
anekaupava [^] sa	aneka upava:sa	1								1						
an-ena's	anenas	1								1						
an-ehas	anehas	1								1						
an-ogas	anojas	1								1						
an-aushadha	anauṣad ^h a		1		1											
anta-ta's	antatas	1								1						
a'nta-tasmin	antatasmin	1								1						
antara-ta's	antaratas	1								1						
antara-pu [^] rusha	antarapu:ruṣa		1		1											
antara-prepsu	antaraprepsu	1										1				
antara-stha	antarast ^h a	1								1						
antara-sthita	antarast ^h ita	1								1						
antaraanveshin	antaraanveṣin		1					1								
anta'r-iksha	antarikṣa		1			1										
antarikshaga	antarikṣaga		1			1										
antar-i [^] ksha	antarikṣa		1			1										
antar-ushya	antaruṣja		1		1											
antar-gala-niva [^] sin	antarja laniva:sin	1								1						

antar-gala-supta	antar jalasupta	1									1					
antar-dushta	antarduşṭa		1		1											
antar-gyotis	antarjyotis	1					1									1
antar-ba ^h shpa	antarba:ṣpa		1								1					1
antar- madaavastha	antar madaavast ^h a	1									1					
antar-vastra	antarvastra	1									1					
antar-va ^h sa	antarva:sa	1									1					
antar-va ^h sika	antarva:sika	1									1					
antar-va ^h sas	antarva:sas	1									1					
antar-visha	antarviṣa		1				1									
antar-ha ^h sa	antarha:sa	1									1					
anta-satkriya	antasatrkrija	1									1					
antas-tapa	antastapa	1									1					
antah-samgn ^h a	antahsaNjña	1										1				
anta-sattva	antasattva	1									1					
anta-salila	antasalila	1									1					
anta-salila-stha	antasalilast ^h a	1									1					
anta-sa ^h nu	antasa:nu	1									1					
anta-sara	antasara	1									1					
anta-sukha	antasuk ^h a	1									1					
anta-stha	antast ^h a	1									1					
andha-tamasa	and ^h atamasa	1									1					
andha-ta ^h misra	and ^h ata:misra	1									1					
a'ndh-as	and ^h as	1									1					
a'ndhas	and ^h as	1									1					
a'nna-dosha	annadoṣa		1						1							
a'nna-rasa	annarasa	1									1					
a'nna-samkara	annasaNkara	1									1					
anya-ketas	anjacetas	1									1					

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a-ketas	acetas	1									1					
apaaya- samdarsana-ga	apaaja saNdarçanaaja	1									1					
api-sasas	apiçasas	2									2					
a-pums	apuNs	1								1						
apurush aapara^dha	apuruşa apara:d^a		1		1											
a-pushkala	apuşkala		1		1											
a-pushpa'	apuşpa		1		1											
a-prishta	aprşta		1	1												
apai^ksha^	apai:kşa:		1			1										
apaikshita	apai:kşita		1			1										
apekshin	apekşin		1			1										
apekshya	apekşja		1			1										
a'p-nas	apnas	1									1					
a'-praketas	apracetas	1									1					
a'-pra-gas	aprajas	1									1					
a'-pra-ga's-ta^	aprajasta	1									1					
apra'-gasya'	aprajasja	1									1					
a-pratima-ogas	apratimaojas	1									1					
a-prati-sa^sana	apraţa:sana	1									1					
a-prati-sheda	apraţed^a		1				1									
a-prati-shtha	apraţş^a		1				1									
a-prati-shthita	apraţş^ita		1				1									
a-pratiaksha	apraţiakşa		1			1										
a-pradakshinam	apradakşinam		1			1										
a-pra-dushta	apraduşta		1		1											
a-pradhrishya	aprad^rşja		1	1												
a-pra-va^sa- gamana	aprava: sagamana	1									1					
a-pra-sasta	apraçasta	1									1					

abhi-ka^n.ksha	ab ^h ika:ṛkṣa		1			1										
a-bhiksha-da~	ab ^h ikṣada		1			1										
abhi-kakshana	ab ^h icakṣaṇa		1			1										
abhi-ka'kshe	ab ^h icakṣe		1			1										
abhi'-tas	ab ^h itas	1									1					
abhi-vayaska	ab ^h ivajaska	1									1					
abhi-na^sika-vivaram	ab ^h ina:sika vivaram	1									1					
a'-stṭhi	ast ^h iti	1									1					
abhi-prishthe	ab ^h iprṣṭ ^h e		1	1												
abhi-praka'kshe	ab ^h ipracakṣe		1			1										
abhi-prepsu	ab ^h iprepsu	1										1				
abhi-bha^shana	ab ^h ib ^h a:ṣaṇa		1								1					1
abhi-bha^shin	ab ^h ib ^h a:ṣin		1								1					1
abhi-sva^min	ab ^h isva:min	1					1									1
abhi-rakshana	ab ^h irakṣaṇa		1			1										
abhi-raksha^	ab ^h irakṣa:		1			1										
abhi-rakshitri	ab ^h irakṣitr		1			1										
abhi-lakshya	ab ^h ilakṣja		1			1										
abhi-lakshyam	ab ^h ilakṣjam		1			1										
abhi-lashani^ya	ab ^h ilaṣaṇi:ja		1								1					1
abhi-lashya	ab ^h ilaṣja		1								1					1
abhi-lashita	ab ^h ilaṣita		1								1					1
abhi-la^sha	ab ^h ila:ṣa		1								1					1
abhi-la^shuka	ab ^h ila:ṣuka		1								1					1
abhi-samsana	ab ^h iṣaNsana	1								1						
abhi-samsin	ab ^h iṣaNsin	1								1						
abhi-sastaka	ab ^h iṣastaka	1									1					
abhi-sasti	ab ^h iṣasti	1									1					
abhi-siras	ab ^h iṣiras	1									1					

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a-dosha	adoṣa		1					1								
a-bhu^mi-shta	ab ^h u:miṣṭa		1				1									
a-bhu^yah-samnivritti	ab ^h u:jah saNnivritti	1									1					
a-bhu^yishtha	ab ^h u:jahiṣṭha		1				1									
abhiasana	ab ^h iasana	1									1					
abhiasu^yaka	ab ^h iasu:jaka	1									1					
abhiasta	ab ^h iasta	1									1					
abhiastam	ab ^h iastam	1									1					
abhia^sa	ab ^h ia:sa	1									1					
abhya^sin	ab ^h ja:sin	1									1					
abhiukshana	ab ^h iuṣaṇa		1		1											
abhiupa gama-tas	ab ^h iupag amatas	1									1					
abhram-kasha	ab ^h raNkaṣa		1								1					1
a-bhru^-vilasa	ab ^h ru:vilasa	1									1					
a-matsara	amatsara	1												1		
a'-manas	amanas	1									1					
a-manas-ka	amanaska	1									1					
a-manushya- nishevita	amanuṣja niṣevita		2		1		1									
a-paksha-pa^tin	apakṣapa:tin		1			1										
a-dvish	adviṣ		1				1									
amara-sadas	amarasadas	2									2					
amara-sarit	amarasarit	1									1					
a-marsh-a	amarṣa		1	1												
a-ma^msa- bhaksha	ama:Nsab ^h akṣa	1	1			1				1						
a'-ma^nusha	ama:nuṣa		1		1											
ama^-va^s-i^	ama:va:si:	1									1					
amitra-karshana	amitrakarṣaṇa		1	1												
a-mi^ma^msya	ami:ma:Nsja	1								1						

amu'-tas	amutas	1									1					
a-bha^shana	ab ^h a:ṣaṇa		1								1					
a-varshin	avarṣin		1	1												
amrīsh-ya- ma^na	amrṣjama:na		1	1												
a-krodha-harsha	akrod ^h ahaṛṣa		1	1												
ambarisha	ambariṣa		1				1									
ambaraokas	ambaraokas	1									1					
amba-sh ^t ha	ambaṣṭ ^h a		1								1					1
ambu-aksha	ambuakṣa		1			1										
ambu-a^sana^	ambua:sana:	1									1					
ambu-pakshin	ambupakṣin		1			1										
a'mbas	ambas	1									1					
a'mbas-tas	ambastas	2									2					
a-yakshma'	ajakṣma		1			1										
a-yatna-tas	ajatnatas	1									1					
a-yatha^-sthita	ajath ^a :st ^h ita	1									1					
a-yasas	ajaças	1									1					
a'y-as	ajas	1									1					
a-yuk-san.khya	ajuksaṇk ^h ja	1				1										1
a-yuga-sapti	ajugasapti	1									1					
a-yuga-arkis	ajugaarcis	1					1									1
a-raga's	araṇas	1									1					
a'ran-va^sa	aranva:sa	1								1						
a'ran-va^sin	aranva:sin	1								1						
a'ran-shash ^t ika^	araṇṣaṣṭ ^t ika:		2							1	1					2
aranyaokas	aranjaokas	1									1					
a-ratnaa^loka- samha^rya	aratnaa:loka saNha:rja	1									1					
a-rantos	arantos	1							1							1
a-rasa'	arasa	1									1					

a-rasika	arasika	1									1					
a-ra^ga'-lakshman	ara:jalakṣman		1			1										
ar-i'-karshana	arikaṣaṇa		1			1										
a'-rishta	ariṣṭa		1				1									
a'-rishti	ariṣṭi		1				1									
ari-su^dana	arisu:dana	1					1									1
ar-psu	arpsu	1											1			
arunaanuga-arkis	aruṇaa nujaarcia	1					1									1
a-rush	aruṣ		1		1											
a-rusha	aruṣa		1		1											
a-rushyat	aruṣjat		1		1											
a'rushi^	aruṣi:		1		1											
a-repas	arepas	1									1					
arkish-mat	arciṣmat		1				1									
ark-i's	arcis	1					1									1
arna-sarid-a^srita	arṇasa rida:çrita	1									1					
a'r-nas	arṇas	1									1					
a'rna-sati	arṇasati	1									1					
artha-kilbishin	art ^b akilbiṣin		1				1									
artha-tas	art ^b atas	1									1					
artha-trishna^	art ^b atrṣṇa:		1	1												
artha-du^shana	art ^b adu:ṣaṇa		1		1											
artha-pa^-rushya	art ^b apa:ruṣja		1		1											
artha-sastra	art ^b açastra	1									1					
artha-samsiddhi	art ^b asaNsidd ^b i	2								1	1					
artha-samkaya	art ^b asaNjaja		1								1					
artha-samdeha	art ^b asaNdeha		1								1					

