LEXICAL PHONOLOGY

by

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ABSTRACT

This thesis develops the model of Lexical Phonology, in which
a subset of phonological rules applies in the lexicon as part of the
word formation component. Phonological rules apply after every morpho-
logical operation, to the output of which morphological operations may
apply once again. The lexicon consists of ordered lexical strata which
function as the domains of application of these phonological and mor-
phological rules. This model eliminates the need for the use of distinct
boundary symbols by allowing phonological rules to have direct access
to morphological information, and imposes severe restrictions on the
class of possible grammars.

The model of Lexical Phonology yields three levels of phonolo-
geical representation, namely, the underlying, the lexical, and the
phonetic. The lexical level of representation is the output of the
lexical rule applications, which is also the input to lexical inser-
tion. It is shown that several interesting formal and psychological
properties converge on this level. Pauses are assigned to lexical
representations after lexical insertion, and therefore, lexical rule
applications are unaffected by pauses, while post lexical rule ap-
lications are blocked by intervening pauses. Speakers' judgments on
the 'sameness' and 'distinctness' of speech sounds are based on lexi-
cal representations. Secret code languages, such as Pig Latin and the
Aib language, take the lexical representation as the input, and so do
speech errors which permute phonological segments. It is suggested that
the lexical level may also have interesting consequences for theories
of speech acquisition, speech recognition, and speech production.

Thesis Supervisor: Morris Halle
Title: Institute Professor
I dedicate this thesis to my four gurus: my father, from whom I imbibed intellectual restlessness; N.S. Prabhu, who introduced me to the excitement of linguistics; M.V. Nadkarni, who led me step by step to the doors of current linguistic research; and Morris Halle, who made me a linguist.
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PROLOGUE

The nagging feeling that there was some truth in the taxonomic phonemic representation was what set me working on this thesis. My first attempt was to revise the conditions that Taxonomic Phonemics imposed on the phonemic-phonetic mapping, so that the level of representation between the underlying and the phonetic could be brought back into phonological theory. After several frustrating attempts, I gave up.

Later, when I started investigating the relation between morphology and phonology, and developed a model in which phonological rules applied in the word formation component, I discovered that this model yielded just the intermediate level of representation I was looking for. It was then that I realised why reviving the taxonomic phonemic level of representation by repairing the conditions imposed on the phonemic-phonetic mapping was impossible: the conditions should be imposed not from the bottom end of phonetics, but from the top, from the interaction between morphology and phonology.

Several people, and several incidents, helped me move towards the discovery. An initial impetus came from the course on computational linguistics given by Joan Bresnan and Ron Kaplan in 1978, where I was exposed to the idea that syntactic rules which have lexical exceptions are lexical rules. What would happen if the same principle applied in phonology as well, I asked myself: the traditional 'morpho-
phonemic' rules would become lexical rules, and 'allophonic' rules would become post lexical rules. The idea that phonological rules could apply in the lexicon took seed in my mind.

A conversation with David Pesetsky about his ideas of cyclic rule application in the lexicon, another with Mark Liberman about lexical access and taxonomic phonemics, and several other bits and pieces slowly formed a pattern around the core of my search for an intermediate level of representation. When I started writing exploratory papers on the subject, several people gave me the help and reassurance I badly needed: Paul Kiparsky, Jay Keyser, Mark Liberman, Bruce Hayes, Dave Shipman, Joan Bresnan, Alec Marantz, Phil Lesourd, Mohamed Guerssel. I remember a long discussion I had with Morris Halle about one of my early immature papers. He tore the paper to bits, and reduced me to the point of tears, then, as I was leaving, called me back and said, "Listen, there is some truth in what you say, so don't give up. Continue working." If Morris hadn't said that then, I may have written a thesis in syntax.

Several people patiently read the drafts of the thesis and helped me with suggestions and criticism: Jim Harris, Ken Hale, Joan Bresnan, Douglas Pulleyblank, Donca Steriade, Lisa Selkirk, Noam Chomsky, Haj Ross, Wayne O'neil. I have also had useful discussions with Vijayakrishnan, Moira Yip, Janet Pierrehumbert, Jane Simpson, Tim Stowell, Joe Perkell, Ken Stevens, Victor Zue, Dennis Klatt, Ed Walker, Will Leben, Ellen Broselow, Wilson Gray, Raj Singh. An initial version
of the stratum theory was presented at the Trilateral Conference on Nonlinear Phonology at the University of Texas at Austin, 1981. I benefited a great deal from the discussion that followed the presentation.

Jane Simpson, Susan Rothstein, Diana Archangeli, Douca Steriade, and Malka Rappaport proofread the thesis with patience and care, and saved me from the mistakes that a nonnative speaker of English makes.

Through three difficult years, the Kiparsky family gave us moral support, and many dinners. Amrit, Jay, and Meena lightened homesickness, and kept us cheerful. Little Peter brought sunshine into our home.

Unitrode gave me sustenance and inspiration during my life at MIT. I cannot forget the kindness of my boss, Sgt. Plouffé, and the friendship of my colleague, Wilson Gray, who cheerfully granted all my unreasonable requests.

I cannot adequately thank my committee: Morris Halle, Paul Kiparsky, and Jay Keyser. I learnt how to do phonology from Morris, who praised me, criticised me, scolded me, and sermonised me into shape. This thesis is as much his work as mine. Paul taught me the need to examine facts meticulously from all possible angles before rushing to a conclusion. From Jay, I learnt to translate thinking into lucid argumentation.
In addition to the academic help they provided, I remain indebted to my committee for being quick to recognise a personal crisis in my life, and executing a solution for it. Without their sensitiveness and understanding, I wouldn't have been able to complete this thesis.

I have freely drawn upon the work on Malayalam that Tara did for her M.Litt. thesis. She went through my thesis with a red pen and rewrote it, retaining the parts she found not objectionable. She disclaims all responsibility for the errors, and since the errors were not intentional on my part, so do I. Only Malushka doesn't!
1.1. The Overview

This thesis seeks to answer two important questions in phonological theory: What is the nature of the relation between phonology and morphology, and what are the levels of phonological representation? The answer to both these questions emerges from the close integration of phonology and morphology in the model of Lexical Phonology I shall develop, in which a subset of phonological rules applies in the lexicon as part of the word formation component, yielding three levels of phonological representation, the underlying, the lexical, and the phonetic.

Phonological rules apply in the lexicon after every morphological operation such as affixation or compounding, to the output of which morphological operations may apply once again, in a cyclic fashion. The lexicon consists of ordered lexical strata which function as the domains of application for these phonological and morphological rules. By allowing phonological rules to have direct access to morphological information, the model of Lexical Phonology eliminates the need for boundary symbols proposed in Chomsky & Halle (1968, henceforth SPE), and imposes severe restrictions on the class of possible grammars.
The output of the phonological and morphological operations in the lexicon, which is also the input to lexical insertion, is the level of lexical representation. It is shown that several interesting formal and psychological properties converge on this level. Pauses are assigned to lexical representations after lexical insertion, and therefore, lexical rule applications are unaffected by pauses, while post-lexical rule applications are blocked by intervening pauses. Speakers' judgments on the 'sameness' and 'distinctness' of speech sounds are based on lexical representations. Secret code languages, such as Pig Latin and the Aib language, take the lexical representation as the input, and so do speech errors which permute phonological segments. It is suggested that the lexical level may also have interesting consequences for theories of speech acquisition, speech recognition, and speech production.

In the sections that follow, I shall sketch a brief outline of the model of Lexical Phonology, with illustrations from English, reserving the details and the burden of argumentation for subsequent chapters.

1.2. Lexical and Post Lexical Domains

It is well known that rules such as trisyllabic laxing and $t + s/ - i$ require morphological information for their correct application, while rules such as the aspiration of voiceless stops and the flapping of $t$ do not. Laxing, for example, applies across $+$ in
divinity (divIn+i+iti + divini+i), but not across # in maidenhood
(mæ+den # hud → *mæ+denhud). t + s/ - i applies only when t is
followed by +: rezident + i → reziden+i (residency), but
kritik + *krisik (critic). In contrast, the rules of aspiration
and flapping are governed by factors which are strictly phonological,
such as the foot and the syllable (Kahn (1976)).

In SPE, the two kinds of phonological processes intermingle
freely, and apply as part of the derivation from the underlying to
the phonetic representation: no theoretical status is assigned to
the distinction between the two types of processes. The model of
Lexical Phonology assumes that rules which require word internal
morphological information, such as trisyllabic laxing and velar soften­ing,
apply in the lexicon, as part of the word formation component;
aspiration and flapping apply post lexically. The principle govern­ing
the distinction between lexical and post lexical applications of
rules is:

(1) Post lexical operations are blind to the internal
structure of words.

1.3. The Organisation of the Lexicon

Having stated that morphologically sensitive phonological
rules apply in the lexicon, I shall now illustrate the precise mode
of application of these rules in the lexicon. I assume that phon­
ological rules apply in word formation immediately after each
morphological operation, and that the output of the phonological processes then becomes the input to further morphological operations. This can be schematised as follows:

The derivation of *presidentiality* illustrates the way (2) works. (For ease of exposition, stress is ignored.)

\[(2)\]

```
+-----------------+            +-----------------+
| morphology      |            | phonology       |
|-----------------|            |-----------------|
```

The derivation of presidentiality illustrates the way (2) works. (For ease of exposition, stress is ignored.)

(3) / prezId  

<p>| output of          | lexical rule applications                          |</p>
<table>
<thead>
<tr>
<th>the lexicon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[ prezı̈d ]</td>
<td>[ [[prezı̈d] ent] ] affixation</td>
</tr>
<tr>
<td></td>
<td>[ [[prezı̈d] ent] y ] affixation</td>
</tr>
<tr>
<td></td>
<td>[ [[prezı̈d] ens] y ] t → s</td>
</tr>
<tr>
<td></td>
<td>(no phonological rules applicable)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ prezı̈denšiæliti ] y → i</td>
</tr>
<tr>
<td></td>
<td>[ phrezı̈denšiæliti ] aspiration</td>
</tr>
<tr>
<td></td>
<td>[ phrezı̈denšiælidi ] flapping</td>
</tr>
<tr>
<td></td>
<td>[ phrezı̈denšiælidi ] nasalisation of V</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[ ......... ] phonetic representation</td>
</tr>
</tbody>
</table>

(For ease of exposition, stress is ignored.)
Given that phonological rules apply after each morphological operation, it follows that phonological rules apply cyclically in the lexicon, each morphological operation creating a new cycle (Pesetsky (1979)). In other words, we derive (4) from (2):

(4) All phonological rule applications in the lexicon are cyclic.

The conjunct of (1) and (4) makes a powerful empirical prediction, stated in (5):

(5) All rules sensitive to word internal morphological information are cyclic rules.

(5) constitutes a significant restriction that Lexical Phonology imposes on the class of possible grammars.

1.4. The Strata

I assume that the lexicon consists of an ordered set of domains that I shall call strata. The notion of the stratum was first suggested by Siegel (1974), and developed further by Allen (1978).² Siegel observes that affixes like \texttt{in-}, \texttt{-ion}, \texttt{-ity}, and \texttt{-al} behave differently from affixes like \texttt{un-}, \texttt{-ness}, \texttt{-less}, and \texttt{-ful}. The former affixes, which she calls Class I affixes, can be attached to roots which are not independent words (e.g. \texttt{ert} in \texttt{inert}), but the latter affixes do not allow themselves to be attached to such roots:
Class I affixes cannot be attached to stems containing class II affixes. Class II affixes, on the other hand, have no such restriction:

(7) a. inorganic incoherent but
    b. unorganic uncoherent
    c. *inclassifiable uncomfortable
d. unclassifiable uncomfortable

Both un- and in- can be attached to stems containing class I affixes like -ic and -ent. Only un-, and not in-, can be attached to stems containing class II affixes like -able. Siegel proposes to account for this asymmetry by ordering all class I affixations prior to all class II affixations. Class I affixation takes place at stratum 1 (one may think of a stratum as an abstract domain or a submodule of the lexicon), class II affixation takes place at stratum 2, and stratum 1 is ordered prior to stratum 2. The following derivations illustrate the effect of stratum ordering:
in- affixation cannot apply to comfortable, because comfort and -able are put together at stratum 2, at which stage in- prefixation can no longer apply. This accounts for the ungrammaticality of (7c).

We may state the Stratum Ordering Hypothesis as follows:

(9) The lexicon consists of an ordered set of strata.