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a-lakshmi^	alakṣmi		1			1										
a-lakshya	alakṣja		1			1										
a-laksh-ana	alakṣaṇa		1			1										
alam-kar-ishnu	alaNkariṣṇu		1				1									
alam-artha-vakas	alamart ^h avacas	1									1					
alambusha^	alaNbuṣa:		1		1											
a^k-shana	a:kṣaṇa		1			1										
a-la^sya	ala:sja	1									1					
ali^ka-supta	ali:kasupta	1									1					
a-lupta-sattva-kosa	aluptasa ttvakoṣa	1									1					
a-loka-sa^ma^nya	alokas a:ma:nja	1									1					
alpa-tegas	alphatejas	1									1					
alpa-medhas	alphamed ^h as	1									1					
alpa-sa's	alpaças	1									1					
alpa-sesha	alpaçeṣa		1					1								
alpa-sattva	alpasattva	1									1					
alpa-sa^ra	alpasa:ra	1									1					
alpa-sna^yu	alpasna:ju	1									1					
alpa-svara	alpasvara	1									1					
alpaan.ga-a^yus	alpaanḡaa:jus	1			1											1
alpaan.ga-bha^s	alpaanḡb ^h a:s	1									1					
alpaan.ga-avasishta	alpaanḡ aavaçiṣṭa		1				1									
alp-i^yas	alpi:jas	1									1					
ava-kshepa	avakṣepa		1			1										
ava-garsha-na	avagarṣaṇa		1	1												
ava-kiki^sha^	avacici:ṣa:		1				1									
ava-tamsa	avataNsa	1								1						
ava-tamsa-ya	avataNsa ^j a	1								1						

avatamsi^~kri	avataNsi:kr	1								1						
ava-tamasa	avatamasa	1									1					
ava-tar-titi^rshu	avatartiti:rṣu		1	1												
a-vatsa^	avatsa:	1												1		
a-vyavasa^~ya- va^hya	avjavasa: java:hja	1									1					
ava-dhamsa'	avad ^h aNsa	1								1						
avanti-sundari^	avantisundari:	1					1									1
avanti-sena	avantisena	1					1									1
avanti-sva^min	avantisva:min	1					1									1
a-prasa^da	aprasa:da	1									1					
ava-bhas-a	avab ^h asa	1									1					
a-varka's	avarcas	1									1					
a-varsha	avarṣa		1	1												
a-varštos	avarṣtos		1	1												1
ava-sish-ta	avaṣiṣṭa		1				1									
ava-sesha	avaṣeṣa		1					1								
ava-sya^	avasja:	1									1					
ava-shtabh-ya	avaṣṭab ^h ja		1								1					1
a'v-as	avas	1									1					
ava's	avas	1									1					
ava-sakta	avasakta	1									1					
ava-sak-thika^	avasakt ^h ika:	1									1					
ava-sanna	avasanna	1									1					
ava-sara	avasara	1									1					
ava-sa'rpana	avasarpaṇa	1									1					
ava-sarpini^	avasarpinī:	1									1					
ava-sana	avasana	1									1					
ava-sita	avasita	1									1					
ava-siti	avasiti	1									1					

ava-seka	avaseka	1								1					
ava-sekana	avasecana	1								1					
ava-skand-a	avaskanda	1								1					
ava-skara	avaskara	1								1					
ava's-ta^t	avastat	1								1					
a-vastu	avastu	1								1					
ava-stha'	avast ^h a	1								1					
a-sthita	ast ^h ita	1								1					
a-sthiti	ast ^h iti	1								1					
ava-sphotana	avasp ^h oṭana	1								1					
avas-yu	avasju	1								1					
ava-ha^sa	avaha:sa	1								1					
ava-ha^syu	avaha:sju	1								1					
a-va^ñ.-manasa-gokara	avañmanasa gocara	1								1					
a'-vi-kshata	avikṣata		1			1									
a'-vi-kshubdha	avikṣubd ^h a		1			1									
a-vi-khya^ta-dosha	avik ^h ja:tadoṣa		1						1						
a-vikakshana	avicaḁṣaṇa		1			1									
a-vida^sin	avidasi:n	1								1					
a'-vidush-tara	aviduṣṭara		1			1									
a'-vidvishe	avidviṣe		1				1								
a'-vidvas	avidvas	1								1					
a'-vidvesha	avidveṣa		1					1							
a-vibu^shana	avibu:ṣaṇa		1			1									
a-vi-sishta	aviṁṣṭa		1				1								
a-visastri'	aviṁastr	1								1					
a-visesh-a	aviṁeṣa		1					1							1
a-vi-svas-at	aviṁvasat	1								1					
a-visha	aviṣa		1				1								

a-visva^s-a	aviçva:sa	1									1					
a-vi-shakta	aviṣakta		1				1									
a-vishaya	aviṣaja		1				1									
a-vi-shahya	aviṣahja		1				1									
a-visha^d-a	aviṣa:da		1				1									
a'v-ishtha	aviṣṭ ^h a		1				1									
avi-shya	aviṣja		1				1									
a-vi-sti^rna	avisti:rṇa	1					1									1
a-vi-spaṣhta	avispaṣṭa	1	1				1				1					1
a-vi-spandita	avispandita	1					1									1
a-vi-smita	avismita	1					1									1
a-vi-smṛita	avismṛta	1					1									1
a-vi-hita-siddha	avihitasidd ^h a	1									1					
a-vii^kṣhita	avii:kṣita		1			1										
a-vrīṣhana	avrṣaṇa		1	1												
a-vrīṣhta	avrṣṭa		1	1												
a'-vrīṣhti	avrṣṭi		1	1												
avai^kṣh-ana	avai:kṣaṇa		1	1												
a-vesa-sadrīṣa	aveṣasadrṣa	1									1					
a-vairi-guṣhta	avairiguṣṭa		1		1											
avaukṣhana	avaukṣaṇa		1			1										
a-vyavasa^yin	avjavasa:jin	1									1					
a-vyava-stha	avjavast ^h a	1									1					
a-vyava-sthita-kitta	avjivas t ^h itacitta	1									1					
a'-viuṣhta	aviuṣṭa		1		1											
asana^pīpa^se	açana:pīpa:se	1									1					
a-sanais	açanais	1					1									1
a-sa's	aças	1									1					
a-sastra	açastra	1									1					

a-sa^s-at	aça:sat	1									1					
a-sa^stra- kakshus	aça:stra cakşus	2	1		1	1					1					1
a-sikshita	açikşita		1			1										
a-siva-samsin	açivaçaNsin	1								1						
a-bhakshana	ab ^h akşana		1			1										
a-sesha	açeşa		1					1								
asesha-ya	açeşaja		1					1								
a-vriksha	avrkşa		1			1										
a-soshya	açoşja		1						1							
a-sreyas	açrejas	1									1					
a's-gha^sa	açg ^h a:sa	1									1					
asva-pa^-da^ta- sa^rameya- maya	açvapa: da:tasa: ramejamaja	1									1					
asva-ra^dhas	açvara:d ^h as	1									1					
asva-vrisha'	açvavrşa		1	1												
asva-sa^da	açvasa:da	1									1					1
asva-sa^din	açvasa:din	1									1					
asva-sa^ra-thya	açvasa:rat ^h ja	1									1					
asva-sena	açvasena	1									1					
asva-stha^na	açvast ^h a:na	1									1					
a'-sha^dha	aşa:d ^h a		1								1					1
asha^dhin	aşa:d ^h in		1								1					1
ash-ta	aştā		1								1					1
ash-ta-ka	aştāka		1								1					1
ash-ta'n	aştān		1								1					1
ashta-pada	aştāpada		1								1					1
asta-ma'	aştāma		1								1					1
ashta-mu^rti	aştāmu:rti		1								1					1
ashta-varsha	aştāvarşa		2	1							1					1

ashta-pushpika^	aṣṭapuṣpika:		2		1						1				1
ashta-shashti	aṣṭaṣaṣṭi		3								3				1
ashtaakshara	aṣṭaakṣara		2		1						1				1
ashta^-dasa'	aṣṭa:daça		1								1				1
ashtaadhya^yi^	aṣṭaad ^h ja:ji:		1								1				1
ashta-navati	aṣṭanavati		1								1				1
ashta-rasaa^sraya	aṣṭaras aa:çraja		1								1				1
ashta-pad	aṣṭapad		1								1				1
ashta^-pada	aṣṭapada		1								1				1
ashtaa^yudha	aṣṭaa:jud ^h a		1								1				1
ashta-vakra	aṣṭavakra		1								1				1
ashtaasi^ti-sahasra	aṣṭaas:ti ahasra	3	1			1					3				2
ashtauttara	aṣṭauttara		1								1				1
ash-ti	aṣṭi		1								1				1
a'sh-tra^	aṣṭra		1								1				1
asht ^h i^la^	aṣṭ ^h i:la		1								1				1
asht ^h i^-va't	aṣṭ ^h i:vat		1								1				1
a's-ti	asti	1									1				
a's-asmi	asasmi	2									2				
asti	asti	1									1				
a's-ya	asja	1									1				
adhya^sita	ad ^h a:sita	1									1				
apa^sya	apa:sja	1									1				
a-sam-yama	asaNjama	1									1				
a-sam-lakshita	asaNlakṣita	1	1		1						1				
a-samsaya	asaNçaja	1									1				
a-slesha	açleṣa		1					1							
a-sam-sarga	açaNsarga	1								1					
a-sam-sa^rin	açaNsa:rin	1								1					

a-sam-srishta	açaNsrṣṭa		1	1												
a-sam-srishtin	açaNsrṣṭin		1	1												
a-sam-ska^ra	açaNska:ra	1							1							
a-sam-skrita	açaNskrita	1							1							
a-sam-stuta	açaNstuta	1							1							
a-sam-sthita	açaNst ^h ita	1							1							
a-sam-sprishta	açaNsprṣṭa	1	1	1					1							
a-sakrit	asakrt	1								1						
a-sakta	asakta	1								1						
a-samkara	asaNkara	1								1						
a-sam-kshipta	asaNkṣipta	1	1			1				1						
a-samkhya	asaNk ^h ya	1								1						
a'-san.ga	asaṅga	1								1						
a-sam-gata	asaNgata	1								1						
a-sam-sukham	asaNsuk ^h am	2							1	1						
a-sa-gati^	asajati:	1								1						
a-sag-gana	asaṅjana	1								1						
a-sagga-ma^na	asaṅgama:na	1								1						
a-sam-ketaya-ma^na	asaNcetaja ma:na	1								1						
a-sam-ga^ta	asaNja:ta	1								1						
a-samgn~a	asaNjña	1								1						
a'-samgn~a^	asaNjña:	1								1						
a'-sat	asat	1								1						
a-satya'	asatja	1								1						
a-sam-dha	asaNd ^h a	1								1						
asat-samparka	asatsaNparka	2								1				1		
a-sadr̥sa	asadr̥ṣa	1								1						
asad-graha	asadgraha	1								1						
as-a'n	asan	1								1						

a's-ana	asana	1									1					
a-sa-na^ma	asana:ma	1									1					
a-sam-ta^pa	asaNta:pa	1									1					
a-sam-tushta	asaNtuṣṭa	1	1		1						1					
a-sam-toṣha	asaNtoṣa	1	1						1		1					
a-sam-dadha^na	asaNd^ha:na	1									1					
a-sam-naddha	asaNnadd^ha	1									1					
a'-sa-patna	asapatna	1									1					
a'-sama	asama	1									1					
a-sama	asama	1									1					
a-samagra	asamagra	1									1					
a-saman~ga	asamaṇja	1									1					
a'-samad	asamad	1									1					
a-samana'	asamana	1									1					
a-samaya	asamaja	1									1					
a-samartha	asamarth^a	1									1					
asama-va^na	asamava:ṇa	1									1					
a-sam-avaita	asamavaita	1									1					
a'-sama^na	asama:na	1									1					
a-sam-asta	asamasta	2									2					
asama-sa^yaka	asamasa:jaka	2									2					
a-sam-a^pta	asama:pta	1									1					
a-sama^vrittaka	asama:vrttaka	1									1					
a-sam-i^kshya	asami:kṣja	1	1		1						1					
a-sam-i^rita	asami:rita	1									1					
a-sam-patti	asaNpatti	1									1					
a-sam-baddha	asaNbadd^ha	1									1					
a-sam-bhava	asaNb^hava	1									1					
a-sam-bha^shana	asaNb^ha:ṣaṇa	1	1								2					1

a-sam-bha [^] sha	asaNb ^h a:ṣa	1	1								2					1
a-sam-bha [^] shya	asaNb ^h a:ṣja	1	1								2					1
a-sam-mata	asaNmata	1									1					
a-sam-mrisha	asaNmṛṣṭa	1	1	1							1					
a-samyak	asamjak	1									1					
a-sarpa-bhu [^] ta	asarpab ^h u:ta	1									1					
a'-sarva	asarva	1									1					
a-savarna	asavarṇa	1									1					
a-savya	asavja	1									1					
a'-sask-at	asaṣcat	1									1					
a'-sasat	asasat	2									2					
a-sah-a	asaha	1									1					
a-saha [^] y-a	asaha:ja	1									1					
a-sah-ishnu	asahiṣṇu	1	1				1				1					
a-sa [^] kshika	asa:kṣika	1	1			1					1					
a-sa [^] da'	asa:da	1									1					
a-sa [^] drisya	asa:dr̥ja	1									1					
a-sa [^] dh-aka	asa:d ^h aka	1									1					
a-sa [^] dha [^] rana	asa:d ^h araṇa	1									1					
a-sa [^] dhu'	asa:d ^h u	1									1					
a-sa [^] dhya	asa:d ^h ja	1									1					
a-sa [^] manya	asa:Nanja	1									1					
a-sa [^] ma [^] nya	asa:Na:nja	1									1					
a'-sa [^] mi	asa:mi	1									1					
a-sa [^] mprata	asa:Nprata	1									1					
a-sa [^] yaka	asa:jaka	1									1					
a-sa [^] ra	asa:ra	1									1					
a-sa [^] hasa	asa:hasa	2									2					
as-i'	asi	1									1					
a-simha [^] sana	asaNha:sana	2									2					

a-sikta	asikta	1									1					
a'sikni^	asikni:	1									1					
a'-sita	asita	1									1					
a's-ita	asita	1									1					
a-siddha	asidd ^h a	1									1					
a'-siddhi	asidd ^h i	1									1					
asi-dhara	asid ^h ara	1									1					
asi-dha^ra^	asid ^h a:ra:	1									1					
a-sinva'	asinva	1									1					
asi-pattra	asipattra	1									1					
a's-u	asu	1									1					
a-sukha	asuk ^h a	1									1					
a-sukh-in	asuk ^h in	1									1					
a-su-tara	asutara	1									1					
asu-tri'p	asutrp	1									1					
a'su-ni^ti	asuni:ti	1									1					
a-sundara	asundara	1									1					
a-subodha	asubod ^h a	1									1					
a'su-ra	asura	1									1					
a-ru-saksha	arusakṣa		1			1										
asura-druh	asuradruh	1									1					
a-surabhi	asurab ^h i	1									1					
asura-rakshasa'	asurarakṣasa	2	1			1					2					
asurya~	asurja	1									1					
a-sulabha	asulab ^h a	1									1					
a'-sushvi	asuṣvi	1	1		1						1					
asu-su^	asusu:	2			1						1					1
a-sustha	astut ^h a	1									1					
asu-sthiraa^dara	asust ^h iraa:dara	2			1						1					1
a-suhrid	asuhrd	1									1					

asuhrid-gana	asuhrdgaṇa	1									1					
a-su^ki-samka^ra	asu:kisaNka:ra	1									1					
a-su^ti	asu:ti	1									1					
asu^ya	asu:ja	1									1					
asu^yaya	asu:jaja	1									1					
asu^ya	asu:ja	1									1					
a-su^rya'	asu:rja	1									1					
asrik-pan.ka-pesham	asrkpaṇka peṣam	1	1						1		1					
asrig-dha^ra^	asrjd ^h a:ra:	1									1					
a-senya	asenja	1									1					
asrin.-maya	asrṇmaja	1									1					
a's-rig	asrj	1									1					
a-sevaka	asevaka	1									1					
a-sev-a^	aseva	1									1					
a-sodha	asod ^h a	1									1					
a-soma	asoma	1									1					
a-s-au'	asau	1									1					
asau-na^man	asauna:man	1									1					
a-saubha^gya	asaub ^h a:gja	1									1					
a-sauvarṇa	asauvarṇa	1									1					
a'-skanna	askanna	1									1					
a-skhalita	ask ^h alita	1									1					
a's-ta	asta	1									1					
astam-yat	astaNjat	1									1					
asta-giri	astagiri	1									1					
astam-gata	astaNgata	1									1					
a-stabdha	astabd ^h a	1									1					
astam-aya	astamaja	1									1					
a-stambha	astamb ^h a	1									1					

asta-samaya	astasamaja	2									2					
a's-ta^	asta:	1									1					
astaakala	astaacala	1									1					
astaabhila^shin	astaab ^h ila:ṣin	1	1								2					1
a'-stuta	astuta	1									1					
a-stu-tya	astutja	1									1					
astu-vid	astuvid	1									1					
a's-tri	astr	1									1					
a'-strita	astrta	1									1					
a'-steya	asteja	1									1					
as-tra'	astra	1									1					
astr-in	astrin	1									1					
a-stri^	astri:	1									1					
a-sambhogin	asaNb ^h ogin	1									1					
astraup anishad	astraup aniṣad	1									1					
a-stha^na	ast ^h a:na	1									1					
astha^snu	ast ^h a:snu	1									1					
a'sthi	ast ^h i	1									1					
a-sthita	ast ^h ita	1									1					
a-sthiti	ast ^h iti	1									1					
asthi-danta- maya	ast ^h ida ntamaja	1									1					
a'-sthira	ast ^h ira	1									1					
asthi-sesha	ast ^h içeṣa	1	1				1				1					
asthi-sthu^na	ast ^h ist ^h u:ṇa	2					1				1					1
a'-sthu^la	ast ^h u:la	1									1					
a-sna^tri'	asna:tr	1									1					
a-sparsana	asparṣana	1									1					
a-spashta	aspaṣṭa	1	1								2					1

a-spris-at	aspr̥cat	1									1					
a-sprisya	aspr̥cja	1									1					
a-sprishta	aspr̥ṣṭa	1	1	1							1					
a-sprishta- puruṣaantara	aspr̥ṣṭa puruṣaantara	1	2	1	1						1					
a-spriha^	aspr̥ha:	1									1					
a-sma'	asma	1									1					
a'-sma	asma	1									1					
a-sma	asma	1									1					
asmat-ku^li^na	asmatku:li:na	1									1					
asmat-sami^pa- tas	asmar sami:patas	3		1							2					1
asmat-tas	asmattas	2									2					
asma-tra	asmatra	1									1					
asmad-artha	asmadart ^h a	1									1					
asmad-i^ya	asradi:ja	1									1					
asma-dri'ak	asradiac	1									1					
asmad-vat	asradvat	1									1					
asma-yu'	asraju	1									1					
asma'aka	asmaaka	1									1					
asma^aka	asma:aka	1									1					
asma^-dr̥isa	asma:dr̥ṣa	1									1					
a-smriti	asmrti	1									1					
asme'	asme	1									1					
asme'-hiti	asme ^h iti	1									1					
asya-va^m	asjava:m	1									1					
as-ra'	asra	1									1					
a-sridh	asrid ^h	1									1					
a-srema'n	asreman	1									1					
asrauttaram	asrauttaram	1									1					
a-sva	asva	1									1					

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a^nu-ku^l-shan.gika	a:nuku:lshan.gika		1											1		1
a^nu-ku^l-shtubha	a:nuku:lštubha		1											1		1
a^nanda-utsava	a:nandautsava	1												1		
a^ntariksha'	a:ntarikṣa		1			1										
a^nvi^ksh-iki^	a:nvi:kṣiki:		1			1										
sam-anu-pra	samanupra	1													1	
anu-sam-pra	anusampra	1			1											1
a^pat-saha^ya	a:patsaha:ja	1												1		
a^pas	a:pas	1									1					
a^pastamba	a:pastamba	1									1					
a^-gosht ^{hi}	a:goṣṭ ^{hi}		1						1							
a^-pa^rshni	a:pa:rṣṇi		1	1												
a^pta-dakshina	a:ptadakṣiṇa		1			1										
a^-su^kta	a:su:kta	1									1					
a^-brahma-sabham	a:brahmasab ^h am	1									1					
a^-bha^sh-a	a:b ^h a:ṣa		1								1					1
a^bhi-sheka	a:b ^h iṣeka		1			1										
a^bhi-shekanika	a:b ^h iṣecanika		1			1										
a^ma^va^sya'	a:ma:va:sja	1									1					
a^-miksha^	a:mikṣa:		1			1										
a^m-ish-a	a:miṣa		1			1										
a^m-is	a:mis	1				1										1
a^mushmi-ka	a:muṣmika		1		1											
a^mushyaayana'	a:muṣjaayana		1		1											
a^ma-ishtaka	a:maiṣṭaka		1			1										
a^-mokshana	a:mokṣaṇa		1			1										
a^-sa^rin	a:sa:rin	1									1					
a^mbhasa	a:mb ^h asa	1									1					