1.5. Phonological Rules and Ordered Strata

Siegel and Allen point out that the morphologically motivated stratum differences correlate with interesting phonological differences. Class II affixes are what SPE calls stress neutral affixes in that they do not change the stress of the stem, while class I affixes may change the stress of the stem. Thus, when -al is attached to dialect at stratum 1, we derive dialectal, but when -hood is attached at stratum 2, the stress does not shift: dialecthood.
Allen observes that \textit{in}-, and not \textit{un}-, undergoes nasal deletion: \([\text{in[legal]}] \rightarrow \text{illegal}\), but \([\text{un[lawful]}] \rightarrow \ast \text{unlawful}\). In order to account for such contrasts, Allen assumes that each stratum assigns its boundary to the morphological structure created at that stratum (Allen (1978:17). Thus, stratum 1 assigns the boundary + to \text{illegal}, and stratum 2 the boundary # to \text{unlawful}. This assignment of boundary symbols within phonological strings is necessary because of Allen's assumption that phonological rules apply to the final output of morphological and syntactic operations, following the SPE position that the input to the phonological component is the surface structure. Given this position, it becomes necessary to record different kinds of morphological operations in terms of different boundary symbols for subsequent reference in phonology (see Pesetsky (1979) for a discussion on this issue).

As stated earlier, the model proposed in this thesis deviates from the SPE position in allowing phonological rules to apply in the lexicon. Given that phonological rules can apply as part of word formation, it is no longer necessary to encode morphological information in terms of boundary symbols. I propose an alternative to the boundary theory by allowing the domains of phonological rules to be defined in terms of morphological strata. In the boundary theory, the fact that nasal deletion applies in \text{illegal}, but not in \text{unlawful}, is accounted for by representing them as \text{in+legal} and \text{un#lawful}, and stipulating that all boundaries except + block the application of phonological
rules unless stated in the structural description of the rule (SPE; 67).

Instead, I define the domain of nasal deletion as stratum 1, and derive the same result:

(10) Nasal Deletion (Domain; Stratum 1)

\[ [+\text{nasal}] \rightarrow \emptyset / \quad [+\text{sonorant}] \]

(11) illustrates the application of the rule:

<table>
<thead>
<tr>
<th>Stratum 1</th>
<th>Stratum 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>[legal]</td>
<td>[un[[law]ful]]</td>
</tr>
<tr>
<td>[in[legal]]</td>
<td></td>
</tr>
<tr>
<td>[i [legal]]</td>
<td></td>
</tr>
<tr>
<td>[law]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[un[[law]ful]]</td>
</tr>
</tbody>
</table>

Nasal deletion applies in *illegal* because the relevant environment \( n1 \) is available at stratum 1, where the rule can apply. *Un* and *lawful* are not put together at stratum 1, and therefore, the sequence \( n1 \) is not available at stratum 1. At stratum 2, where *un-* is prefixed to *lawful*, the rule is no longer applicable as its domain is restricted to stratum 1.

We noted earlier that trisyllabic laxing takes place across +, but not across \( \# \). I account for this property of laxing by specifying the domain of the rule as \textbf{stratum 1}: 
We may state the assumption that allows us to eliminate boundary symbols as the Stratum Domain Hypothesis:

(13) The domain of a rule is specified as a set of continuous strata.

1.6. The Opacity Principle

Consider the rule of sonorant syllabification in English, formulated in SPE as follows:

(14) sonorants become syllabic/ C --- # (p.85)

We may formally state (14) as (15):³

(15) [ +son]→ V / C --- #

(15) accounts for words like hinder, cylinder, and burglar, in which the final sonorant is syllabic, in contrast to the r and l in hindrance, cylindrical, and burglar. SPE notes that the noun twinkling (in the sense of 'instant') is bisyllabic, while the participle
twinkling is trisyllabic: [twɪŋklɪŋ]_N vs [twɪŋklɪŋ]_V. In order to account for the contrast, SPE assumes the following representations:

(16) a. twinkl + ing_N   b. twinkl # ing_V

(15) applies in (16b), but not in (16a), as the l in the latter is not followed by #.

Let us assume that English morphology requires four strata: stratum 1 (class I derivation); stratum 2 (class II derivation); stratum 3 (compounding); stratum 4 (productive inflections); and that the participial -ing is attached at stratum 4, while the nominalising -ing is a class II derivational affix attached at stratum 2.

We may now state the sonorant syllabification rule as applying at stratum 4:

(17) Sonorant Syllabification (Domain: St ratified 4)

\[ [+\text{son}] \rightarrow V / \text{C} \]

Instead of referring to #, (17) simply refers to the bracketing, i.e., the constituent structure of the word. The derivations of twinkling_N and twinkling_V are given below:
It is important that (17) should not apply to twinkling N. We can guarantee this result by assuming that this form has no internal brackets at stratum 4: [[twinkl]V ing]V, but [twinkling]N. (17) demands ] after the sonorant, and in [twinkling]N, this structural condition is not met.

The general principle assumed in (18) can be stated as the Opacity Principle:

(19) The internal structure at one stratum is invisible to the processes at another.

We may look at the Opacity Principle as a device that erases all the internal brackets at the end of all the morphological opera-
tions at each stratum. Principle (1), that post lexical rule applications are blind to the internal structure of words, can now be seen as deriving from the Opacity Principle. All word internal brackets are embedded at the end of the last lexical stratum: post lexical operations, as a result, have no access to word internal structure, which is what (1) says.

We may note that the principle of Lexical Integrity, first proposed in Chomsky (1970), follows directly from the Opacity Principle. The Lexical Integrity Principle says that syntactic rules cannot move material into or out of lexical items, or modify their structure. What this means is that syntactic rules are blind to the internal structure of words. If word internal brackets are not present in the output of the lexicon, it follows that syntactic rules cannot refer to word internal structure.

1.7. Boundary to Stratum Translation

In SPE, the use of boundary symbols serves two functions: (i) If a rule contains a boundary symbol such as + or # in its structural description, it applies to a string only if the string contains the required boundary. (17) shows how this function of the boundary symbol is taken care of in Lexical Phonology by defining the domain of the rule as the stratum associated with the boundary, and replacing the boundary with brackets. (ii) If the structural description of a rule does not contain a boundary, but
the phonological string does, the presence of the boundary in the string blocks the application of the rule. Nasal deletion (as in (11)), and trisyllabic laxing (as in (12)), show how this effect is taken care of in Lexical Phonology by defining the domain of the rule as a stratum that preceded the one which is associated with the boundary that blocks the rule. Thus, the use of boundary symbols is eliminated in Lexical Phonology by allowing phonological rules to have direct access to morphological information, that is, by defining the domains of phonological rules in terms of morphological strata, and allowing them to apply at the relevant stratum.

1.8. Rules with Lexical and Post Lexical Domains

The Stratum Domain Hypothesis (1.5.) allows phonological rules to have more than one stratum as their domain. Rules with multiple strata do exist in natural languages, as will be demonstrated in 2.1. There are rules, in fact, which apply at both the lexical and the post lexical domains. An example is the rule of palatalisation which changes $s$ to $ś$, the relevant part of which may be stated as: $s + ĺ/ \rightarrow yV$ (where $V$ is an unstressed vowel). The rule applies lexically, in *facial* (fæs] y]æɛl → feyɛl), and post lexically (in some dialects), in *miss you* (mis yu + misyɛ). Other examples from English are the rhythm rule, and $r$ deletion in British English (3.3.1.2.). In Malayalam, the rule that inserts a glide between two
vowels applies at all the lexical strata, and at the post lexical stratum as well (see 4.2.).

As has been pointed out already, Lexical Phonology differs from SPE in setting up the lexicon as a separate module for the application of phonological rules. It is logically possible to distinguish between the lexical and phrasal modules in terms of the partitioning of the set of phonological rules, and say that rules $R_1, R_2, \ldots R_i$ belong to module A, and rules $R_j, \ldots R_n$ belong to module B. It is important to note that this not the option adopted by Lexical Phonology. Rules do not belong to different modules; rather, they have one or more modules assigned to them as their domain. This conception of the stratum may be schematised as follows:

(20) Lexicon

\[ \text{Stratum 1} \]
\[ \text{Stratum 2} \]
\[ \ldots \]
\[ \text{Stratum } n \]

Output of the Lexicon

Post lexical stratum

Phonetic representation

Phonology

\[ \text{Rule 1} \]
\[ \text{Rule 2} \]
\[ \ldots \]
\[ \text{Rule } j \]
As can be seen from this diagram, the phonological component is a module independent of the lexicon, containing rules which may apply lexically, post-lexically, or both.

1.9. Morphology, Syntax, and Ordered Strata

I assume that the morphological component contains rules such as the following:

(21)a. \( N \rightarrow \text{Adj} \) -ity \hfill (e.g. civility)
b. \( N \rightarrow \text{Adj} \) -ness \hfill (e.g. goodness)
c. \( N \rightarrow N \ N \) \hfill (e.g. powerhouse)
d. \( N \rightarrow N \) plur. \hfill (e.g. boys)

How are morphological rules of this kind associated with the stratum structure? I suggest that, like phonological rules, morphological rules can have their domains defined in terms of lexical strata. Thus, (21a) will have stratum 1 as its domain; (21b), stratum 2; (21c), stratum 3; and (21d), stratum 4.

The syntactic component generates syntactic structures, the lexicon generates words, and the operation of lexical insertion puts the two together. If so, one may expand (20) to incorporate syntax and morphology into the model as follows:
1.10. The Lexical Level of Representation

An essential feature of (22) is that phonological rules can apply in the lexicon, before lexical insertion, as well as to the output of the lexicon, after lexical insertion. I assume that what is entered in the lexicon as a lexical entry is a word, and refer to the phonological representation of words as the **Lexical Representation**. (22) derives a model of phonology that has three levels of representation, namely, the underlying, the lexical, and the phonetic:
The derivation of presidentiality in (3) illustrates the three levels of representation: /prezǐd/ (underlying), prèzidenšíälity (lexical), and [phrèzidɛnšíælɪDɪ] (phonetic).

There are several interesting properties that converge on the level of lexical representation. The judgments of the native speakers of a language on the sameness and distinctness of sounds appear to be based on this level, not on the underlying or the phonetic. Thus, speakers of English judge the p in pin and spin to be the same sound, in spite of the phonetic difference in aspiration ([phin] vs [spin]) and the first vowel in metric and met to be the same, in spite of the underlying distinction (/e/ vs /e/). They also judge the second vowels in divine and divinity to be different, in spite of the underlying identity: /ɪ/. The lexical representations of these words reflect the judgments: pin, spin, metrik, met, divayn, diviniti.
Another phenomenon that the model in (23) accounts for is the behaviour of phonological rules with respect to pauses. Compare, for example, the rule of trisyllabic laxing with the rule of flapping. When asked to pronounce words slowly, syllable by syllable, for example, English speakers say, /di...vi...ni...ti/, not *[di..vay..ni..ti] or *[di..vi..ni..D1]. This shows that the rule of flapping that changes t to D is blocked by an intervening pause, but not the rule of laxing that changes \( \text{\=i} \) to i.

We can account for this difference in behaviour between pause sensitive (e.g. flapping) and pause blind (e.g. laxing) rules by assuming that pauses are assigned to phonological strings after lexical insertion. It follows that rules applying before lexical insertion will be insensitive to pauses, since pauses do not exist at that stage, and that rules applying after lexical insertion will be blocked by the presence of pauses.

There are many other phenomena which converge on the level of lexical representation. Secret code languages, such as Pig Latin, the Aib language of English, and the pa language of Malayalam, take the lexical representation as the input, perform the operation of the code on it, and apply the post lexical rules to the output of the code. Speech errors which permute segments take place at the level of lexical representation. Phenomena of this kind illustrate that the output of the lexical component of phonology is not like other stages
in a derivation, but constitutes a level of linguistic representation which has important psychological consequences.

The lexical level of representation is the level at which lexical items (= words) are represented in the mental lexicon. Given this assumption, the behaviour of code languages, speech errors, etc. can be viewed as operations on the mental representations which are the input to online processing. It is also speculated that what learners do when they come across a new word is to enter it in the lexicon in terms of the lexical level, as this level is available to the learner without the knowledge of the morphological structure of the word. The acquisition of the underlying representation of the morphemes involved takes place at a more relaxed pace, as and when morphological information becomes available to the learner from related words.

Given this approach to the acquisition of phonology, underlying representations, and the lexical rules which derive lexical representations from them, can be looked upon as serving to reduce the burden of storing lexical entries. What lexical rules do, in other words, is to encode the regularities of the lexicon.

Lexical Phonology has consequences for speech production and recognition as well. Given that words are stored in the lexicon in terms of lexical representations, it is possible to conceive of a model of speech production which takes lexical representations as
the input, and computes the phonetic representations from them, thereby eliminating the complex computations involving lexical processes. Speech recognition can be seen as involving (among other things) a bottom up computation of lexical representations from phonetic representations, thereby eliminating the need to determine the morphological structure of a word in order to identify its underlying representation.

In sum, by assuming a closer integration of phonology and morphology than has been assumed in currently available models of grammar, we arrive at a model of phonology that is intuitively more satisfying, and explanatorily more powerful, and which, at the same time, has the right consequences for a wider range of language related phenomena.
Footnotes for Chapter I

1. See Bresnan (1971), and Pesetsky (1979).

2. Siegel and Allen use the term 'level' to refer to what I call stratum. I replace 'level' with 'stratum' in order to avoid confusion with the more common use of the term 'level' to refer to a level of linguistic representation. (Chomsky (1957, 65).


4. Whether nominalising -ing is a class I or class II suffix is irrelevant for my analysis. Note, however, that -ing is a stress neutral suffix, indicating that it belongs to class II rather than class I.

5. This is not to say that human beings do not perceive sublexical phonetic distinctions. To the extent that all human beings have some phonetic skills to a greater or lesser degree, they do perceive gross phonetic distinctions. It is not, however, difficult to separate language based judgments from language independent phonetic judgments, as the latter tend to exhibit as much individual variation, say, as the aptitude for music, while the former are shared by all speakers of the language community.
Chapter II: THE STRATUM THEORY

This chapter develops an important component of Lexical Phonology, namely, the theory of ordered strata. The basic question in our enquiry will be: how best is the relation between morphology and phonology characterised? All theories agree that phonological rules require information about the different junctions between morphological forms. SPE makes morphological information available to phonology by encoding it in distinct boundary symbols. The stratum theory developed in this chapter investigates the alternative of more direct access to morphological information. I shall show that the stratum theory is both explanatorily and descriptively preferable.

The essential elements of the Stratum Theory are the Stratum Ordering Hypothesis, the Stratum Domain Hypothesis, the Opacity Principle, the cyclic application of rules, and the device of the Loop. The Stratum Ordering Hypothesis says that the lexicon consists of an ordered set of strata. The Stratum Domain Hypothesis states that the domains of rules are specified in terms of continuous strata. The Opacity Principle makes the internal structure at one stratum invisible at another.

The Loop is a device that allows two adjacent strata to be inputs to each other. In English, for example, class II affixes
can be attached to compound stems ([ex[frogman]]); compound, in turn, can be formed out of stems that contain class II affixes ([township][committee]). Given that the stratum of class II affixation precedes that of compounding, we can account for forms like exfrogman with a loop from the compounding stratum to the class II stratum.

The basic structure of the stratum theory is developed and illustrated using facts of Malayalam phonology. Malayalam is of particular interest to the theory because of the presence of two kinds of productive compounds in the language, subcompounds and cocompounds. These compounds raise extremely interesting issues about the relation between phonology and morphology, and therefore, I shall examine the phonology of compounding in Malayalam in detail.

The analysis of Malayalam compounding is followed by the application of the model to English and Dakota. In each case, the stratum theory is found to be explanatorily more adequate than the boundary theory.

2.1. Subcompounds and Cocompounds

Malayalam has two kinds of productive compounds, which, adopting the terminology of Sweet (1871), I shall call sub(ordinate) compounds and co(ordinate) compounds.
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(1) Subcompounds

a. taaraakaantamara 'Tara's husbands'
   (taara 'a name'; kaanta 'husband'; mara 'plural')

b. taamarakkanaan 'lotus-eyed person'
   (taama 'lotus'; kaan 'eye'; -an 'masc. singular')

(2) Cocompounds

a. acchanamamamaara 'parents'
   (acchan 'father'; amma 'mother'; mara 'pl.')

b. yaksakinnagarangandharaadigala 'Yaksa's, Kinnara's, Gandharwa's, etc.'
   (yaksan; kinnan; garanga; adi 'etc.'; kal 'pl.')

Subcompounds have the structure 'modifier + head'; cocompounds have the coordinate structure of 'stem + stem + stem...', corresponding to the 'dwanda' compounds in Sanskrit. There are various reasons why the two kinds of compounds should be distinguished from each other, and also from inflectional and derivational affixation, and phrasal concatenation. I shall briefly discuss below some of these reasons.

2.1.1. Preliminary Exploration

2.1.1.1. Gemination

One reason why subcompounds should be distinguished from cocompounds is that the former, and not the latter, exhibit the process of stem final and stem initial gemination of obstruents in Dravidian stems.1
(3) Subcompounds:
   a. $[[\text{kaa~}]_2[\text{maram}]] \rightarrow \text{kaatt\~}\text{maaram}$
      forest tree forest tree
   b. $[[\text{kayar}_2[\text{kattil}]] \rightarrow \text{Kayatt\~}\text{kattil}$ (rr $\rightarrow$ tt)
      rope cot cot made with rope

(4) Cocompounds:
   a. $[[[\text{aat}]]_3[\text{maat}]]\text{kal} \rightarrow \text{aat\~}\text{maat\~}\text{kal}$
      goat cow pl. cattle
   b. $[[[\text{kayar}_3[\text{kampi}_3[\text{ca\~}\text{nalal}]]_2[\text{wargam}]]] \rightarrow$
      rope wire chain category
      kayar\~kampica\~nalalawargam
      the category of ropes, wires, and chains

   The stem final $t$ and $r$ geminate in (3), but not in (4).

   Like stem final gemination, stem initial gemination also takes place in subcompounds, but not in cocompounds:

(5) Subcompounds
   a. $[[[\text{pett}]]_2[\text{pattaayam}]]\text{kal} \rightarrow \text{pettipattaayayagjal}$
      box grain bin pl. grainbins used as boxes
   b. $[[[\text{aana}]]_2[\text{ku~}\text{t}~\text{ra}]] \rightarrow \text{aanakkutir}a$
      elephant horse home that is like an elephant

(6) Cocompounds
   a. $[[[\text{pett}]]_3[\text{pattaayam}]]\text{kal} \rightarrow \text{pettipattaayayagjal}$
      boxes and grainbins
   b. $[[[\text{aana}]]_3[\text{ku~}\text{t}~\text{ra}]]\text{kal} \rightarrow \text{aanakutir}akal$
      elephants and horses
Observe that the stems in (5) and (6) are the same. Therefore, the difference in gemination between subcompounds and cocompounds cannot be attributed to any morphological peculiarity of the stem.

Given that stem final and stem initial gemination takes place in subcompounds but not in cocompounds, how do we encode this in the grammar? One possible way would be to introduce new boundary symbols to distinguish between two kinds of compounds. We may, for example, mark subcompounds with the symbol \( \#\# \), and cocompounds with \( \# \) (derivation: +; inflection: #). The rule of gemination can then be stated as (7):

\[
(7) \text{ onset } \rightarrow \text{ } /\% \rightarrow \#^3
\]

Such multiplication of boundaries, however, is ad hoc and unrevealing.

Several linguists, Rotenberg (1978), Harris (to appear), Selkirk (1980) among them, have proposed that the use of morphological tree structures allows for the elimination of boundaries. I shall propose that a more efficient way of eliminating boundary symbols is to develop the idea of "level ordering" in Siegel (1974) and Allen (1978) ('stratum ordering' in my terminology). I depart crucially from Siegel and Allen in assuming that phonological rules can apply in the lexicon at various morphological strata.

In order to account for the facts of Malayalam gemination,
let us assume that the language has the following lexical strata:

(8) Stratum 1: Derivation
Stratum 2: Subcompounding
Stratum 3: Cocompounding
Stratum 4: Inflection

Let us also assume that gemination applies at the stratum of subcompounding, but not at any other strata. The basic structure of the theory implied by such an approach can be schematised as follows:

(9) Lexicon

```
\[
\begin{array}{c}
\text{subcompounding} \\
\text{cocompounding} \\
\vdots
\end{array}
\]
```

phonological rules:
1. gemination  
   (domain: subcompounding)
2. rule ...  
   ...

After every morphological operation such as affixation and compounding, the set of phonological rules is scanned for applicability. The domains of application of phonological rules are specified in terms of the strata at which the morphological operations take place, and a phonological rule applies at a stratum just in case the domain of that rule includes that stratum.
Given these assumptions, the rule of gemination can be stated as follows:

(10) Gemination (Domain : Sc) (Sc = subcompound stratum)

\[
\text{Onset } \rightarrow \bigwedge % \rightarrow \]

The derivation of \( \text{pašu}^{\text{kkutti}}\text{kkirukkanmaar} \) 'people crazy about calves' (\( \text{pašu} \) 'cow'; \( \text{kuṭṭi} \) 'child'; \( \text{kirukkan} \) 'mad man'; \( \text{maar} \) 'pl.') will be as follows:

(11)

\[
\begin{array}{c|c}
\text{subcompound} & \text{compounding} \\ \hline
\text{[[pašu][kkutti]]} & \text{gemination} \\ \text{[[pašu][kkutti]]} & \text{compounding} \\ \text{[[pašu][kkutti]][kirukkan]} & \text{gemination} \\ \text{[[pašu][kkutti]][kkirukkan]} & \text{gemination} \\
\hline
\text{inflection} & \text{compounding} \\ \text{[[pašu]kkutti][kirukkan] maar} & \text{affixation} \\
\hline
\text{phon. rules} & \text{phon. rules}
\end{array}
\]

The contrast between \( \text{kaṭṭ̄maar} \) (3a) and \( \text{aat̄maat̄} \) (4a) can thus be explained as follows: in \( \text{kaṭṭ̄maar} \), the compounding takes place at the subcompound stratum, where the gemination environment \( t\) is accessible to rule (10). In \( \text{aat̄maat̄} \), on the other hand, the two stems are put together at the cocompound stratum, and \( t\) appears only after the domain of application of gemination is crossed.
2.1.1.2. Nasal Deletion

Malayalam has rules that apply in both subcompounds and
cocompounds, but not in a sequence of two words or in a sequence
of a stem and an affix. An example of such a process is stem final
nasal deletion.

(12) Subcompounds
a. \([\text{maram}_2 \text{[kutira]}] \rightarrow \text{marakkutira}\)
   tree horse wooden horse
b. \([\text{manusyan}_2 \text{[mrgam]}] \rightarrow \text{manusyamrgam}\)
   man animal beastly man

(13) Cocompounds
a. \([\text{sukham}_3 \text{[dukkham]}] \rightarrow \text{suahkanukham}\)
   pleasure sorrow pleasure and pain
b. \([\text{yak}_3 \text{[kinnaran]}_3 \text{[gandharwan]} \text{maar}] \rightarrow \text{yaksakinnaranagandharwanmaar}\)
   Yaksha's, Kinnara's, and Gandharwa's

(14) Inflections
a. \([\text{maram} \text{kal}] \rightarrow \text{maranna}\)
   tree pl.

b. \([\text{manusyan} \text{maar}] \rightarrow \text{manusyanmaar}\)
   man pl.

c. \([\text{manusyan} \text{oott}] \rightarrow \text{manusyanoot}\)
   man dat.
(15) Across words

a. manusyan mariccu → manusyan mariccu
   man died (*manusya mariccu)

b. yaksan kinnarane nulli → yaksan kinnarane nulli
   Yaksha Kinnara pinched (*yaksa kinnarane nulli)
   nom. acc.
   (The Yaksha pinched the Kinnara.)

c. katam kont mutinnu → katam konta mutinnu
   debt with destroyed (*kata konta mutinnu)
   (We are destroyed by debt.)

There is a process of nasal deletion in derivational morphology that appears to be misleadingly similar to nasal deletion in compounds. This process, which I shall refer to as n-deletion, is illustrated below:

(16) a. aaroogyam 'health'; anaaroogyam 'ill health'
    b. aawaranam 'cover'; aanaawaranam 'uncover'
    c. aikyam 'unity'; aanaikyam 'disunity'

(17) a. sukham 'happiness'; asukham 'unhappiness'
    b. kramam 'order'; ak mmmam 'disorder'
    c. satyam 'truth'; asatyam 'falsehood'

The nasal in the negative prefix an- deletes when followed by a consonant. I shall state the rule as follows:

(18) n-deletion (Domain: De) (De = Derivational stratum)
    n → Ø / — [C

n-deletion differs from the nasal deletion in compounds in
at least two respects. First, n-deletion applies only when followed by a consonant (cf. (16) and (17)); nasal deletion applies before vowels as well:

(19) a. \([\text{wrksam}]_2[\text{agram}] \rightarrow \text{wr} \text{ksaagram}\)  
    tree top tree top

b. \([\text{mukham}]_2[\text{aawaranam}] \rightarrow \text{mukhaawaranam}\)  
    face cover cover for the face

c. \([\text{janam}]_2[\text{aikyam}] \rightarrow \text{janaikyam}\)  
    people unity unity of the people

(20) a. \([\text{suuryan}]_3[\text{candran}]_2\text{maar} \rightarrow \text{suuryacandranmaar}\)  
    sun moon pl. the sun and the moon

b. \([\text{sukham}]_3[\text{asukham}]_2\text{kal} \rightarrow \text{sukhaasukhappal}\)  
    happiness sorrow pl. happiness and sorrow

c. \([\text{jananam}]_3[\text{maranam}]_2\text{kal} \rightarrow \text{jananamaranappal}\)  
    birth death birth and death

Second, n-deletion applies only to n, while nasal deletion applies to m as well. Consider the behaviour of \text{sam}- 'together':

(21) a. \text{yoogam} 'joining' ; \text{samyoogam} 'joining together'

b. \text{taapam} 'heat' ; \text{san\text{a}apam} 'sympathy' (m → n)

c. \text{tr\text{p\text{ti}}} 'satisfaction' ; \text{san\text{t\text{p\text{ti}}} 'contentment'}