[illegible]

a^rshaba	a:rşaba		1	1												
a^rsheya	a:rşeya		1	1												
a^rshau^dha^	a:rşau:q ^h a:		1	1												
a^rshtishena'	a:rştişena		2	1			1									
a^lakshya	a:lakşja		1			1										
a^las-ya	a:lasja	1								1						
a^lidha- visesha-sobhin	a:liq ^h a viçşaçpb ^h in		1					1								
a^sesha	a:çşa		1					1								
a^vatsar aantam	a:vats araantam	1												1		
a^vas	a:vas	1								1						
a^vas-ati'	a:vasati	1								1						
a^vas-a	a:vasa	1								1						
a^vi-ka-sau- trika	a:vikas autrika	1								1						
a^vid-vas	a:vidvas	1								1						
a^vish-karana	a:vişkaraṇa		1				1									
a^vishta	a:vişṭa		1				1									
a^vi's	a:vis	1					1									1
a^veshta	a:veṣṭa		1					1								
a^samsa	a:saNsa	1								1						
a^sams-i-tri	a:saNsitr	2							1	1						
a^sas	a:ças	1								1						
a^sa^~va^sas	a:ça:va:sas	2								2						
a^ishtha	a:işṭ ^h a		1				1									
a^sir-vakanaa ^kshepa	a:çirvacana a:kşepa	1			1											
a^si^~visha'	a:çi:vişa		1				1									
a^susuksha'ni	a:çuçukşanṇi		1			1										
a^su-sushka	a:çuçuşka		1		1											
a^su-sravas	a:çuçravas	1								1						

a [^] su-samdheya	a:çua aNd ^h ēja	1			1											1
a [^] -va [^] sin	a:va:sin	1									1					
a [^] srayaa ^saasiddha	a:çrajaa: çaasidd ^h a	1									1					
a [^] -slishta-sa [^] nu	a:çliṣṭasa:nu		1				1									
a [^] -slesha	a:çleṣa		1					1								
a [^] -sva [^] s-a	a:çva:sa	1									1					
a [^] sha [^] dha	a:ṣa:ḍ ^h a		1								1					1
a [^] sha [^] dhi [^]	a:ṣa:ḍ ^h i:		1								1					1
a [^] shtamika	a:ṣṭamika		1								1					1
a [^] s	a:s	1									1					
a [^] s-te	a:ste	1									1					
a [^] sta [^] m	a:sta:m	1									1					
adhya [^] sita	ad ^h ja:sita	1									1					
sam-adhi	samad ^h i	1													1	
a [^] s-a	a:sa	1									1					
a [^] -samsa [^] ram	a:saNsa:ram	2								1	1					
a [^] -sakta	a:sakta	1									1					
a [^] -sakti'	a:sakti	1									1					
a [^] -san.g-a'	a:sangga	1									1					
a [^] -sa'n~g-ana	a:sanjana	1									1					
a [^] -satti	a:satti	1									1					
a [^] -sa'de	a:sade	1									1					
a [^] sa'n	a:san	1									1					
a [^] s-ana	a:sana	1									1					
a [^] sani [^] -kri	a:sani:kr	1									1					
a [^] sandika [^]	a:sandika:	1									1					
a [^] -sanna	a:sanna	1									1					
a [^] -prasava [^]	a:prasava:	1									1					
a [^] -sapinda	a:sapiṇḍa	1									1					

a^-sapta-ma	a:saptama	1									1					
a^-sampa^ti	a:sampa:ti	1									1					
a^-samudra	a:samudra	1									1					
a^-sava	a:sava	1									1					
a^-sa^t	a:sa:t	1									1					
a^-sa^d-ana	a:sa:dana	1									1					
a^-sa^yam	a:sa:jam	1									1					
a^-sa^ra	a:sa:ra	1									1					
a^s-ika^	a:sika:	1									1					
a^s-ita	a:sita	1									1					
a^sidha^ra	a:sid ^h a:ra	1									1					
a^-sisa^d-ayi-shu	a:sisa:dajiṣu	2	1				2				1					1
a^s-i^na	a:si:na	1									1					
a^-si^ma^ntam	a:si:ma:ntam	1									1					
a^sura	a:sura	1									1					
a^-srikva	a:srkva	1									1					
a^-srishti	a:srṣṭi	1	1	1							1					
a^-seka	a:seka	1									1					
a^-se'kana	a:sekana	1									1					
a^-seddhri	a:sedd ^h r	1									1					
a^-sedha	a:sed ^h a	1									1					
a^-sev-ana	a:sevana	1									1					
a^-skand-a'	a:skanda	1									1					
a^skra	a:skra	1									1					
a^-stara	a:stara	1									1					
a^-sta'rana	a:starana	1									1					
a^sti-ka	a:stika	1									1					
a^stik-ya	a:stikja	1									1					
a^sti^ka	a:sti:ka	1									1					

a^s-te	a:ste	1									1					
a^-stha^	a:sthā:	1									1					
a^-stha^na	a:sthā:na	1									1					
a^-stha^ni	a:sthā:ni	1									1					
a^-sthita	a:sthita	1									1					
a^-spada	a:spada	1									1					
a^-spha^lana	a:sp ^h alana	1									1					
a^-sphota	a:sp ^h oṭa	1									1					
a^s-ya	a:sja	1									1					
a^-sra^va'	a:sra:va	1									1					
a^sva	a:sva	1									1					
a^-sva^d-a	a:sva:da	1									1					
a^-han-a's	a:hanas	1									1					
a^-hasa	a:hasa	1									1					
a^-nihsarana- ma^rga	a:nihsaraṇa ma:rga	1										1				
a^-nirgama- stha^na	a:nirgama sthā:na	1									1					
ikshu'	ikṣu		1			1										
ikshva^ku'	ikṣva:ku		1			1										
ikkha^-sadrīsa	icc ^h a:sadrīṣa	1									1					
ikkha^-sampad	icc ^h a:saNpad	1									1					
i'-tas	itas	1									1					
iti-haa^sa	itihaa:sa	1									1					
i-nak-sh	inakṣ		1			1										
indi^vara-aksha	indi:varaakṣa		1			1										
i'nd-yasas	indjaṣas	1									1					
ind-avatamsa	indavataNsa	1								1						
ind-purusha	indpuruṣa		1		1											
indra-dhanu's	indrad ^h anus	1			1											1
indra-sena^	indrasena:	1									1					

ukshan-yu'	ukşanju		1			1										
uksh-a'n	ukşan		1			1										
ug-rush	ugruş		1		1											
ukka-kais- a^sana-tas	ucckais a:sanatas	3				1				2						1
uk-kakshus	uccakşus	1	1		1	1										1
ukka-samsraya	uccasa Nçraja	1								1						
uk-kiki^sha^	uccici:şa:		1			1										
ukkair-ukkaih- sravas	uccairu ccaihçravas	1								1						
ukkair-ukkais- tara^m	uccairu ccaistara:m	1				1										1
ukkair- bha^shana	uccair b^a:şana		1							1						1
ukkair-bha^shya	uccair b^a:şja		1							1						1
ukkaih-siras	uccaihçiras	1								1						
ukkaih-sravas	uccaih çravas	1								1						
ukkais	uccais	1				1										1
ukkais-tara	uccaistara	1				1										1
ukkaih-stha^na	uccaih st^a:na	1									1					
uk-khiras	ucc^hiras	1								1						
u'k-khishta	ucc^hişta		1			1										
uk-khi^rsha-ka	ucc^hi:rşaka		1	1												
uk-khush-ka	ucc^huşka		1		1											
uk-khesha	ucc^heşa		1					1								
uk-kkvasanna	ucc^hasanna	1								1						
uk-khva^sita	ucc^ha:sita	1								1						
uk-khca^sa	ucc^ha:sa	1								1						
uk-khva^sin	ucc^ha:sin	1								1						
ug-gesha'	uğgeşa		1					1								

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ut-sa^ha	utsa:ha	1												1		
ut-sa^hin	utsa:hin	1												1		
ut-suka	utsuka	1												1		
utsuka-ya	utsukaja	1												1		
ut-su^tra	utsu:tra	1												1		
ut-srīṣṭi	utsrṣṭi	1	1	1										1		
ut-sek-a	utseka	1												1		
ut-sedha	utseḍha	1												1		
ut-sthala	utstḥala	1												1		
ut-sraṣṭavāya	utsraṣṭavja	1	1							1				1		1
ut-sra^vin	utsra:vin	1												1		
ut-svapna^ya	utsvapna:ja	1												1		
uda-sparsana	udasparṣana	1								1						
udakaupasparṣana	udakaupa sparṣana	1								1						
udak-tas	udaktas	1								1						
ud-ambhas	udambḥas	1								1						
ud-arkis	udarcis	1					1									1
uda-va^s-a	udava:sa	1								1						
ud-ava-sita	udavasita	1								1						
ud-a^sitri	uda:sitr	1								1						
ud-a^-sthita	uda:stḥita	1								1						
ud-a^s-i^na	uda:si:na	1								1						
ud-i^ksha^	udi:ksha:		1			1										
ud-etos	udetos	1							1							1
u'd-egas	udejas	1								1						
ud-garshana	udgarṣaṇa		1	1												
ud-ghosha	udgḥoṣa		1						1							
ud-dhu^s-ita	uddḥu:ṣita		1		1											
ud-ba^shpa	udba:ṣpa		1							1						1

upa-ni-sha'd	upaniṣad		1				1									
upa-nish-kramaṇa	upaniṣ kramaṇa		1				1									
upa-nyas-ana	upanjasana	1								1						
upa-nyasa^	upanjasa:	1								1						
upa-prekshana	upaprekṣaṇa		1			1										
upa-praisha	upapraiṣa		1				1									
upa-bha^sha	upab ^h a:ṣa		1							1						1
upa'rish-ta^t	upariṣṭa:t		1				1									
upari-laksh-aka	uparilakṣ aka		1			1										
upala-prakshin	upala prakṣin		1			1										
upala-vishama	upalaviṣama		1				1									
upa-lip-sa^	upalipsa:	1										1				
upa-varsha	upavarṣa		1	1												
upa-vasatha'	upavasat ^h a	1								1						
upa-va^s-a	upava:sa	1								1						
upa-vishta	upaviṣṭa		1				1									
upa-siksha^	upaçikṣa		1			1										
upa-slesha	upaçleṣa		1					1								
upa-shtambha	upaṣṭamb ^h a		1							1						1
upa-samvya^na	upasa Nvja:na	1								1						
upa-sam-ha^ra	upasa Nha:ra	1								1						
upa-samkra^nti	upasa Nkra:nti	1								1						
upa-samkshepa	upa saNkṣepa	1	1			1				1						1
upa-samkhya^na	upa saNk ^h ja:na	1								1						
upa-sam-gamana	upasaN gamana	1								1						

upa-sattri	upasattr	1									1					
upa-sadana	upasadana	1									1					
upa-samdhyam	upasaNd ^h jam	1									1					
upa-sapatni	upasapatni	1									1					
upa-sarana	upasarana	1									1					
upa-sargana	upasarjana	1									1					
upa-sarga	upasarga	1									1					
upa-sarp-ana	upasarpana	1									1					
upa-sadya	upasadja	1									1					
upa-sanna	upasanna	1									1					
upa-sa [^] ntvana	upasa :ntvana	1									1					
upa-sindhu	upasind ^h u	1									1					
upa-sunda	upasunda	1									1					
upa-se'kana	upasecana	1									1					
upa-sev-aka	upasevaka	1									1					
upa-skara	upaskara	1									1					
upa-stambha	upastamb ^h a	1									1					
upa-sta'rana	upastarana	1									1					
u'pa-sti	upasti	1									1					
upa-sti're	upastire	1									1					
u'pa-stuti	upastuti	1									1					
upa'-stha	upast ^h a	1									1					
upa'-stha [^] tavya	upast ^h a:tavja	1									1					
upa'-stha [^] -tri	upast ^h a:tr	1									1					
upa'-stha [^] -na	upast ^h a:na	1									1					
upa'-stha [^] yika	upast ^h a:jika	1									1					
upa'-stha [^] yin	upast ^h a:jin	1									1					
upa'-sthita	upast ^h ita	1									1					
upa-hasti-ka [^]	upahastika:	1									1					

ush-tra	uṣṭra		1		1										
ushtr-ika^	uṣṭrika:		1		1										
ush-na'	uṣṇa		1		1										
ushnaamsu	uṣṇaaNçu		1		1										
ushnaa^lu	uṣṇaa:lu		1		1										
ushn-i-man	uṣṇīman		1		1										
ushnih	uṣṇih		1		1										
ushni^-kri	uṣṇī:kr		1		1										
ushni^sha	uṣṇī:ṣa		1		1										
ushnaudaka	uṣṇaudaka		1		1										
ush-man	uṣman		1		1										
us-a'r	usar	1			1										1
us-ra'	usra	1			1										1
us-ra^	usra:	1			1										1
u's-ri	usri	1			1										1
usri-ka	usrika	1			1										1
usr-iya	usrija	1			1										1
u^k-us	u:cus	1			1										1
u^r-mradas	u:mradas	1							1						
u^rdhva-drishti	u:rd ^h vadrṣṭi		1	1											
u^rdhva-retas	u:rd ^h varetas	1							1						
u^sh-a	u:ṣa		1		1										
u^shara^yita	u:ṣarajita		1		1										
u^sh-us	u:ṣman		1		1										
u^sh-ma'n	u:ṣman		1		1										
u^shma-pa	u:ṣmapa		1		1										
rik-tas	rktas	1				1									
ri'ksha	rkṣa		1			1									
riksha'	rkṣa		1			1									
ri'kshaishti	rkṣaiṣṭi		2			1	1								