Since the a→ an alternation in (16) and (17) is not the result of nasal deletion in compounds, and nasal deletion does not apply in (21), I shall conclude that nasal deletion does not occur in derivational morphology. The rule of nasal deletion could be stated as (22)
in a theory that makes use of phonological boundaries to encode morphological information:

(22) Nasal + φ / — {###}

Within the stratum theory, on the other hand, the rule is:

(23) Nasal Deletion (Domain: Sc, Cc) (Cc = Cocompound)
Nasal + φ / — ][

2.1.1.3. Vowel Lengthening

Another process that applies in subcompounds and cocompounds, but not in derivations, inflections, and word sequences is stem final vowel lengthening:

(24) Subcompounds

a. [[taara]₂[kaantan]] → taaraakaantan₄
   a name husband Tara's husband

b. [[rati]₂[deewi]] → ratiideewi
   a name goddess the goddess Rati

c. [[wadhu]₂[gham]] → wadhuugham
   bride house bride's home

(25) Cocompounds

a. [[[taara]₃[kaantan]]maar] → taaraakaantanmaar₃
   a name a name pl. Tara and Kantan

b. [[[baalika]₃[baalan]maar] → baalikaabaalanmaar₃
   girl boy pl. girls and boys

c. [[[bhaarya]₃[bhartaakkan]maar] → bhaaryaabhartaakkanmaar₃
   wife husband pl. couples
(26) Derivations

a. \([ati \ [kramam]] \rightarrow atikramam\)
   extreme order beyond order

b. \([anu \ [ka\text{\textae}nam]] \rightarrow anuka\text{\textae}nam\)
   together doing imitation

c. \([prati \ [dhwani]] \rightarrow pratidhwani\)
   against sound echo

(27) Inflections

a. \([ta\text{\textae}ra \ e] \rightarrow ta\text{\textae}raye\)
   a name acc.

b. \([ta\text{\textae}ra \ kk'] \rightarrow taarak'k'\text{\textae}\)
   dat.

c. \([bha\text{\textae}rya \ maar] \rightarrow bha\text{\textae}ryamaar\text{\textae}\)
   wife pl.

d. \([parawa \ kal] \rightarrow parawaka\text{\textae}\)
   dove pl.

(28) Across words

a. \(ta\text{\textae}ra \ parannu \rightarrow ta\text{\textae}ra \ parannu\)
   a name said Tara said

b. \(bha\text{\textae}rya \ ka\text{\textae}ranam \rightarrow bha\text{\textae}rya \ ka\text{\textae}ranam\)
   wife reason because of wife

We formulate the rule of vowel lengthening as follows:\(^5\)

(29) Vowel Lengthening \hspace{1cm} (Domain: Sc, Cc)

\[
\text{Rime} \rightarrow \wedge / \quad [\]
\]
2.1.1.4. Vowel Sandhi

We saw that the domain of gemination is the subcompounding stratum. The rules of nasal deletion and vowel lengthening apply at the subcompounding as well as the cocompounding strata. I shall now show that the process of vowel sandhi which merges two adjacent vowels into a single one applies at the strata of derivation, sub-compounding, and cocompounding.

In compounding, the vowels fused together undergo further changes of vowel height, the details of which we shall come to in 4.4.2. Vowel sandhi in compounds is illustrated by the following examples:

(30) Subcompounds
   a. \([\text{mahaa}_{2}\text{[indran]}] \rightarrow \text{maheendran} \]
      great Indra  great Indra
   b. \([\text{nilha}_{2}\text{[ambãram]}] \rightarrow \text{nilaambãram} \]
      blue  sky  blue sky

(31) Cocompounds
   a. \([\text{wee}_{3}\text{[itihaasam]}\text{kal}] \rightarrow \text{weedetihaasaggal} \]
      scripture  myth  pl. scriptures and myths
   b. \([\text{sukham}_{3}\text{[asukham]}\text{kal}] \rightarrow \text{sukhaasukhaggal} \]
      health  ill health  health and illness

When the infix \(-\text{a-}\) is inserted in the first syllable of a noun to form an abstract noun, it merges with the following rime:
Thus, the domain of vowel sandhi includes the stratum of derivation.

Vowel sandhi does not apply at the level of inflections, as shown by (27a). The following examples show that vowel sandhi does not apply across words:

(33) a. bhaar-ya alari → bhaar-ya y alari
wife screamed

b. paa-su atbhu-tappettu → paa-su w atbhu-tappettu
cow wondered

In sum, I have shown that morphological information can be made accessible to phonological rules by allowing the phonological rules to apply in the lexicon, and specifying their domains in terms of morphological strata. 2.1.1.2., 2.1.1.3., and 2.1.1.4. show that a phonological rule must be allowed to have multiple strata as its domain: a theory that restricts domain assignments to single strata does not account for the facts of Malayalam.

The principle that governs the assignment of domains to rules is repeated below:

(34) The Stratum Domain Hypothesis
The domain of a rule is specified as a set of continuous strata.
Notice the stipulation that rule domains should be continuous. That is to say, if a rule has stratum 2 and stratum 4 as its domain, then, by (34), we are forced to include stratum 3 also as its domain. The continuity of strata is by no means a necessary requirement in the stratum theory. It is possible, for example, to abandon the continuity requirement and hold a weaker version of the Stratum Domain Hypothesis, as in (35):

(35) The domain of a rule is specified as a set of strata.

In the absence of empirical evidence against (34), however, I shall adopt this stronger and more restrictive version of the hypothesis.

2.1.2. The Mechanics

2.1.2.1. The Stratum Structure

The discussion in 2.1.1. shows that we must assume Malayalam to have at least four strata of word formation, derivational, sub-compounding, cocompounding, and inflectional. These strata are ordered as follows:

(36) \begin{align*}
\text{Stratum 1 : derivations} \\
\text{Stratum 2 : subcompounding} \\
\text{Stratum 3 : cocompounding} \\
\text{Stratum 4 : inflections}
\end{align*}
This ordering makes the correct prediction that derivational affixes cannot be attached to compounds (or inflected stems), and that compounds cannot contain inflected stems:

(37) a. gamanaagamananäjalä 'goings and comings'
   b. gamanaagamananiyantranam 'control of goings and comings'
   c. *gamanaagamananäjaläniyantranam

(gamanam 'going'; aagamanam 'coming'; -kal 'pl.
   niyantranam 'control

As (37c) shows, the plural inflection -kal cannot occur inside a compound. This holds for case inflections as well. It is difficult to offer formal evidence for or against the relative ordering of derivations and compounding, as both subcompounds and cocompounds are noun+noun compounds; the semantic relationships, however, show that (36) is not incorrect:

(38) a. satyam 'truth' ; asatyam 'falsehood'
   b. sät tyapreemam 'love of truth'; asatyapreemam 'love of falsehood'

asatyapreemam cannot mean 'hatred of truth', which is what we would expect if the structure were [a [[satyam] [preemam]]]. Arguments based on meaning relationships can sometimes be misleading, but considering the fact that there are no cases in which the meaning of the compound is computed before the meaning of the affix is combined with the stem, I shall assume that (38) is indeed correct, until evidence to the contrary is discovered.
2.1.2.2. The Loop

An interesting problem arises from the fact that a subcompound may contain a cocompound, and a cocompound may contain a subcompound, in both the right and the left members of the compound.

(39) a. N₁ ~ N₂ N₃ ~ N₄ N₅

yaksan kinnaran kuuttam → yaksakinnaракkuuttam
Yaksha Kinnara group group of Yakshas & Kinnaras

b. N₁ ~ N₂ N₃ ~ N₄ N₅ N₆ N₇ N₈ N₉ N₁₀

maatr sneeham patni widweesam wikaaram kal
mother love wife hatred emotion plur.

→ maatrasneehapatniwidweesawikaaranpala
the emotions of mother love and wife hatred
In (39a), $N_1$ is a subcompound which contains a cocompound ($N_2$) as its left member. In (39b), $N_5$ and $N_6$ are subcompounds, $N_3$ is a cocompound, and $N_4$ is a subcompound. In (39c), $N_3$ and $N_4$ are cocompounds, and $N_2$ is a subcompound.

If the ordering of statements is strictly as given in (36), the stems of subcompounds should not themselves be cocompounds. It is, therefore, necessary to say that the output of cocompounding can optionally be an input to subcompounding. For this, I propose the device of the 'loop', which works as follows:

\begin{equation}
\begin{array}{c}
\text{Stratum 1: Derivations} \\
\downarrow \\
\text{Stratum 2: Subcompounding} \\
\downarrow \\
\text{Stratum 3: Cocompounding} \\
\downarrow \\
\text{Stratum 4: Inflections}
\end{array}
\end{equation}

It is important to note that the loop in (40) is $\binom{2}{3}$, rather than $\binom{3}{2}$. That is to say, even though subcompounds and cocompounds can be inputs to each other, the stratum of subcompounding precedes...
that of cocompounding. The empirical consequences of this ordering are discussed in 2.1.3.

2.1.2.3. The Opacity Principle

Note that the k in kuuttaam geminates, while that in kinnaaran does not, in (39a). This is, in fact, what is expected, because kuuttaam is the constituent of a subcompound, while kinnaaran is the constituent of a cocompound. The derivation of the compound is as follows:

(41)

<table>
<thead>
<tr>
<th>subcompound</th>
<th>coocompound</th>
</tr>
</thead>
<tbody>
<tr>
<td>([\text{yaksan}] \ [\text{kinnaaran}])</td>
<td>compounding</td>
</tr>
<tr>
<td>([\text{yaksa }] \ [\text{kinnaaran}])</td>
<td>nasal deletion</td>
</tr>
<tr>
<td>(\text{vowel sandhi})</td>
<td></td>
</tr>
</tbody>
</table>

Note that the internal bracketing of yaksakinnaran should
not be seen at the subcompound stratum, if gemination is not to apply to it. This follows from the Opacity Principle, repeated below:

(42) The Opacity Principle

The structure at one stratum is invisible at another stratum.

Observe that (42) imposes a powerful restriction on possible grammars, and is desirable on a priori grounds. The principle also guarantees that the bracketing [[yakṣa][kinnaraṇ]] is invisible at the subcompounding stratum.

Pesetsky (1979) proposes a convention that erases internal brackets at the end of a derivation. This convention has similar, but not identical results as the Opacity Principle; it is, therefore, necessary to examine how (42) differs empirically from this convention.

(43) Bracket Erasing Convention

Given the nested constituents

\[ \ldots \ldots n-1 \ldots \ldots n \]

the last rule of cycle \( n \) is: erase \( n-1 \).

The following derivation illustrates the application of the Bracket Erasing Convention.
(44) \textit{untheatricality}

\begin{tabular}{|l|l|}
\hline
Stratum 1 & \\
\hline
\text{[theatre]} &  \\
\text{[[theatre]ic]} & \text{-ic affixation} \\
\text{[theatric]} & \text{BEC} \\
\text{[[theatric]al]} & \text{-al affixation} \\
\text{[theatrical]} & \text{BEC} \\
\text{[[theatrical]ity]} & \text{-ity affixation} \\
\text{[theatricality]} & \text{BEC} \\
\hline
\end{tabular}

\begin{tabular}{|l|l|}
\hline
Stratum 2 & \\
\hline
\text{[un [theatricality]]} & \text{un- affixation} \\
\text{[untheatricality]} & \text{BEC} \\
\hline
\end{tabular}

The effect of BEC is to erase the internal brackets at the end of every morphological operation. The effect of (42), on the other hand, is to erase the brackets at the end of a stratum:

(45) \textit{untheatricality}

\begin{tabular}{|l|l|}
\hline
Stratum 1 & \\
\hline
\text{[theatre]} &  \\
\text{[[theatre]ic]} & \text{-ic affixation} \\
\text{[[[theatre]ic]al]} & \text{-al affixation} \\
\text{[[[theatre]ic]al]ity]} & \text{-ity affixation} \\
\text{[theatricality]} & \text{by (42)} \\
\hline
\end{tabular}

\begin{tabular}{|l|l|}
\hline
Stratum 2 & \\
\hline
\text{[un[theatricality]} & \text{un- affixation} \\
\hline
\end{tabular}

In 4.5.3., I shall show that the Bracket Erasing Convention is too strong, as there are cases of affixation which are sensitive to the internal structure of the stems.
2.1.3. Stress and Tone

2.1.3.1. Preliminary Facts

The basic facts of word stress in Malayalam are:

(46) a. If the first syllable of a word has a short vowel and the second syllable a long one, the primary stress falls on the second syllable; in all other cases, primary stress is on the first syllable.

b. Secondary stress (the evidence for which is the appearance of a high tone. Discussed below.) falls on all the remaining long vowels.

Given below are a few examples:

(47) a. waṟaṁ 'will come'
    b. wāṟam 'boon'
    c. waṟaṁ 'week'
    d. wāṟāṁ 'will gather'

(48) a. paraṟi 'complaint'
    b. pāṉḍayanaṁ 'reading'
    c. māṟaṭakam 'eme mlld'

(49) a. angaṟasātmilkaṟaṇam 'ca bon assimilation'
    b. mṛgamaṇḍadīrāsāyanam 'a medicine'

Malayalam is not a tone language. However, it is necessary to distinguish between word level intonation and phrase level intonation of in Malayalam. The facts of word level intonation are:

(50) a. The primary stressed syllable has a low tone.
    b. The last syllable of the word has a high tone.
    c. All the secondary stressed syllables have high tones.
The assignment of tones is illustrated in (51):

(51) a. \( \text{parāṭi}^{L\ H} \)  b. \( \text{parāṭ}^{L\ H} \)  c. \( \text{paaraśayanam}^{L\ H\ H} \)

We can account for the rising pitch contour, or the word melody, by assuming that it is of the form \( LH \): the low tone is anchored to the primary stress, while the high tone spreads. In order to specify where it spreads, we propose the following convention for building trees:

(52) Foot construction

a. Construct feet on all long vowels.
b. Mark the first syllable as extrametrical (cf. Hayes (1980)) if it has no foot and is followed by a foot.
c. Construct feet on initial and final vowels.

(53) Word tree

Construct a left branching tree on feet.

(54) Tone

\( H \) spreads to all tree

Examples for the application of (52)-(54) are given below:

(55) a. \( \text{marat} \text{akam} \)  b. \( \text{paraśayanam} \)  c. \( \text{paraśti} \)

\[
\begin{array}{c}
\text{marat} \text{akam} \\
\text{paraśayanam} \\
\text{paraśti}
\end{array}
\]

(52a)

\[
\begin{array}{c}
\text{marat} \text{akam} \\
\text{paraśayanam} \\
\text{paraśti}
\end{array}
\]

(52b)

\[
\begin{array}{c}
\text{marat} \text{akam} \\
\text{paraśayanam} \\
\text{paraśti}
\end{array}
\]

(55b)

\[
\begin{array}{c}
\text{marat} \text{akam} \\
\text{paraśayanam} \\
\text{paraśti}
\end{array}
\]

(55c)
2.1.3.2. Compounds

The facts of stress and tone dealt with in 2.1.3.1. are of particular interest to us because subcompounds and cocompounds exhibit differences in stress and tone assignment. A subcompound with a single primary stress and a single word melody acts as a unit, irrespective of the number of stems in it, while each stem in a cocompound is a separate unit, with stress and tone assignment taking place on every stem:

(56) Subcompounds

a. [[[tārātā]₂[kaanta]₃]maaṛ̣a]
   
   a name husband pl. (Tara's husbands)

b. [[[mātarget]₂[widweėam]₃]]
   
   religion hatred (hatred of religion)

(57) Cocompounds

a. [[[ācchan]₃[āmmā]₃]maaṛ̣a]
   
   father mother pl. (parents)

   
   Yaksha Kinnara Gandha ṭwa pl.
In (56a), the *kaa* of the second stem is not considered the first syllable for the purposes of stress assignment, and is not assigned primary stress. In (56b), *ta* in the first stem is not considered the last syllable, and has no high tone on it. Both these facts follow from the assumption that the two compounds are single units for the purposes of stress and tone assignment. In contrast, the first syllable of *ama* in (57a) is assigned a primary stress, and the second syllable of *acchan* receives a high tone, indicating that the two stems are distinct units for stress and tone assignment.

Thus, noncompound words in subcompounds are treated identically for the purposes of stress and tone assignment, which takes place only after all the operations of subcompounding. The domain of stress and tone assignment is stipulated to be the cocompounding stratum. Sample derivations are given below:

(58) a. *matawidweeșam*

\[
\begin{array}{c}
\text{Sc} \\
\text{Cc}
\end{array}
\]

\[
\begin{array}{c}
\text{L} \quad \text{H} \quad \text{H} \\
\text{L} \quad \text{H}
\end{array}
\]

\[
\begin{array}{c}
\text{[matam] [widweeșam]} \\
\text{[[matam][widweeșam]]} \\
\text{[[mața ] [widweeșam]]}
\end{array}
\]

\[
\begin{array}{c}
\text{compounding} \\
\text{nasal deletion}
\end{array}
\]

\[
\begin{array}{c}
\text{E} \quad \text{E} \quad \text{F}
\end{array}
\]

\[
\begin{array}{c}
\text{stress and tone}
\end{array}
\]
b. acchanammamaarə 8

L H L H

Sc | no rules
---|---
Cc | F F F F
   | [ acchan ] [ amma ]
   | L H L H
   | F F F F
   | [[ acchan ] [ amma ]]
   | L H L H
Infl. | F F F F
 | [[acchanamma] maarə]
 | L H L H

Note that the inflectional ending maarə does not receive any secondary stress, and there is no high tone on the syllable. This follows from the stipulations that (i) the domain of stress and tone assignment is the cocompounding stratum, and (ii) inflections are attached after the cocompounding stratum (2.1.2.1.).

The interesting cases of tone assignment are found in those subcompounds which contain cocompounds as one of their constituents. Observe that the sequence mata widweesam in (56b) has a single word melody (LHH), while the same sequence has two melodies in (59a) (LH LH):

(59) a. jaṭi mata widweesam

L H L H L H
b. 

\[
\begin{array}{c}
\text{stem} \\
\text{N}_1 \\
\text{N}_2 \\
\text{N}_3 \\
\text{N}_4 \\
\text{N}_5 \\
\end{array}
\]

\[\text{jaati ma\text{\textcommata}m widwe\text{\textcommata}sam}\]

caste religion hatred (hatred of caste and religion)

(60) \text{jaatimatawidwe\text{\textcommata}sam}

<table>
<thead>
<tr>
<th>De</th>
<th>[jaati] [ma\text{\textcommata}m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>affixation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sc</th>
<th>---- ----</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>compounding</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cc</th>
<th>F F F F</th>
</tr>
</thead>
<tbody>
<tr>
<td>[jaati] [ma\text{\textcommata}m]</td>
<td>stress &amp; tone</td>
</tr>
<tr>
<td></td>
<td>L H</td>
</tr>
<tr>
<td></td>
<td>F F F F</td>
</tr>
<tr>
<td></td>
<td>L H</td>
</tr>
<tr>
<td></td>
<td>[jaati][ma\text{\textcommata}m]</td>
</tr>
<tr>
<td></td>
<td>L H</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sc</th>
<th>F F F F</th>
</tr>
</thead>
<tbody>
<tr>
<td>[[jaatimata][widwe\text{\textcommata}sam]]</td>
<td>compounding</td>
</tr>
<tr>
<td></td>
<td>L H L H</td>
</tr>
<tr>
<td></td>
<td>F F F F</td>
</tr>
<tr>
<td></td>
<td>L H L H</td>
</tr>
<tr>
<td></td>
<td>[jaatimata][widwe\text{\textcommata}sam]</td>
</tr>
<tr>
<td></td>
<td>L H L H</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cc</th>
<th>F F F F F F</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ jaatimata widwe\text{\textcommata}sam ]</td>
<td>stress &amp; tone</td>
</tr>
<tr>
<td></td>
<td>L H L H</td>
</tr>
<tr>
<td></td>
<td>L H</td>
</tr>
<tr>
<td></td>
<td>---- ----</td>
</tr>
<tr>
<td></td>
<td>compounding</td>
</tr>
</tbody>
</table>
2.1.3.3. Stress and Tone Assignment in the Boundary Theory

It would be instructive to enquire at this point how the facts of stress and tone described above can be accounted for in a theory that makes use of distinct boundary symbols rather than ordered strata to characterise the domain of phonological rules. In order to distinguish between subcompounds and cocompounds in stress and tone assignment, the boundary theory must stipulate that word tree construction cannot take place across the cocompound boundary $$\#$$, the inflectional boundary $\#$, and the word boundary $$\#$$.$^{10}$ Given the assumptions of metrical theory, such a stipulation would result in an odd projection of feet as well as boundary symbols. This disjunction is unnecessary in the stratum theory.

Even if a projection of boundary symbols and feet were allowed, the boundary theory is incapable of accounting for stress and tone assignment in compounds like (59), in which a subcompound contains a cocompound as one of its members.

Consider the contrast between (61) a and b:

(61) a. [[[jaaṭi][maṭa][wiḍweṣam]] : sub
  \[
  \begin{array}{ccc}
  L & H & L \\
  \text{LH} & L & H \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{co} \\
  \text{N} \\
  \text{N} \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{N} \\
  \text{N} \\
  \end{array}
  \]
  
  b. [[[kaamuka][[bhārtr̥][sahoodaṇaṇa]][maṛa]: co
  \[
  \begin{array}{ccc}
  L & H & L \\
  \text{LH} & L & H \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{co} \\
  \text{N} \\
  \text{N} \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{N} \\
  \text{N} \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{N} \\
  \text{N} \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{Lover} \\
  \text{husband} \\
  \text{brother} \\
  \text{pl.} \\
  \end{array}
  \]
  \[
  \begin{array}{c}
  \text{N} \\
  \text{N} \\
  \end{array}
  \]
  
  (Lovers and husband's brothers)
In terms of boundaries, (61) a and b receive identical representation: \( X \# \# Y \# \# Z \):

\[(62)\] a. \textit{jäätì \# mä́ča \# widweśam} \\
b. \textit{kaamuka \# bhaŕt̥a \# sahoda̲ran \# maṅga}

The representations in (62) a and b do not make the necessary distinctions for stress and tone assignment. One may think of exploiting the bracketing difference to account for the distinction. Thus, in addition to stipulating that \( \# \) blocks stress and tone assignment, one may say that the rules apply cyclically, from smaller to larger the brackets. However, this assumption leads to incorrect results of assigning primary stress and a LH melody to every stem in a subcompound. Thus, the boundary theory has no account for the contrast between (61) a and b.

2.1.4. Summary

The structure of the model of phonology that emerges out of 2.1 is: a subset of phonological rules has the lexicon as the domain of application. These rules apply prior to lexical insertion, thereby making a distinction between lexical rule applications and post lexical rule applications. The lexicon consists of a set of ordered strata, and the domains of phonological rules are characterised as sets of continuous strata.
Morphological and phonological operations are interspersed in a cyclic fashion. Every time a morphological operation takes place at a stratum, the set of phonological rules which have that stratum as their domain are scanned for applicability.

(63) \[
\text{Morphological process} \quad \rightarrow \quad \text{Phonological process}
\]

(63) has the effect of making all rule applications in the lexicon cyclic, without stipulating them to be so (see also Pesetsky (1979)).

It must be pointed out that the rules we have discussed so far do not provide any evidence that lexical rules MUST apply cyclically, after every morphological operation. They could equally well be accounted for by assuming that the phonological rules apply at the end of all the morphological operations at every stratum.

(64) \[
\begin{array}{c}
\text{Stratum } i \\
\text{morphological processes}
\end{array} \quad \rightarrow \quad \begin{array}{c}
\text{Phonology} \\
\text{rule 1} \\
\text{rule 2} \\
\vdots \\
\end{array}
\quad \begin{array}{c}
\text{Stratum } i + 1 \\
\text{morphological processes}
\end{array}
\]

The strongest position would be either that all lexical rule applications are cyclic, or that all of them are noncyclic. There is evidence that at least some lexical rule applications must be cyclic (Kiparsky (1979); Hayes (1980)). Therefore, I shall assume, in
the absence of counterevidence, that all lexical rule applications are cyclic, and adopt (63), which yields this result.

The stratum structure of Malayalam and the phonological rules associated with the strata are summarised in (65):

(65) Strata Phonological rules

- stratum 1: derivations: vowel lengthening (domain: 2,3)
- stratum 2: subcompounding: nasal deletion (domain: 2,3), gemination (domain: 2)
- stratum 3: cocompounding: vowel sandhi (domain: 1,2,3)
- stratum 4: inflections: stress (domain: 3), tone (domain: 3)

2.2. General Issues

2.2.1. What is a Stratum?

The assumption that lay behind our analysis of subcompounds and cocompounds was that they are generated by rules (66)a and b respectively:

(66) a. N $\rightarrow$ NN  (subcompounds)
b. N $\rightarrow$ N*  (cocompounds)
There are no node labels that distinguish between the two kinds of compounds, such as $N^{\text{sub}}$ and $N^{\text{co}}$. Thus, the subcompound \textit{pašukkutti kal} 'calves', and the cocompound \textit{acchanamamaara} 'parents' will have identical configurational structures:

(67) a. $\quad N \quad N \quad \text{plur.}$
    $\quad N \quad N \quad \text{plur.}$
    $\quad \text{pasu kutti kal}$
    $\quad \text{acchan amma maar}$
    $\quad \text{cow child pl.}$
    $\quad \text{father mother pl.}$

The distinction between subcompounds and cocompounds is made in terms of the stratum at which the stems are put together. (66a) has the subcompounding stratum as its domain, and (66b), the cocompounding stratum.