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ekaakshara	ekaakṣara		1			1										
ekaanudishtha	ekaanuḍiṣṭha		1				1									
eka [^] nta- vidhvamsin	eka:nta vid ^h aNsin	1							1							
eka-samupeta	ekasamupeta	1								1						
ekauddishtha	ekauddiṣṭha		1				1									
enaakshi [^]	eṇaakṣi:		1			1										
etat-sama	etatsama	1												1		
etat-samgn~aka	etatsaNjṇaka	1												1		
etasmin	etasmin	1								1						
etad-avastha	etadavast ^h a	1								1						
eta [^] -driksha	eta:drkṣa		1			1										
edhas	ed ^h as	1								1						
e'n-as	enas	1								1						
evam-vidvas	evaNvidvas	1								1						
evam-vishaya	evaNviṣaja		1				1									
evam-avastha	evamavast ^h a	1								1						
e-sha'	eṣa		1					1								1
e'sh-a	eṣa		1					1								1
aika-svarya	aikasvarja	1								1						
aikshava'	aikṣava		1			1										
aikshva [^] ka'	aikṣva:ka		1			1										
aitiha [^] s-ika	aitiha:sika	1								1						
aishi [^] ka	aiṣi:ka		1				1									
aishtaka	aiṣṭaka		1				1									
aishtika- paurtika	aiṣṭika paurtika		1				1									
o'k-as	okas	1								1						
o'g-as	oḡas	1								1						
og-ishtha	oḡiṣṭ ^h a		1				1									
o'sh-a	oṣa		1						1							

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kakubha'- surabhi	kakub ^h a surab ^h i	1									1					
ka'ksha	kakṣa		1			1										
kakshi^~vat	kakṣivat		1			1										
kakshya^~	kakṣjā:		1			1										
kan.-kan-varsha	kaṇkaṇvarṣa		1	1												
kan.-kan- varshin	kaṇkaṇvarṣin		1	1												
kata-a^kshepa	kaṭaa:kṣepa		1			1										
kati-nivasana	kaṭinivasana	1									1					
kathaupanishad	kaṭ ^h a upaniṣad		1				1									
ka'n-as	kaṇas	1									1					
kanta-kautsa	kaṇṭakautsa	1												1		
kantha- bhu^shana	kaṇṭ ^h a b ^h u:ṣana		1		1											
kantha-su^tra	kaṇṭ ^h asu:tra	1									1					
kantha-sthali^	kaṇṭ ^h ast ^h ali:	1									1					
kanthaa^slesha	kaṇṭ ^h a a:çleṣa		1					1								
kati^~musha	kaṭi:muṣa		1		1											
katha^~ prasan.ga	kaṭ ^h a: prasanga	1									1					
katha^~sesha	kaṭ ^h a:çeṣa		1					1								
katha^avaseshi	kaṭ ^h a: avaçeṣi		1					1								
katha^~sandhi	kaṭ ^h a:sand ^h i	1									1					
katha^~sarit- sa^gara	kaṭ ^h a: saritsa:gara	2									1			1		
ka-sukham	kasuk ^h am	1									1					
ka'n-rasa	kanrasa	1									1					
ka'n-sutra	kansutra	1								1						
kanakaa^sana	kanaka a:sana	1									1					

kanish-ka	kanişka		1				1									
kan-i-shkan	kanişcan		1				1									
ka'n-ishth-a	kanişt ^h a		1				1									
kan-du ^h shin	kandu:şin		1		1											
kan-bhaiksha	kanb ^h aikşa		1			1										
kan-stha ^h	kanst ^h a:	1							1							
kapa ^h ta-vakshas	kapa:ṭa vakṣas	1	1			1					1					
kapi-vastu	kapivastu	1									1					
kapi-shthala	kapişt ^h ala		1				1									
kapi-samhita ^h	kapisaNhita	1					1									1
kapola-kasha	kapolakaşa		1							1						1
kam-sambhava	kamsaNb ^h ava	1										1				
kamalaaksha	kamalaakşa		1			1										
kamalai ^h kshana	kamalai: kṣaṇa		1			1										
kara-kisalaya	kara kisalaja	1					1									1
kara-bhu ^h shana	karab ^h u:ṣaṇa		1		1											
ka'r-as	karas	1								1						
kara-stha	karast ^h a	1								1						
kara'-sna	karasna	1								1						
kar-ishnu	karişṇu		1				1									
kar-ishyat	karişjat		1				1									
karishya	karişja		1				1									
ka'ri ^h sha	kari:şa		1				1									
karna- bhu ^h shana	karna b ^h u:ṣaṇa		1		1											
karna-visha	karnaṽiṣa		1				1									
karna-siri ^h sha	karnaçiri:şa		1				1									
karna-veshta	karnaṽeṣṭa		1					1								

karnaantika- avatamsa	karṇaantika avataNsa	1							1						
karni^-suta	karṇi:suta	1					1								1
kartu-manas	kartumanas	1								1					
kar-tos	kartos	1						1							1
karpa^sa	karpa:sa	1								1					
karpura-saras	karpurasaras	2								2					
karma-kshama	karmakṣama		1			1									
karmakeshta	karmaceṣṭa		1					1							
karma-dushta	karmaduṣṭa		1		1										
karma-dosha	karmadoṣa		1						1						
karma-nishtha	karmaniṣṭha		1				1								
karma-nya^sa	karmanya:sa	1								1					
karma- mi^ma^msa^	karma mi:ma:Nsa:	1							1						
karma-tas	karmatas	1								1					
karma-stha	karmastha	1								1					
karmaabhya^sa	karma abha:sa	1								1					
karsh-a	karṣa		1	1											
kala-bha^shin	kalabha:ṣin		1							1					1
kala-hamsa	kalahaNsa	1							1						
kal-usha	kaluṣa		1			1									
ka'lpa-kshaya	kalpakṣaya		1							1					
kalpa-sutra	kalpasutra	1								1					
kalmasha	kalmaṣa		1							1					1
kalma^sha	kalma:ṣa		1							1					1
kalma^sh-ita	kalma:ṣita		1							1					1
kalya^na- lakshana	kalja:ṇa lakṣaṇa		1			1									
kalya^na- sva^mi-kesava	kalja:ṇa sva:mikeṣava	1								1					

ka'vasha	kavaṣa		1								1					1
kavi-sasta	kaviṣasta	1									1					
kavaushna	kavauṣṇa		1		1											
kasha	kaṣa	1									1					1
kash-pa [^] sha [^] na	kaṣpa:ṣa:ṇa		2								2					2
kasha [^] ya	kaṣa:ja		1								1					1
kash-ta	kaṣṭa		1								1					1
kash-tapas	kaṣṭapas	1	1								2					1
k-as-un	kasun	1									1					
ka-stambhi [^]	kastambhi:	1									1					
kastu [^] rika [^]	kastu:rika:	1									1					
kastu [^] ri [^]	kastu:ri:	1									1					
ka'-sma [^] t	kasma:t	1									1					
ka [^] msya	ka:Nsja	1								1						
ka [^] ka-paksha	ka:papakṣa		1		1											
ka [^] kaakshi- nya [^] ya	ka:kaa kṣinja:ja		1		1											
ka [^] kutstha	ka:kust ^h a	1			1											
ka [^] kshi [^] vati [^]	ka:kṣi:vati:		1		1											
ka [^] n.ksha	ka:ṅkṣa		1		1											
ka [^] n.ksh-aniya	ka:ṅkṣaṇija		1		1											
ka [^] tha-u- panishad	ka:t ^h a upaniṣad		1				1									
ka [^] dambara- sagdhika [^]	ka:dambara saḡd ^h ika:	1									1					
ka [^] -purusha	ka:puruṣa		1		1											
ka [^] ma-tas	ka:matas	1									1					
ka [^] ma-ka [^] ra- va [^] da-bhaksha	ka:maca: rava:d ab ^h akṣa	1			1											
ka [^] ma-bhaksha	ka:mab ^h akṣa		1		1											
ka [^] ma-rasika	ka:marasika	1									1					

ka^ma-varsha	ka:mavarṣa		1	1												
ka^ma-va^sin	ka:mava:sin	1								1						
ka^ma-sa^sana	ka:maṣasana	1								1						
ka^ma-sa^stra	ka:maṣa:stra	1								1						
ka^ma-su	ka:masu	1								1						
ka^ma-sutra	ka:masutra	1								1						
ka^ya-stha	ka:jast ^h a	1								1						
kasma^t	kasma:t	1								1						
kasmin	kasmin	1								1						
ka^rana-tas	ka:raṇatas	1								1						
ka^ra-skara	ka:raskara	1								1						
ka^ru^sha	ka:ru:ṣa		1		1											
ka^rta-svara-maya	ka:rta svaramaja	1											1			
ka^rtsn-ya	ka:rtsnja	1											1			
ka^rpa^sa	ka:rpa:sa	1								1						
ka^rpa^sa-sautrika	ka:rpa:sa sautrika	2								2						
ka^rpa^saasthi	ka:rpa:saat ^h i	1								1						
ka^rpa^s-ika	ka:rpa:sika	1								1						
ka^rya-karanaapeksha^	ka:rjakara ṇaapekṣan	1			1											
ka^rya-tas	ka:rjatas	1								1						
ka^rya-dhamsa	ka:rja d ^h aNsa	1							1							
ka^rya-vyasana	ka:rja vjasana	1								1						
ka^rya-siddhi	ka:rjasidd ^h i	1								1						
ka^rya-sesha	ka:rjaçeṣa		1					1								
ka^rya-sakiva	ka:rjasaciva	1								1						
ka^rya-apekshin	ka:rjaapekṣin		1			1										
ka^ryaarthasiddhi	ka:rjaart ^h a sidd ^h i	1								1						

ka^rya- upeksha^	ka:rjaupekṣa		1			1										
ka^rsha-ka	ka:rṣka		1	1												
ka^rsh-ika	ka:rṣika		1	1												
ka^rshna	ka:rṣṇa		1	1												
ka^rshnaayasa	ka:rṣṇaajasa	1	1	1						1						
ka^rshn-ya	ka:rṣṇja		1	1												
ka^latas	ka:latas	1								1						
ka^lasya	ka:lasja	1								1						
ka^la- ka^n.kshin	ka:lak a:ṅkṣin		1			1										
ka^la-kshepa	ka:lakṣepa		1			1										
ka^la-puruṣa	ka:lapuruṣa		1		1											
ka^la-samrodha	ka:las aNrod ^h a	1								1						
ka^la-san.khya^	ka:lasaṅk ^h ja	1								1						
ka^la-sarpa	ka:lasarpa	1								1						
ka^la-sutra	ka:lasutra	1					1									
ka^laatyaya apadiṣṭa	ka:laatjaja apadiṣṭa	1				1										
ka^laanu sa^rya	ka:laanu sa:rja	1			1											1
ka^la-kshama	ka:lakṣama		1			1										
ka^la-ayasa	ka:laajasa	1								1						
ka^li-dasa	ka:lidasa	1								1						
ka^li^-vila^sin	ka:livila:sin	1								1						
ka^lush-ya	ka:luṣja		1		1											
ka^vya-goshṭi^	ka:vjagoṣṭi:		1						1							
ka^vya-rasa	ka:vjarasa	1								1						
ka^vya- mi^ma^msa-ka	ka:vjami: ma:Nsaka	1								1						
ka^vya-su^tra	kavjasu:tra	1								1						
ka^sha	ka:ṣa:ja		1							1						1

ka^sha^ya	ka:ṣa:ja		1						1				1
ka^shtha'	ka:ṣtʰa		1						1				1
ka^shtha'- loṣṭa-maya	ka:ṣtʰa loṣṭamaja		1						1				
ka^shtha'- stambha	ka:ṣtʰa stambʰa	1	1						2				1
ka^shtha^	ka:ṣtʰa:		1						1				1
ka^shth-ika	ka:ṣtʰika		1						1				1
ka^s-a	ka:sa	1							1				
ka^s-a'	ka:sa	1							1				
ka^sa^ra	ka:sa:ra	1							1				
ka^'s-ika^	ka:sika:	1							1				
kim-vishaya-ka	kiNviṣajaka		1			1							
kim-sakhi	kiNsakʰi	1						1					
kiknasa	kiknasa	1							1				
kim-puruṣa	kiNpuruṣa		1	1									
kila^s-a	kila:sa	1							1				
kilbish-a	kilbiṣa		1			1							
kilbish-sprit	kilbiṣsprt	1	1			1						1	
kishkindha	kiṣkindʰa		1			1							
kishku	kiṣku		1			1							
kisalaya	kisalaja	1				1							1
ki's	kis	1				1							1
ki^kasa	ki:kasa	1							1				
ki^-driksha	ki:drṣṭi		1	1									
ki^r-sesha	ki:rṣeṣa		1				1						
ki^r-sa^ra	ki:rsa:ra	1		1									1
ki^r-sena	ki:rsena	1		1									1
ki^r-soma	ki:rsoma	1		1									1
kuk-shi'	kukṣi		1			1							
kukshi^	kukṣi		1			1							

kuṭi-manas	kuṭīmanas	1									1					
ku-tapasvin	kutapasvin	1									1					
ku'-tas	kutast	1									1					
kutas-tya	kutastja	1									1					
ku-ta^pasa	kuta:pasa	1									1					
ku'ts-a	kutsa	1												1		
ku-da^ra-driṣṭi	kuda:ra drṣṭi		1	1												
ku-parik-sha-ka	kuparik ṣaka		1			1										
ku-pari^kshita	kupari: kṣita		1			1										
ku-purusha	kupuruṣa		1		1											
ku-bhikshu	kub ^h ikṣu		1			1										
ku-deshna	kudeṣṇa		1					1								
ku-sam-bhava	kusaNb ^h ava	1			1											1
ku-sena	kusena	1			1											1
kumbha'- sambhava	kumb ^h a saNb ^h ava	1									1					
kumbhi'-nasa	kumb ^h inasa	1									1					
kumbhi'-nasi^	kumb ^h inasi:	1									1					
kuran.gaakshi^	kuraggaakṣi:		1			1										
ku-rahasya	kurahasja	1									1					
kuru-kshetra	kurukṣetra		1			1										
kula-krama- stḥiti	kulakrama st ^h iti	1									1					
kula-kshaya	kulakṣaya		1			1										
ku-lakshana	kulakṣaṇa		1			1										
kula-purusha	kulapuruṣa		1		1											
kula-pa^ms-ani^	kulapa:Ns ani:	1								1						
kula-pratishṭa	kulapratīṣṭa		1				1									
kula-prasu^ta	kulaprasu:ta	1									1					

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kusuma-dhanus	kusuma d ^h anus	2			2											2
kusum-aya	kusumaja	1			1											1
kusuma-lakshman	kusuma lakṣman	1	1		1	1										1
kusuma-a [^] sana	kusuma a:sana	2			1						1					1
kusuma-sa [^] ra	kusuma sa:ra	2			1						1					1
kusuma-sa [^] yaka	kusum asa:jaka	2			1						1					1
kusuma-surabhi	kusum asurab ^h i	2			1						1					1
kusuma-stabaka	kusum astabaka	2			1						1					1
kusuma-a [^] kara	kusum aa:kara	1			1											1
kusuma-a [^] sava	kusum aa:sava	2			1						1					1
kusuma-a [^] stara	kusum aa:stara	2			1						1					1
kusuma-astra	kusu maastra	2			1						1					1
kusum-ita	kusumita	1			1											1
kusuma-ishu	kusumaiṣu	1	1		1		1									1
kusumbha	kusumb ^h a	1			1											1
kusumbha-kshetra	kusumb ^h akṣetra	1	1		1	1										1
kusu [^] la	kusu:la	1			1											1
ku-sriti	kusrti	1			1											1
ku-sauhrda	kusaihrda	1			1											1
ku-stri [^]	kustri:	1			1											1
ku-stha [^] na	kust ^h a:na	1			1											1
ku-sva [^] min	kusva:min	1			1											1
ku [^] ta'-ta [^] pasa	ku:tata:pasa	1									1					

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

go-raksha^	goraksha:		1			1									
go-rakshya	gorakṣja		1			1									
go-va^sa	gova:sa	1								1					
go-sva^min	gosva:min	1						1							1
go-vrisha	govrṣa		1	1											
go-vrishana	govrṣaṇa		1	1											
go-si^r-sha	goçi:rṣa		1				1								
go-shth-ika	goṣṭ ^h aika		1					1							
go-shthi^	goṣṭ ^h i:		1					1							
goshthe-saya	goṣṭ ^h eçaja		1					1							
gosh-pada	goṣpada		1					1							
go-stana	gostana	1						1							1
gaura-sarshapa	gaura sarṣapa	1	1	1						1					
gaushthika	gauṣṭ ^h ika		1		1										
gna^s-pa'ti	gna:spati	1								1					
grapsa	grapsa	1										1			
gra'sa	grasa	1								1					
grasira	grasira	1								1					
grasta	grasta	1								1					
gras-ana	grasana	1								1					
gras-ishnu	grasiṣṇu	1	1				1			1					
graha-grasta	grahagrasta	1								1					
grahana-sambhava	grahaṇa saNb ^h ava	1								1					
graha-sama^gama	graha sama:gama	1								1					
graha-agre-sara	graha agresara	1						1							1
gra^ma-niva^sin	gra:ma niva:sin	1								1					
gra^ma-pishta	gra:mapiṣṭa		1				1								

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ghrita-prush	g ^h rtapruş		1		1										
ghrita-snu'	g ^h rtasnu	1								1					
ghrita'-snu	g ^h rtasnu	1								1					
ghrita-havishka	g ^h rahavişka		1			1									
ghrita-ishtaka	g ^h rtaiştaka		1			1									
gharsha	g ^h arşa		1	1											
ghrisha	g ^h rşa		1	1											
ghrishta	g ^h rşta		1	1											
gharshaya	g ^h arşaja		1	1											
ghri'shu	g ^h rşu		1	1											
gho'sha	g ^h oşa		1					1							
ghosha-ka	g ^h oşaka		1					1							
ghosh-ana	g ^h oşana		1					1							
ghosha-vat	g ^h oşavat		1					1							
gho'sh-i	g ^h oşi		1					1							
ghosh-tri	g ^h oştr		1					1							
ghrams	g ^h raNs	1							1						
kaka^s-ti	caka:sti	1								1					
kakora-akshi^	cakoraakşi:		1			1									
kakra-raksha	cakrarakşa		1			1									
kakra-sena	cakrasena	1								1					
kash-te	caşte		1							1					1
kaksh-a'ni	caکشانی		1			1									
ka'ksh-ani	caکشانی		1			1									
ka'ksh-an	caکشان		1			1									
kakshur-vishaya	caکشور vişaja		2			1	1								
kakshuh-sravas	caکشوھ çravas	1	1			1					1				
kakshush-pati	caکشوشپاتی		2			1	1								
kakshush-ya	caکشوشیا		2			1	1								

<i>ka'n-as</i>	canas	1									1					
<i>kanas-ya'</i>	canasja	1									1					
<i>kanasita</i>	canasita	1									1					
<i>kanishtha</i>	caniṣṭha		1				1									
<i>kand-da^sa</i>	candda:sa	1									1					
<i>kand-rasa</i>	candrasa	1									1					
<i>kandra-kshaya</i>	candrakṣaja		1			1										
<i>kandra-pra^sa^da</i>	candra pra:sa:da	1									1					
<i>kandra-masa</i>	candramasa	1									1					
<i>kandra-sa^ra</i>	candrasa:ra	1									1					
<i>kandra-samgn~a</i>	candra saNjṇa	1									1					
<i>kandra-simha</i>	candrasaNha	1									1					
<i>kandra-sva^min</i>	candra sva:min	1									1					
<i>kandra-ha^sa</i>	candraha:sa	1									1					
<i>kam-asa'</i>	camasa	1									1					
<i>karana-nya^sa</i>	caraṇaṇja:sa	1									1					
<i>karana-prishtha</i>	caraṇ aprṣṭha		1	1												
<i>karana-prasa^ra</i>	caraṇa prasa:ra	1									1					
<i>kara'-vayas</i>	caravajas	1									1					
<i>kar-i-shnu</i>	carīṣṇu		1				1									
<i>kar-kri-she</i>	carkrṣe		1	1												
<i>karma-bhastri^ka</i>	carma b ^h astri:ka	1									1					
<i>kar-sh-ani'</i>	carṣaṇi		1	1												
<i>karshani^</i>	carṣaṇi:		1	1												
<i>kala-sva-bha^va</i>	calasva b ^h a:va	1									1					
<i>kash-aka</i>	caṣaka		1								1					1

kitra-nyasta	citranjasta	1									1					
kitra-paksha	citrapakṣa		1			1										
kitra-bha ^h shya	citrab ^h a:ṣja		1								1					1
kitra-sravastama	citra çravastama	1									1					
kitra'-sena	citrasena	1									1					
kitra-stha	citrast ^h a	1									1					
kitra-sthala	citrast ^h ala	1									1					
kint-visha-ghna	cintviṣag ^h na		1				1									
kint-upashita	cintupaṣita		1								1					1
kipita-na ^h sa	cipiana:sa	1									1					
kipita-na ^h sika	ciṭāna:sika	1									1					
kira-pra-va ^h sin	cirapra:vin	1									1					
kira-eshapantya ^h	cira eṣapantja:h		1					1								
kira-sthita	cirast ^h ita	1									1					
kira-sam-kita	cirasaNcita	1									1					
kira-a ^h yusha	ciraa:juṣa		1		1											
kira-a ^h yus	ciraa:jus	1			1											1
kira-ushita	cirauṣita		1		1											
ki ^h na-pishta	ci:napiṣṭa		1				1									
ki ^h ra-vasana	ci:ravasana	1									1					
ki ^h ra-va ^h sas	ci:rava:sas	2									2					
ku-kshobh-ay- ishu	cukṣo b ^h ajīṣu		2			1	1									
kurikura-sabda	curicu rasabda	1									1					
ku ^h shaya	cu:ṣaja		1		1											
ku ^h sh-ana	cu:ṣaṇa		1		1											
ke't-as	cetas	1									1					
ke't-ishtha	cetiṣṭ ^h a		1				1									
ke'shta	ceṣṭa		1					1								