Now, (66a) is not the only morphological rule that applies at the subcompounding stratum. For instance, as we shall see in 4.5., and 4.6., the following rules also apply at this stratum:

(68) The Causative Rule

\[ V \rightarrow V -ik'k' \quad \text{e.g.} \]

\[ V \]
\[ \text{oof} \quad \text{ik'k'} \quad \text{'run-intr.' cause} \]
\[ \text{'run-tr.'} \]
(69) The Verbal Compound Rule
\[ N \rightarrow N V \text{-}i \quad \text{e.g.} \quad N \]
\[ \text{ambara(m) cumb} \text{-}i \]
\[ \text{sky kiss agentive} \]
\[ \text{'sky scraper'} \]

In other words, it is not subcompounds alone which are generated at stratum 2, but causative verbs and verbal compounds as well. For mnemonic purposes, however, I shall continue to refer to stratum 2 as the subcompounding stratum.

Similarly, the derivational stratum is associated with rules such as \( N \rightarrow a N \) ((16a)); \( N \rightarrow \text{sam} N \) ((21)); \( A \rightarrow \text{prati} A \) ((26c)). The inflectional stratum attaches number and case inflections to nouns: \( N \rightarrow N \text{num case} \); and tense inflections to verbs: \( V \rightarrow V \text{tense} \).

Given this approach to morphology, the rules which make a distinction between two morphological processes must apply at the appropriate stratum, as the morphological distinction is not available in the final output of the word formation component. 2.1. demonstrates this with respect to phonological rules. Semantic rules follow the same mode of application. Thus, cocompounds have the meaning of 'X and Y and ...', while subcompounds have various meanings such as 'X made with Y' (e.g. marakkutif \( \text{a 'wooden horse'} \)), 'Y's X' (kutirawaala \( \text{ 'horse's tail'} \)), 'X that operates with Y' ( kutirawasti \( \text{ 'horse cart'} \) etc. These semantic relationships must
be established at the stratum at which each compound is generated, paralleling the application of phonological rules described in 2.1.

What this shows is that each stratum is associated with sets of morphological, semantic, and phonological rules which have that stratum as their domain. This conception of the lexicon can be schematised as follows:

The relative order of the phonological and semantic components is irrelevant, but it is important that the morphological component precedes the other two.

A stratum, thus, is an abstract domain, at which several morphological, semantic, and phonological properties converge. The only intrinsic property of a stratum is the ordering relation it holds with respect to the other strata. The rest of its properties are derived from the application of various rules which have that stratum as their domain of application.

A stratum may be conceived of as a location, with an index
attached to it. Each location carries the following instructions:

(71) **Location i**

a. Search the grammar for rules with index $i$, and apply them.

b. Go to location $j$.

The notion of the stratum is similar to the notion of the component in linguistic theory, with one crucial difference. A component is identified by the processes and types of representations it contains. In other words, a component is uniquely associated with a set of rules and representations. No such unique association is possible with a stratum, as the same rule or representation may be associated with more than one stratum.

2.2.2. Rule Ordering in Lexical Phonology

Does Lexical Phonology require the extrinsic ordering of phonological rules? Supposing that stratum $S_i$ is ordered prior to stratum $S_j$, and that rules $P_i$ and $P_j$ have $S_i$ and $S_j$ respectively as their sole domains, it would follow that the application of $P_i$ would precede the application of $P_j$. If so, can we maintain the Unordered Rule Hypothesis such as the one proposed in Koutsoudas, Sanders, & Noll (1974), which says that rules apply whenever they are applicable, subject to universal restrictions on their application? Can the ordering of strata take care of the apparent counterexamples to the Unordered Rule Hypothesis?
A brief look at the facts of Malayalam phonology reveals that extrinsic ordering of phonological rules is, indeed, necessary, independently of stratum ordering. Consider the interaction between nasal deletion (2.1.1.2.) and vowel lengthening (2.1.1.3.). Both nasal deletion and vowel lengthening have the subcompounding and cocompounding strata as their domains; hence the stratum theory says nothing about the relative order of their application. Now, we find that the vowels before deleted nasals do not lengthen, as shown by the contrast between (72) and (73):

(72) a. [[jaaraan][gIrham]] \[\rightarrow jaa\text{-}agIr\text{-}ham\]
    lover house lover's house

b. [[kaalam][san\text{-}dee\text{-}sam]] \[\rightarrow kaala\text{-}sa\text{-}dee\text{-}sam\]
    time message the message of time

(73) a. [[bhaara\text{-}ya][gIrham]] \[\rightarrow bhaa\text{-}yaagIr\text{-}ham\]
    wife house wife's house

b. [[kala][san\text{-}dee\text{-}sam]] \[\rightarrow kala\text{-}sa\text{-}dee\text{-}sam\]
    art message the message of art

The vowel in the last syllable of the first stem lengthens in (73), but not in (72). These examples present a classic case of extrinsic ordering:

(74) Vowel lengthening  
    Nasal deletion
Another example that demonstrates the need for extrinsic ordering of phonological rules is the interaction of the process of vowel onglide formation and the processes of post nasal and inter-vocalic voicing.

(76) Vowel Onglide Rule

\[ V \rightarrow \hat{\alpha}V / [+\text{voice}] \]

\[ / -\text{son.} \]

(77) a. talam \( \rightarrow \) [talam] \( \sim \) dalam \( \rightarrow \) [d\( \hat{\alpha} \)alam]

't a room' 'petal'

b. paalam \( \rightarrow \) [paalam] \( \sim \) baalan \( \rightarrow \) [b\( \hat{\alpha} \)aalan]

'bridge' 'boy'

c. \( \tilde{t}i\tilde{r}am \rightarrow [\tilde{t}i\tilde{r}am] \sim \) diinam \( \rightarrow \) [d\( \hat{\alpha} \)iinam]

'shore' 'disease'

The onglide \( \hat{\alpha} \) is inserted after \( \_d \) and \( \_b \), but not after \( \_t \) and \( \_p \).

The rule of post nasal voicing is:

(78) Post Nasal Voicing

\[ \begin{bmatrix} -\text{son.} \\ -\text{cont.} \end{bmatrix} \rightarrow [+\text{voice}] / [+\text{nasal}] \]
(79) a. kampi → [kambi] 'a metal rod'

b. kaŋtu → [kaŋdu] 'saw'

c. cem + ḫaamæc → [cendɑamæɾa]
   red lotus       red lotus

For the present purposes, I formulate the rule of intervocalic voicing (for details, see 4.1.5.) as follows:

(80) Intervocalic Voicing

\[
\begin{array}{c}
[-\text{son.}] \\
[-\text{cont.}] \\
\end{array}
\rightarrow [+\text{voice}] / \nu \rightarrow \nu
\]
The rules (76), (78), and (80), all apply in the post lexical domain, as shown by the fact that they apply across words:

(82) a. ṭaṣi碘 ewiţe + ṭaṣi碘 ewiţe (vowel onglide)
Rashid where Where is Rashid?

b. ṭaaman pooyi + ṭaamambooyi (post nasal voicing)
Rama went Rama went

c. kutti karannu + kutti karannu (intervoc. voicing)
child cried child cried

Given that these rules apply in the same domain, the stratum ordering says nothing about their relative order of application. Nevertheless, we find that the vowel onglide rule must apply prior to the voicing rules. Contrast a and b:

(83) a. maţan + [mađan] 'a fool'

b. mađan + [mađan] 'slow person'

(84) a. waaţam + [waaţam] 'rheumatism'

b. waaţam + [waaţam] 'argument'

In order to account for the fact that the vowel onglide rule does not apply in (83a) and (84a), we stipulate the following order:

(85) Vowel onglide
     Post nasal voicing
     Intervocalic voicing
2.3. Excursions into Other Languages

In this section, I shall present brief illustrations of the application of the stratum theory to English and Dakota, in order to give a clearer picture of the model by examining familiar phenomena, as well as to clarify the kinds of predictions the theory makes.

2.3.1. English

2.3.1.1. How many strata does the lexicon of English require? How are they ordered? The first approximation is provided by (86):

\[(86) \text{Stratum ordering in English}\]

Stratum 1: Class I affixation (*in-, -ity, -ion, -ic...*)

Stratum 2: Class II affixation (*un-, re-, -dom, -ship...*)

Stratum 3: Compounding

Stratum 4: Inflection

It has been pointed out by Selkirk (to appear) that class II derivations can be attached to compound stems, even though class I derivations cannot (Siegel (1974), Allen (1978)). Thus, though *in self-sufficient* and *in outmoded* are impossible, *un#self-sufficient* and *ex#frogman* are not. In order to account for these facts, we provide a loop from 3 to 2:
(87) Stratum Ordering in English

\[ \begin{align*}
\text{Stratum 1: Class I derivations} \\
\text{Stratum 2: Class II derivations} \\
\text{Stratum 3: Compounding} \\
\text{Stratum 4: Inflections}
\end{align*} \]

Is there a loop from stratum 4 to 3? Evidence suggests that there cannot be such a loop, even though Selkirk cites compounds like arms conscious and pants suit to show that compounds can contain inflected stems. Alongside these compounds, we also have trouser-leg (*trousers-leg, *trouser, trousers), and scissor-cut (*scissors-cut, *scissor, scissors). Observe that the prohibition on inflected stems extends to the tense inflections as well. Thus, as Selkirk herself notes, *scrubs woman and *scrubbed woman are impossible in English. I shall, therefore, conclude that inflected stems cannot be compounded in English. Compounds such as arms conscious and pants suit are marginal, and some alternative explanation will have to be offered for them.

Note that (87) correctly predicts that derivational affixes cannot be attached to inflected stems: *programser (programmer), *weaponry (weaponry), *kingsdom (kingdom), *childrenlike (childlike). A loop from 4 to 3 would also amount to a loop from 4 to 2, and we would have no explanation for the impossibility of attaching derivational affixes to inflected stems.
2.3.1.2. Defining the domain of a rule as stratum 1 has the effect of allowing the rule to apply across +, but not across # or ##. SPE notes that there are no rules in English which are blocked by the presence of +, and stipulates the convention that a rule of type (88a) is optionally interpretable as (88)b, c, and d:

\[
\begin{align*}
& \text{(88) a. } A \rightarrow B/ X \rightarrow Y \\
& \quad b. A \rightarrow B/ X \rightarrow + Y \\
& \quad c. A \rightarrow B/ X + \rightarrow Y \\
& \quad d. A \rightarrow B/ X + \rightarrow + Y
\end{align*}
\]

This convention guarantees that + is incapable of blocking phonological rules, unlike the other boundaries.

In Lexical Phonology, it is unnecessary to have anything corresponding to this convention. Observe that + is, in fact, the boundary associated with class I derivations, and is, therefore, the juncture at stratum 1. The only way for a phonological rule not to apply across a stratum 1 juncture is for it to be assigned to a previous stratum, which does not exist. Thus, no phonological rule can be blocked by the juncture at stratum 1. Generalising, we may say that defining the domain of a rule as stratum $S_i$ and not stratum $S_j$ (where $S_i$ is prior to $S_j$) has the effect of allowing the rule to apply across the boundaries associated with $S_i$ and the preceding strata, and blocking the application of the rule across the boundaries associated with $S_j$ and the subsequent strata. Thus, the effects of rule
blocking across boundaries follows from the organisation of the lexicon, and requires no special stipulations.

Consider, for example, the phenomenon of word stress in English. It is a matter of general observation that class II affixes are stress neutral, while class I affixes may cause a stress shift. SPE accounts for this contrast by stipulating that the rules of word stress apply across \(+\), but not across \(\#\). In a metrical theory of stress that makes use of boundary symbols, what this means is that foot construction cannot apply across \(\#\):

\[
\begin{align*}
(89) \quad a. \text{\em dialect} & \quad b. \text{\em dialectal} & \quad c. \text{\em dialectdom} \\
\text{word} & \quad \text{word} & \quad \text{word} \\
\text{F} & \quad \text{F} & \quad \text{F} \\
\wedge & \quad \wedge & \quad \wedge \\
\text{sw} & \quad \text{sw} & \quad \text{sw} \\
\text{dia(lect)} & \quad \text{dia(lect)+al} & \quad \text{dia(lect)#dom}
\end{align*}
\]

\[
\begin{align*}
\text{not d. *\em dialectdom} \\
\text{word} & \quad \text{word} \\
\text{F} & \quad \text{F} \\
\wedge & \quad \wedge \\
\text{sw} & \quad \text{sw} \\
\text{dia(lect)#dom}
\end{align*}
\]

If foot construction is an operation on the projection of rimes (Hayes (1980)), this is a strange stipulation: in order to guarantee that the foot in (89d) is not built, one has to assume that foot trees are built on a projection of rimes as well as boundary symbols (see also 2.1.3.3.).
Lexical Phonology accounts for the stress neutrality of class II affixes by assuming that the domain of foot construction is stratum 1.\(^{14}\) This domain assignment has the effect of not allowing \# and ## inside a foot. Given below are the derivations which illustrate the application of this solution.