<i>ke'shtaya</i>	ceṣṭaja		1					1								
<i>keshta</i>	ceṣṭa		1					1								
<i>keshta^</i>	ceṣṭa:		1					1								
<i>kaitya-vriksha</i>	caitjavrkṣa		1			1										
<i>koksha</i>	cokṣa		1			1										
<i>kosh-a</i>	coṣa		1						1							
<i>kauksha</i>	caukṣa		1			1										
<i>khat-vriksha</i>	c ^h atvrkṣa		1			1										
<i>khand-tas</i>	c ^h andtas	1									1					
<i>khand-as</i>	c ^h andas	1									1					
<i>khand-sa^stra</i>	c ^h andṣa:stra	1									1					
<i>khand-su^tra</i>	c ^h andsu:tra	1												1		
<i>khard-is</i>	c ^h ardis	1					1									1
<i>khard-i's</i>	c ^h ardis	1					1									1
<i>kha^ndas-a</i>	c ^h a:ndas	1									1					
<i>kha^ndog-upanishad</i>	c ^h a:ndog upanishad	1				1										
<i>kha^ya^-samgn~a^</i>	c ^h a:ja:s aṇṇa:	1									1					
<i>khidra-anusa^rin</i>	c ^h idra anusa:rin	1				1										1
<i>khin-na^sya</i>	c ^h inna:sja	1									1					
<i>gaksh-i-ti</i>	jakṣiti		1			1										
<i>ga'ksh-at</i>	jakṣat		1			1										
<i>gaksh-i-van</i>	jakṣivan		1			1										
<i>gagak-kakshus</i>	jagaccakṣus	1	1			1	1									1
<i>gagat-prasiddha</i>	jaḡat prasidd ^h a	1									1					
<i>gagat-pra^sa^ha</i>	jaḡat pra:sa:ha	1									1					
<i>gagat-srashtri</i>	jaḡatsraṣṭr	1	1								1			1		1
<i>gagat-sva^mitva</i>	jaḡat sva:mitva	1									1					

<i>gagan-niva</i> ^sa	jagan niva:sa	1									1					
<i>gaga-ogas</i>	jajaojas	1									1					
<i>ga'n-esha</i>	janeṣa		1					1								
<i>ga'n-asau</i>	janasau	1									1					
<i>ganaka-simha</i>	janak asiNha	1									1					
<i>ganaka-suta</i> ^	janakasuta:	1									1					
<i>gana-da</i> ^ha- sthana	janada:ha st ^h ana	1									1					
<i>gana-sammaida</i>	jana saNmaida	1									1					
<i>ga'n-i-tos</i>	janitos	1							1							1
<i>gani-divasa</i>	janidivasa	1									1					
<i>gan-ishya</i>	janiṣja		1				1									
<i>ganma-kshetra</i>	janma kṣetra		1			1										
<i>gan-us</i>	janus	1			1											1
<i>ganma-gyeshtha</i>	janma jjeṣṭ ^h a		1					1								
<i>ganma-tas</i>	janmatas	1									1					
<i>ganma-riksha</i>	janmarkṣa		1	1												
<i>ganma-vasu</i> ^da	janma vasu:da	1									1					
<i>ganma-stha</i> ^na	janma st ^h a:na	1									1					
<i>ganma-a</i> ^spada	janma a:spada	1									1					
<i>gaya-ghosha</i>	jajag ^h oṣa		1						1							
<i>gaya-ghoshana</i>	jajag ^h oṣaṇa		1						1							
<i>gaya-lakshmi</i> ^	jajalakṣmi:		1			1										
<i>gaya-simha</i>	jajasiNha	1									1					
<i>gaya-skanda</i>	jajaskanda	1									1					
<i>gaya-sena</i>	jajasena	1									1					

<i>gaya-stambha</i>	jajastamb ^h a	1									1					
<i>gaya-sthala</i>	jajast ^h ala	1									1					
<i>gaya-sva[^]min</i>	jajasva:min	1									1					
<i>gaya-avaghosha</i>	jajaavag ^h oṣa		1						1							
<i>gay-ishnu</i>	jajiṣṇu		1				1									
<i>gaya-sena</i>	jajasena	1									1					
<i>gay-u's</i>	jajus	1			1											1
<i>garad-ashti'</i>	jaradaṣṭi		1								1					1
<i>gar-a's</i>	jaras	1									1					
<i>gara[^]-sandha</i>	jara:sand ^h a	1									1					
<i>gala-kusuma</i>	jalakusuma	1			1											1
<i>gala-a[^]sana</i>	jalaa:sana	1									1					
<i>tap-as</i>	tapas	1									1					
<i>tapas-ya</i>	tapasja	1									1					
<i>tapas-ya[~]</i>	tapasja	1									1					
<i>tapas-vin</i>	tapasvin	1									1					
<i>tapas-vat</i>	tapasvat	1									1					
<i>tap-ishtha</i>	tapiṣṭ ^h a		1				1									
<i>tap-ush-i</i>	tapuṣi		1		1											
<i>tap-ush-pa[^]</i>	tapuṣpa:		1		1											
<i>tap-us</i>	tapus	1			1											1
<i>tam-as</i>	tamas	1									1					
<i>tamas-a'</i>	tamasa	1									1					
<i>tamah-spris</i>	tamahsPriç	1										1				
<i>tamis-ra</i>	tamisra	1					1									1
<i>tamis-paksha</i>	tamispakṣa	1	1			1	1									1
<i>tamo-va[^]sas</i>	tamova:ças	1									1					
<i>taraksha</i>	tarakṣa		1			1										
<i>tara-tama-tas</i>	taratamatas	1									1					
<i>tar-as</i>	taras	1									1					

taras-vat	tarasvat	1									1					
taras-vin	tarasvin	1									1					
taru-shanda	taruṣaṇḍa		1		1											
tark-sa^stra	tarkça:stra	1									1					
tark-saṁgraha	tarksaṅgraha	1				1										1
tarsh-a	tarṣa		1	1												
tala-tas	talatas	1									1					
talava-upanishad	talava upaniṣad		1				1									
tav-as	tavas	1									1					
tav-ish-a	taviṣa		1				1									
tav-ish-i^	taviṣi:		1				1									
tav-ish-i^ya	taviṣi:ja		1				1									
tavish-ya	taviṣja		1				1									
tav-iyas	tavijas	1									1					
tash-tri	taṣṭr		1								1					1
tas-kara	taskara	1									1					
taskara^-ya	taskara:ja	1									1					
ta-smat	tasmat	1									1					
ta^kshna	ta:kṣṇa		1			1										
ta^tsth-ya	ta:tstḥja	1												1		
ta^-driksha	ta:drkṣa		1			1										
ta^p-a-upanishad	ta:pa upaniṣad		1				1									
ta^p-ay-ishnu	ta:pajiṣṇu		1				1									
ta^pas-a	ta:pasa	1									1					
ta^marasa	ta:marasa	1									1					
ta^misra	ta:misra	1					1									1
ta^mas-a	ta:masa	1									1					
ta^mra-sa^sana	ta:mraṣ a:sana	1									1					

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tri-sastra	triṣastra	1									1					
tri-paksha	tripakṣa		1			1										
tri-okas	triokas	1									1					
tri-pishtapa	tripiṣṭapa	1					1									
tri-puruṣa	tripuruṣa	1			1											
tri-prisṭha	triprṣṭha	1		1												
tri-ras-aka	trirasaka	1									1					
tri-va [^] rshika	triva:rṣika		1	1												
tri-varsha	trivarṣa		1	1												
tri-vishtapa	triviṣṭapa		1				1									
tri-vishti	triviṣṭi		1				1									
tri-siras	triṣiras	1									1					
tri-si [^] rsha	triṣi:rṣa		1	1												
tri-si [^] rshan	triṣi:rṣan		1	1												
tri-shadha-stha	triṣad ^h ast ^h a	1	1				1				1					
tri-shavana	triṣavaṇa		1				1									
tri-sna [^] yin	trisna:jin	1					1									1
tri-shash	triṣaṣ		2				1				1					1
tri-shtub-anta	triṣṭubanta		1				1									
tri-shtubh	triṣṭub ^h		1				1									
tri-satya	trisaṭja	1					1									1
tri-sa ^{md} haya	trisaNd ^h ja	1					1									1
tri-savana	trisvana	1					1									1
tri-sa [^] dhana	trisa:d ^h ana	1					1									1
tri-suparna	trisuparṇa	1					1									1
tri-stana	tristana	1					1									1
tri-stha [^] na	trist ^h a:na	1					1									1
tri-srotas	trisrotas	2					1				1					1
tri ^h -sna [^] na	trihsna:na	1										1				

tre-hrita-sat-vasva	trehṛta satvasva	2									2					
tre-sthita	trest ^h ita	1						1								
trai-ma [^] s-ika	traima:sika	1									1					
trai-va [^] rshika	traiva:rṣika		1	1												
traishṭubh-a	traīṣṭub ^h a		1				1									
trai-srotas-a	traisrotasa	2					1				1					1
tri-aksha	triakṣa		1			1										
tri-akshara	triakṣara		1			1										
tri-adhisṭha [^] na	triad ^h i ṣṭ ^h a:na		1				1									
tri-vrishaba	trivrṣaba		1	1												
tri-ashtaka	trīṣṭaka		1			1										1
tri-ashta-varsha	trīṣṭavarṣa		2	1		1										1
tvaksh-as	tvakṣas	1	1			1					1					
tvak-sa [^] ra	tvaksa:ra	1				1										1
tvag-uttara-a [^] san.ga	tvaguttara a:sanḡa	1									1					
tvag-dosha	tvagdoṣa		1						1							
tvag-doshin	tvagdoṣin		1						1							
tvan.-ma [^] msa-asthi	tvaṇma:Nṇaast ^h i	1									1					
tvash-ti	tvaṣṭi		1								1					1
tvash-tri	tvaṣṭr		1								1					1
tvish	tviṣ		1				1									
tvish-i	tviṣi		1				1									
tvesh-a	tveṣa		1					1								
tsar-u	tsaru	1									1					
damsh-tra	daNṣṭra		1							1						1
damshtr-in	daNṣṭrin		1							1						
dams-ana	daNsana	1								1						
dams-u	daNsu	1								1						