Note that no new feet are formed at stratum 2, and the existing foot trees are undisturbed. The joining together of feet into word trees takes place at stratum 2. Alternately, one may assume that word tree formation can take place at both 1 and 2. I cannot think of any empirical consequence which hinges on these alternatives.
Class II suffixes like -ness, -less, and -dom do not have any stress on the suffixes themselves. On the other hand, some class II suffixes like -ship, -hood, and -like, and all the class II prefixes I can think of (un-, de-, re- ...) are inherently stressed: childlike, kingship, manhood, unknown, redesign. In order to account for the contrast, I shall assume that -ship, -hood, un-, etc. have inherent feet.

(91) kingdom kingship

\[ S_1 \]

<table>
<thead>
<tr>
<th></th>
<th>kingdom</th>
<th>kingship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[king]</td>
<td>[king]</td>
</tr>
<tr>
<td>F</td>
<td>[king]</td>
<td>[king]</td>
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<tr>
<td>F</td>
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</tbody>
</table>

foot construction

\[ S_2 \]

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<tr>
<th></th>
<th>kingdom</th>
<th>kingship</th>
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<tbody>
<tr>
<td>F</td>
<td>[king]</td>
<td>[ship]</td>
</tr>
<tr>
<td>F</td>
<td>[dom]</td>
<td>[ship]</td>
</tr>
</tbody>
</table>

affixation

\[ S_2 \]

<table>
<thead>
<tr>
<th></th>
<th>kingdom</th>
<th>kingship</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>[king]</td>
<td>[ship]</td>
</tr>
<tr>
<td>F</td>
<td>[dom]</td>
<td>[ship]</td>
</tr>
</tbody>
</table>

word tree

Observe that the rule governing the word tree at stratum 2 is: the stem is assigned S. Thus, we have manhood but unknown. One may venture to suggest that this can be accounted for by the following universal principle:

(92) Unless otherwise required by the grammar, the stem is dominant.

When a class II affix is attached to a stem, the primary stress is always on the stem. In contrast, most compounds generally
take the primary stress on the first stem. What this means is that
the compound stress rule applies only at stratum 3 (because 3 is
the stratum of compounding), and not at prior or subsequent strata.
We state the compound stress rule as follows:

(93) Compound Stress Rule (Domain: Stratum 3)

The right node is strong iff branching.

(Liberman & Prince (1976))

Compare the derivations of unknown and blackbird:

(94)  

\[
\begin{array}{c|c|c}
\text{S}_1 & \text{unknown} & \text{bláckbird} \\
\hline
[\text{known}] & [\text{black}][\text{bird}] & \\
F & F & F \\
[\text{known}] & [\text{bláck}][\text{bird}] & \text{foot construction} \\
\hline
\text{S}_2 & F & F \\
\hline
[\text{un[known]}] & \text{affixation} & \\
w \sw & F & F \\
\hline
\text{S}_3 & & \\
\hline
\end{array}
\]

To summarise, we find that foot construction takes place in
English at stratum 1. There are no labelling conventions at stratum 2,
and the universally unmarked condition that the stem is dominant
applies. Stratum 3 is the domain of the compound stress rule.
2.3.1.4. There are three types of apparent problems for our analysis of English morphology. The first type is illustrated by words like *nuclear physicist*. If we adopt the bracketing suggested by the meaning of the word ('one who studies nuclear physics', not *'a physicist who is nuclear'*), we arrive at [[nuclear physicist]], which violates the generalisation that class I affixes are not attached to compounds. Note, however, that semantic bracketing does not always correspond to morphological bracketing. *English grammarian*, for example, can mean 'one who studies English grammar', but we do not for this reason propose the bracketing [[English grammar]N P ian]. Given that some principle of semantic interpretation is necessary to account for *English grammarian*, we can adopt the bracketing [[nuclear][physicist]], and allow the same principle to apply to it.

The second type of problem is found in words like *developmental* and *governmental*. If the -ment in these words is a class II affix, we arrive at the structure [[[stem]class II affix]class I affix], which our analysis of English morphology disallows. We suggest that the -ment in these cases, unlike the -ment in, say, *fulfillment*, is a class I affix. Some support for this position is offered by the stress shift in these words (development vs developmental). Class II affixes do not cause stress shift.

The third problem is seen in words like *ungrammaticality* and *extrametricality*. Assuming that *un* is attached to adjectives and not to nouns (*unfortunate*, but *unfortune*), the bracketing
has to be [[un[grammatical]]ity], which involves the attachment of a class I affix to a stem containing a class II affix. At this point, I do not have a solution to this problem.

2.3.2. Compounding in Dakota

2.3.2.1. Basic Facts

Chambers & Shaw (1980; henceforth C&S) show that there are two kinds of compounds in Dakota, which they refer to as lexical and syntactic compounds, illustrated in (95)a and b respectively:

(95) a. hā | wakhā → hāwakhā (lexical)
      night holy the northern lights

      b. hā # wakhā → hāwakhā (syntactic)
      holy night

C&S use the boundary | for lexical compounds, # for syntactic compounds, and + for inflections. The semantics of syntactic compounds, as illustrated by (95b), is compositional, while that of lexical compounds is almost totally unproductive. There are several phonological processes in which the distinction between the two compounds clearly shows up. As illustrated in (95), for example, lexical compounds have a single stress, while syntactic compounds have two. C&S take care of the stress facts with the following rules:
(96) Dakota Accent Rule (DAR) (p. 325)

\[ V \rightarrow \acute{V} / \#(C_0V)C_0 \]

(97) Compound Accent Rule (CAR) (p. 327)

\[ \acute{V} \rightarrow \grave{V} / [\#\ldots \acute{V} \ldots \# \ldots \#]_{N_iV} \]

The environment \# is met only once in (95a) (\#h\#wak\#h\#), but twice in (95b) (\#h\#wak\#h\#), and therefore, DAR applies to both stems in (95b). CAR follows, reducing the second \( \acute{V} \) to \( \grave{V} \).

Dakota has several other processes that demand the distinction between lexical and syntactic compounds. One of them is the rule of stem formation, given by C&S as follows:

(98) Stem Formation (p. 330)

\[ \emptyset \rightarrow a/ C \rightarrow \# \]

(98) derives [čepa] 'to be fat' from the underlying ##čep##. The rule applies word internally in syntactic compounds, but not in lexical compounds:

(99) a. čheγ #zi → čheγazi 'yellow kettle'
    b. čheγ| zi → čhexzi 'brass kettle'

Similarly, the rule of devoicing applies only in lexical compounds:

(100) \[ z \rightarrow s \]

\[ \acute{z} \rightarrow \grave{s} \]

\[ \gamma \rightarrow x \]
(100) changes γ to x in (99b). 17

2.3.2.2. The Ordering of Strata in Dakota

An interesting feature of Dakota morphology is that the processes of compounding and derivation apply to inflected stems. Consider, for example, the behaviour of the inflectional prefixes wa 'I', ya 'you', and ni 'you':

(101) Non derived words

waupa 'I lay down' (wa + ūpa)

(102) Compound words

a. čhokhū 'to plan to kill' (čho| khū)
b. čhowákhū 'I plan to kill (someone)' (čho[wa + khū])
c. čhoýákhu 'you plan to kill (someone)' (čho[ya+khū])

(103) Derived words

a. yeyá 'send' (ye 'go'; ya 'you')
b. yewáya 'I send (someone)'
c. niyéwasí 'I ordered you to go' (sí 'order')

Observe that the inflectional morphemes wa and ya occur inside С compounds ((102)b,c), as well as inside С derivations ((103)b,c), showing that inflectional affixation is an input to both derivation and compounding. The Dakota facts present a marked case: in most languages, inflectional affixation is not an input to derivational affixation, shown by the fact that derivational affixes cannot be
attached to inflected stems. I give below the unmarked universal stratum ordering and the marked Dakota ordering:

(104) Unmarked Stratum Ordering

\[
\begin{align*}
&\text{stratum 1: derivations} \\
&\text{stratum j: inflections}
\end{align*}
\]

(105) Dakota

\[
\begin{align*}
&\text{stratum 1: inflections} \\
&\text{stratum j: derivations}
\end{align*}
\]

Expanding (105) on the basis of the information available in C&S, we arrive at the following stratum ordering in Dakota:

(106) Dakota stratum ordering

\[
\begin{align*}
&\text{Stratum 1: Inflection} \\
&\text{Stratum 2: Derivation} \\
&\text{Stratum 3: 'Lexical' compounding in C&S} \\
&\text{Stratum 4: 'Syntactic' compounding in C&S}
\end{align*}
\]

In passing, we note that the Dakota facts confirm our assumption that inflectional affixation takes place in the lexicon, rather than in syntax (see also Lieber (1980), Selkirk (to appear), Bresnan (in press: a, b)). This assumption is to be contrasted with the approach taken in, say, the Government Binding Theory (Chomsky (1981)) in which inflections attach to their stems in syntax by means of rules such as affix hopping. Given Chomsky's assumption that derivational
affixation takes place in the lexicon (Chomsky (1970)), and the fact that inflectional affixation is an input to derivation, it follows that inflectional affixation should also take place in the lexicon.

2.3.2.3. The Domains of Rules

We are now ready to define the domains of Dakota rules in terms of the strata in (106). The stem formation rule ((98) for C&S) clearly belongs to stratum 4.

(107) Stem Formation (Domain: Stratum 4)

\[ \emptyset \rightarrow a / C \]  

The rule of devoicing ((100)) in the stratum theory would belong to strata 2 and 3:

(108) Devoicing (Domain: Strata 2-3)

\[ z \rightarrow s / \]  

\[ \tilde{z} \rightarrow \tilde{s} / \]  

\[ y \rightarrow x / \]  

The DAR ((96)) should apply at stratum 4, as it applies only when the syntactic compound boundary is present:

(109) Dakota Accent Rule (Domain: Stratum 4)

\[ v \rightarrow \tilde{v} / [(C_0 V)C_0 \rightarrow 18] \]  

The CAR ((97)) also belongs to stratum 4.
(110) The Compound Stress Rule (Domain: Stratum 4)

\[ \hat{V} + \hat{V} / [[[\ldots \hat{V} \ldots] [\ldots \hat{\ldots} \ldots]]] \]

The derivations of (95) a and b are given below:

(111) hāwākhā 'northern lights'

<table>
<thead>
<tr>
<th></th>
<th>hā</th>
<th>wakhā</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S₃</td>
<td>[[hā] [wakhā]]</td>
<td>compounding</td>
</tr>
<tr>
<td>S₄</td>
<td>hāwākhā</td>
<td>DAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAR</td>
</tr>
</tbody>
</table>

(112) hāwakhā 'holy night'

<table>
<thead>
<tr>
<th></th>
<th>hā</th>
<th>wakhā</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td></td>
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<tr>
<td>S₂</td>
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<tr>
<td>S₃</td>
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<td></td>
</tr>
<tr>
<td>S₄</td>
<td>hā</td>
<td>wakhā</td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>[[hā][wakhā]]</td>
<td>compounding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CAR</td>
</tr>
</tbody>
</table>
2.3.2.4. Advantages of the Stratum Treatment

2.3.2.4.1. Assuming that the presence of all boundaries except + blocks phonological rules unless stated in the structural description of the rule, the formulation of DAR by C&S as in (96) is incorrect. Observe that the rule applies across |, as shown by (113):

(113) a. cho|k?ū + chok?ū 'to plan to kill' (p. 325, 6)

b. skal|o+mani + skalomani 'he goes about in order to play' (p.328)

There can be an optional | both before and after the second C₀ in the rule. For DAR to apply correctly in (113), C&S will have to reformulate the rule as:

(114) V+V / #(C₀V)(|)C₀(|)

Rule (114) misses the generalisation that DAR simply ignores the presence of | anywhere in the string. Why, for example, couldn't there have been a rule like (115)?

(115) V+V / #(C₀V)(#)C₀(|)

Rules like (115) are unstateable in the stratum framework, as the Opacity Principle would prevent referring to junctures at different strata. In the boundary theory, however, (114) and (115) have the same status: there is no reason to prefer one to the other. Now, as far as I know, rules such as (115) do not exist in natural
languages. If so, the stratum theory allows possible rule types and correctly disallows impossible rule types, while the boundary theory allows impossible rule types (e.g. (115)), and sometimes disallows possible rule types (e.g. stress and tone in Malayalam).

2.3.2.4.2. As seen in 2.3.2.1., Dakota exhibits the following peculiar properties:

(116) a. Inflections do not block phonological rules.
    b. Inflections can occur inside \& derivations.

C&S assign the boundary + to inflections. Given the SPE approach to boundaries, we would expect inflections to be characterised in terms of # rather than +. C&S obviously use + instead because phonological rules apply freely across inflectional junctions in Dakota (e.g. DAR in (113b); (103)), and it is only + which does not block phonological rules.