daksh-a	dakṣa		1			1										
daksha-kratu	dakṣakratu		1			1										
daksh-ina	dakṣiṇa		1			1										
dakshina-ga^nu- akta	dakṣiṇa ja:nuakta		1			1										
dakshina-tas	dakṣiṇatas	1	1			1					1					
dakshina-paska- ardha	dakṣiṇa paṇcaard ^h a	1				1										
dakshina^	dakṣiṇa:		1			1										
dakshina-agni	dakṣiṇ aagni		1			1										
dakshina^t	dakṣiṇa:t		1			1										
dakshina^- dva^ra	dakṣiṇa :dva:ra		1			1										
dakshina-ayana	dakṣiṇaajana		1			1										
dakshina- samkra^nti	dakṣiṇa saNkra:nti	1	1			1					1					
dakshina-aranya	dakṣiṇa araṇja		1			1										
dakshina-vat	dakṣiṇavat		1			1										
dakshina- a^varta	dakṣiṇa a:varta		1			1										
dakshina-siras	dakṣiṇaṣiras	1	1			1					1					
dakshin-a^hi	dakṣiṇa:hi		1			1										
dakshini^-kri	dakṣiṇi:kr		1			1										
dakshin-i^ya	dakṣiṇi:ja		1			1										
dakshina-itara	dakṣiṇ aitara		1			1										
dakshinena	dakṣiṇena		1			1										
dakshinais	dakṣiṇais	1	1			1	1									1
dakshina-uttara	dakṣiṇ auttara		1			1										
danda-ka^shtha	daṇḍaka:ṣṭ ^h a		1								1					1
danda-da^sa	daṇḍada:sa	1									1					

datta-dṛiṣṭi	dattadrṣṭi		1	1												
da-dhrish	dad ^h rṣ		1	1												
da-dhrish-va ⁿ	dad ^h rṣva:n		1	1												
danta-prakṣha ^l -ana	danta prakṣa:lana		1			1										
danta-praveshta	dantapraveṣṭa		1					1								
danta-va ^s as	dantava:sas	2									2					
danta-veshta	dantaveṣṭa		1					1								
danta-sa ^m gharsha	danta saNg ^h arṣa		1	1												
danta-adhisht ^h ita	danta ad ^h iṣṭ ^h ita		1				1									
dama-ghosha	dama ^g hoṣa		1						1							
darpa-sa ^a ra	darpa:sara	1									1					
darbha-su ^a ki	darb ^h asu:ci	1									1					
darbha-muṣṭi	darb ^h amuṣṭi		1		1											
darbha-stamba	darb ^h a stamba	1									1					
darsa-tasya	darçatasya	1									1					
darsana-vishaya	darçana viṣaja		1				1									
darsa-pu ^a rṇa-ma ^a sa	darça pu:rṇama:sa	1									1					
dala-sas	dalaças	1									1					
dav-ish-a ^a ni	daviṣa:ṇi		1				1									
dav-ish ^h ta	daviṣṭ ^h a		1				1									
dasa-ma ^a sya	daçama:sja	1									1					
dasa-lakshana-ka	daçala kṣaṇaka		1			1										
dasa-varsha	daçavarṣa		1	1												
dasa-va ^a rshika	daçavarṣika		1	1												
dasa-sata-aksha	daçaç ataakṣa		1			1										
dasa-siras	daçaçiras	1									1					

dasa-si^rsha	daçaçî:rşa		1	1												
dasa-sa^has-ra	daçasa: hasra	2								2						
dasas-ya	daçasja	1								1						
dasa-akshara	daçakşara		1			1										
dasa-antarushya	daçan taruşja		1		1											
dash-ta	daşta		1							1						1
dasya	dasja	1								1						
dasma	dasma	1								1						
das-ra	dasra	1								1						
das-yu	dasju	1								1						
da^ksha	da:kşa		1			1										
da^ksha^yana	da:kşa:janā		1			1										
da^ksha^yan-in	da:kşa:janin		1			1										
da^kshina^-tya	da:kşina:tja		1			1										
da^kshin-ya	dakşinja		1			1										
da^ksh-ya	da:kşja		1			1										
da^ra-samgraha	da:ras aNgraha	1								1						
da^ru-sesha	da:ruçeşa		1					1								
da^rshta^nt-ika	da:rşṭ a:ntika		1	1												
da^s-a	da:sa	1								1						
da^'s-a	da:sa	1								1						
da^s-ush-e'	da:çuşe		1		1											
da^sa-gana	da:sajana	1								1						
da^si^	da:si:	1								1						
da^si^-kri	da:si:kr	1								1						
da^si^-da^sa	da:si:da:sa	1								1						
da^seraka	da:seraka	1								1						
da^s-ya~	da:sjā	1								1						

dik-prekshana	dikprekṣana		1			1									
dig-vasana	digvasaṇa	1								1					
dig-va^sas	digva:sas	2								2					
di-drik-sha^	didrkṣa:		1			1									
dit-sa^	ditṣa:	1											1		
didda^~kshema	didda:kṣema		1			1									
di-dhak-sha^	did^hakṣa:		1			1									
di-dhi-shu'	did^iṣu		1				1								
dina-kshaya	dinakṣaya		1			1									
dina-avasa^na	dinaav asa:na	1								1					
dip-su	dipsu	1										1			
div-as-a	divasa	1								1					
divasa-kara	divasakara	1								1					
divasi^~kri	divasi:kr	1								1					
divasa-i^svara	divasa i:çvara	1								1					
divas-pati	divaspati	1								1					
divi-shad	diviṣad		1				1								
di'vo-da^sa	divoda:sa	1								1					
diva-okas	divaokas	1								1					
divya-kakshus	divjacakṣus	1	1		1	1									1
divya-purusha	divjapuruṣa		1		1										
divya-ma^~nusha	divjam a:nuṣa		1		1										
divya-samka^sa	dijasa Nka:ça	1								1					
divya-stri^	divjastri:	1								1					
divya-anshadha	divjaa nṣad^a		1						1						1
dish-ta	diṣṭa		1				1								
dish-ti	diṣṭi		1				1								

dur-adhyavasa^ya	durad ^h ja vasa:ja	1									1					
dur-anusht ^h eya	duranu ṣṭ ^h eya		1		1											
dur-abhiraksha	durab ^h irakṣa		1			1										
dur-abhisamdhi	durab ^h i saNd ^h i	1					1									1
dur-a^lakshya	dura:lakṣja		1			1										
dur-a^va^sin	dura:va:sin	1									1					
dur-a^sada	dura:sada	1									1					
dur-asis	duraçis	1					1									1
dur-i^ksha	duri:kṣa		1			1										
dur-upandishta	durupa ndiṣṭa		1				1									
dur-upasarpin	durup asarpin	1									1					
durga-simha	durgasiNha	1									1					
dur-gosh ^h ki^	durgoṣṭki:		1						1							
dur-sena	dursena	1		1												1
dur-divasa	durdivasa	1									1					
dur-dr ^h ishta	durdrṣṭa		1	1												
dur-dharsha	durd ^h arṣa		1	1												
dur-bhaksha	durb ^h akṣa		1			1										
dur-bha^sha	durb ^h a:ṣa		1								1					1
dur-bha^shita	durb ^h a:ṣita		1								1					1
dur-bhiksha	durb ^h ikṣa		1			1										
dur-vyasanin	durvjasanin	1									1					
dur-manas	durmanas	1									1					
dur-manushya	durmanuṣja		1		1											
dur-marsha	durmarṣa		1	1												
dur-marshana	durmarṣaṇa		1	1												
dur-medhas	durmed ^h as	1									1					

dur-yasas	durjaças	1									1					
dur-lakshya	durlakṣja		1			1										
dur-svamin	dursvamin	1		1												1
dur-lasita	durlasita	1									1					
dur-vakas	durvacas	1									1					
dur-vasa	durvasa	1									1					
dur-va^sa^na	durva:sa:na	1									1					
dur-va^sas	durva:sas	2									2					
dur-vilasita	durvilasita	1									1					
dur-vishaha	durviṣaha		1				1									
dur-vyavasita	durvjavasita	1									1					
dur-vyavastha^pa-ka	durvjavast ^h a: paka	1									1					
dur-vyasana	durvjasana	1									1					
duv-as	duvas	1									1					
duvas-ya	duvasja	1									1					
duvas-ya^t	duvasja:t	1									1					
dus-kikitsa^	duçcikitsa:	1												1		
dus-kikitsita	duçcikitsita	1												1		
dus-kikitsya	duçcikitsja	1												1		
dus-keshrita	duçceṣṭita		1					1								
dus-keshita^	duçceṣṭa:		1					1								
duh-sa^sana	duhça:sana	1									1					
duh-sikshita	duhçikṣita		1			1										
duh-sishya	duhçisja		1				1									
dush	duş		1		1											
dush-kara	duşkara		1		1											
dush-karman	duşkarman		1		1											
dush-sa^dhana	duşsa:d ^h ana	1	1		1										1	
dush-ka^yastha-kula	duşka:jast ^h a kula	1	1		1						1					

dushkrita- karman	duṣkṛta karman		1		1											
dushkriti	duṣkṛti		1		1											
dush-ta	duṣṭa		1		1											
dushta-a^tman	duṣṭa a:tman		1		1											
dush-ti	duṣṭi		1		1											
dushtuti	duṣṭuti		1		1											
dush-parigraha	duṣpa rigraha		1		1											
dush-pa^rshni- graha	duṣparṣṇi graha		2	1	1											
dush-pradharsha	duṣpra d^arṣa		2	1	1											
dush-prasaha	duṣprasaha	1	1		1					1						
dush-pra^sada	duṣpra:sada	1	1		1					1						
dush- prasa^dhana	duṣ prasa:d^ana	1	1		1					1						
dush- prasa^dhya	duṣ prasa:d^ja	1	1		1					1						
dush-preksha	duṣprekṣa		2		1	1										
dush-prekshya	duṣprekṣja		2		1	1										
dushmanta	duṣmanta		1		1											
dushyanta	duṣjanta		1		1											
duh-shanta	duḥṣanta		1								1					
duh-shama	duḥṣama		1								1					
dus	dus	1			1											1
dustara	dustara	1			1											1
du-stha	dust^a	1			1											1
duh-samlakshya	duhsa Nlakṣja	1	1			1					1					
dussani	dussani	2			1										1	1
duh-samska^ra	duhsa Nska:ra	2							1		1					

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