C&S's assignment of + to inflections, although it guarantees the right results, is unprincipled. Their treatment is inadequate also in that it does not relate (116a) and (116b). In Lexical Phonology, given (116b), (116a) follows. Recall that the junction associated with stratum 1 is incapable of blocking phonological rules. Given that inflections can occur inside \& derivations, we are forced to conclude that the stratum of inflection precedes that of derivation, and as there is no evidence that anything precedes inflection, the inflectional stratum becomes stratum 1. It follows, therefore, that
the juncture of inflections cannot block phonological rules.

Given that in English, class I derivations constitute the innermost layer of morphology, our theory would assign it to stratum 1, and thereby make its juncture incapable of blocking rules. Similarly, given that inflections constitute the innermost layer in Dakota, the stratum theory makes the inflectional juncture incapable of blocking rules. In other words, Lexical Phonology explains the association of + with class I derivations in English and with inflections in Dakota.

In sum, we find that the lexical theory allows us to account for the optionality of morphological junctures in a principled manner. This theory disallows those types of optionality of junctures which do not occur in natural languages. The stratum treatment also brings together the two facts of Dakota that inflections occur inside derivations, and that inflectional junctures do not block phonological rules.

2.4. Alternatives to the Stratum Theory

2.4.1. Junctures and Domains

There are two kinds of information that phonological rules require of morphology, which may be characterised as juncture information and domain information. The juncture information, to use Rotenberg's (1978) terminology, consists of edges and junctions.
Thus, when two forms \([a_1, a_2 \ldots a_n]_A\) and \([b_1, b_2 \ldots b_n]_B\) combine together to form \([[]]_A[[]]_B\), we can say that \(a_1\) and \(a_n\) occur at the edges of \(A\), and \(b_1\) and \(b_n\) occur at the edges of \(B\), and that \(a_n\) and \(b_1\) occur at the junction between \(A\) and \(B\).

All phonological theories require the juncture information. Thus, in SPE, rules of the form (117a) refer to edges, and (117b) to junctions:

(117) a. \(X \rightarrow Y/ + + \); \(X \rightarrow Y/ \# \#\)

b. \(X \rightarrow Y/ +b \); \(X \rightarrow Y/a\# \#\)

In the lexical framework, rules of the form (118a) refer to edges, and (118b) to junctions:

(118) a. \(X \rightarrow Y/ \# \); \(X \rightarrow Y/ [\# \#\]

b. \(X \rightarrow Y/ +b \); \(X \rightarrow Y/ a\) [\# \#\]

In addition to juncture information, phonological rules need to know about the morphological domain in which they apply. One of the primary means of making use of domain information in SPE was to encode it in terms of distinct boundary symbols, thereby packing the domain and juncture information simultaneously into a symbols or 'par with the linear segmental symbols. Thus, the symbol + would roughly mean 'juncture, class I affixation', and # would mean 'juncture, class II affixation or inflection'.


In addition to using boundary symbols, SPE made use of node labels on phrase structure trees to specify the domain information in phonological rules. Thus, to encode the fact that the compound stress rule in English applies in the domain of compounds, and the nuclear stress rule applies in the domain of phrases, SPE labelled the brackets in the structural descriptions of the rules with N, NP, etc.:

(119) a. ...X]_{N,A,V} \quad \text{(compound stress rule)}

b. ...X]_{NP,VP,PP...} \quad \text{(nuclear stress rule)}

2.4.2. The Boundary Alternative

SPE has the following mechanism for assigning boundaries:

(120) a. All morphemes are flanked by the boundary +.

   b. All major categories and their projections
      \((N, V, A, NP, VP...)\) are flanked by \#.

\(\text{(120a)}\) derives representations like (121):

(121) a. \[A \rightarrow N \rightarrow \text{divine+} \rightarrow \text{ity+} \]

b. \[A \rightarrow A \rightarrow \text{un+} \rightarrow \text{known+} \]
Subsequent application of (120b) yields representations like (122):

(122) a. N
   #divine#ity#

b. A
   #un#known#

c. A
   #tele+graph+ic#

d. NP
   #the## black## bird## pl.##

SPE also requires a readjustment rule that changes # to + in the case of affixes like -ity and -ic (class I affixes), thereby deriving divine+ity and tele+graph+ic from (122) a and c. Another readjustment rule changing ## to # derives black##bird## from (122d), as (120b), incorrectly assigns ## before an inflectional suffix in compounds. This readjustment rule applies to class II affixes as well:

ex##frog##man → ex#frog##man.
This discussion shows that there is no principled assignment of boundaries in SPE. The correct boundary is ensured by ad hoc readjustment rules which rectify the incorrect outputs of (120b).

Boundary assignment becomes far more complicated than in English when we take a language like Malayalam. Readjustment rules would be required to change # to + in derivations, to ## in subcompounds, and to ## in cocompounds. What is the environment for these readjustment rules? It cannot be the case that individual morphemes trigger the rules, because the same morpheme sequences can be either subcompounds or cocompounds. One way to insert the correct boundaries would be to assume that subcompounds and cocompounds are distinguished by node labels such as N^{sub} and N^{co}. We may now think of the following mechanism for boundary insertion or for the application of readjustment rules:

(123) Insert ## between the stems dominated by N^{sub}, and ## between the stems dominated by N^{co}.

This approach can be extended to other boundaries as well. Now, if it is the node labels that tell us which boundary symbol to insert, why do we need separate boundary symbols at all? Instead of formulating the rule of gemination in subcompounds as (124), for example, we may formulate it as a rule that applies in N^{sub}, as in (125):

(124) onset \rightarrow \wedge \% \rightarrow ##

(125) onset \rightarrow \wedge \% \rightarrow [\text{ in } N^{sub}]
An alternative to (124) would be to adopt the stratum theory for the purposes of morphology, and stipulate that each stratum assigns its own boundary symbol as part of the derivation (cf: Allen (1978)). Once again, the question arises why boundary symbols are necessary in addition to the notion of morphological strata. The point that emerges out of this discussion is that boundary symbols only duplicate the information provided by node labels like $\text{N}_\text{sub}$ or by morphological strata, and are therefore redundant in phonology.

Let us now turn to the consequence of formulating phonological rules in terms of boundaries. The stratum theory crucially assumes that (i) the structure at one stratum is invisible to the rules at another (Opacity Principle), (ii) the domains of rules are continuous strata (Stratum Domain Hypothesis), and (iii) the strata are ordered in relation to each other (Stratum Ordering Hypothesis). These assumptions have empirical consequences which are of relevance to a comparison between the stratum theory and the boundary theory.

Consider, first, a rule of the following type:

(126) $A \rightarrow B / X+Y \rightarrow #Z$

The boundary $+$ belongs to stratum 1, and $#$ to stratum 2 or a subsequent stratum. Reference to the junctions at two different strata in the same rule is disallowed by the Opacity Principle (see also 2.3.2.). Hence, the Opacity Principle forbids the formulation of a rule equivalent to (126). Rules like (126), as far as
I know, do not exist in natural languages. If so, we find that the stratum theory, not the boundary theory, correctly rules out the impossible rule types in natural languages.

One may object that the same result can be derived from the boundary theory by incorporating the Opacity Principle. Note that the Opacity Principle is a necessary component of the stratum theory: without it, there would be no way of distinguishing between the brackets assigned at different strata. In the boundary theory, on the other hand, the principle is an extra stipulation designed for the sole purpose of accounting for the impossible rule types.

Another instance of the restrictiveness of the stratum theory comes from the Stratum Domain Hypothesis, which says that the domains of rules must be continuous strata. Recall that rules like nasal deletion, vowel lengthening, and vowel sandhi in Malayalam have more than one stratum as their domain. The domain of vowel sandhi, for example, consists of strata 1, 2, and 3. In 4.2, we shall see a rule that inserts a glide between two adjacent vowels, with all the lexical strata and the post lexical stratum as its domain. It is logically conceivable that a rule applies at stratum 1, 2, and 4, without applying at 3. The Stratum Domain Hypothesis, however, forbids such a domain assignment, and therefore, such a process is untestable as a single rule in the lexical theory. Thus, the theory would rule out a dialect of Malayalam in which vowel sandhi applied in derivations and cocompounds, but not in subcompounds. Such
dialects do not, in fact, exist. In the boundary theory, however, nothing prevents rules from applying in the environment of + and $$\#$$, and not $$\#\#$$.

One may incorporate the effect of the Stratum Domain Hypothesis in the boundary theory by defining a hierarchy of boundaries such as $$+ \#\# \# \#$$, and stipulating that no rule may mention two nonadjacent boundaries. Such a stipulation, though yielding the desired result, would be entirely ad hoc. Given the independently motivated ordering of domains in the stratum theory, on the other hand, the most natural assumption would be that the domains are not discontinuous.

The third prediction that the stratum theory makes deals with rule blocking, and is derived from the Stratum Ordering Hypothesis. As was illustrated in 2.3.1., the effect of a rule being blocked by a boundary $$B_j$$ is achieved in the stratum theory by assigning stratum $$S_i$$ as the domain of the rule, where $$B_j$$ is associated with a stratum following $$S_i$$. It follows from this treatment of rule blocking that a rule which applies across a strong boundary will also apply across a weaker boundary:

$$(\text{weak } \leftarrow + \#\# \# \# \rightarrow \text{strong}).$$
Conversely, a rule that is blocked by a weak boundary will also be blocked by a stronger boundary. These are powerful empirical predictions, not available to the boundary theory except by stipulation.
The strongest argument against the boundary theory is that it is descriptively inadequate. For the facts for which the stratum theory has a simple account, the boundary theory does not have an adequate description, as seen in 2.1.3.3.

In sum, the lexical model of phonology allows us to eliminate the ad hoc use of boundary symbols by referring to morphological information more directly, in terms of the independently motivated morphological strata and morphological bracketing. This model is explanatorily superior in that it correctly disallows phonological rule types and rule interactions which the boundary theory allows. At the descriptive level, the lexical model can account for all the existing phenomena that the boundary theory can account for, but there exist phenomena in natural languages such as the stress and tone assignment in Malayalam which are easily accounted for within the lexical approach, but not within the boundary approach.

2.4.3. The Node-Domain and Level-Domain Theories

Specifying the domains of phonological rules in terms of morphological strata is not the only alternative to the boundary theory. In the theory of phonology proposed by Selkirk (to appear), for example, domains are characterised in terms of the node labels of phrase structure trees without appealing to the notion of morphological strata (see also Rotenberg (1978)). I shall refer to Selkirk's
theory as the 'node-domain' theory, in contrast to the 'stratum-domain' theory advocated in this thesis. In what follows, I shall give a comparison of the two theories.

In Selkirk's theory, what corresponds to strata are X bar categories like $X^0$, $X^{-1}$, $X^{-2}$, etc., where the negative numerals indicate levels below $X^0$. In order to account for the distributional properties of class I and class II affixes in English, for example, Selkirk assumes that class I affixes are subcategorised for "roots" ($X^{-1}$), and class II affixes for "words" ($X^0$). The structure of *theatrical*, *unbroken*, and *arm chair* would thus be:

$$\begin{align*}
\text{theatrical, unbroken, and arm chair}
\end{align*}$$

The effects of stratum ordering are built into rewrite rules as follows:

(128) a. $X^{-1} \rightarrow \text{affix } X^{-1}$ ($X^{-1}$ affix)
    b. $X^0 \rightarrow X^{-1}$
    c. $X^0 \rightarrow \text{affix } X^0$ ($X^0$ affix)
    d. $X^0 \rightarrow X^0 X^0$

(128a) defines class I affixation, (128c) defines class II
affixation and inflection, and (128d) defines compounding. As stated earlier, class I affixes are subcategorised for $X^{-1}$, and class II affixes for $X^0$. Therefore, $X^{-1}$ can contain monomorphemic forms, and forms derived through class I affixation, but not forms derived through class II affixation or compounding ($X^0$). The stress neutrality of class II affixes is taken care of by defining the domain of foot construction as $X^{-1}$. The rule of nasal deletion (in illegal), trisyllabic laxing, etc., are also restricted to $X^{-1}$.

This use of X bar categories like $X^{-1}$ and $X^{-2}$ is unmotivated, and does not yield any of the advantages of the X bar theory, such as the characterisation of the rule types, cross categorial generalisations, etc. A more fruitful way of making use of the X bar theory in word formation would be to assume that it is affixes which are $X^{-1}$ categories. For example, one may think of the following representation for words like unpatriotic:

\[
\begin{align*}
(129) & \\
 & \begin{array}{c}
A^0 \\
\downarrow \ \\
A^{-1} \\
\begin{array}{c}
N^0 \\
\downarrow \ \\
A^{-1} \\
\text{un patriotic}
\end{array}
\end{array}
\end{align*}
\]

Reinterpreting Williams' (1979) insight, we may assume that the category of the node dominating the affix + stem (or stem + affix) combination is determined by the affix. This assumption need not be stipulated in this theory, since, given the X bar framework, it follows that the affix ($X^{-1}$) is the head in the rule $X^0 \rightarrow X^0 X^{-1}$.
(or $X^{-1}X^0$), and the dominating node takes up the category of its head.

In this system, as in Selkirk's, we may assume that affixes are subcategorised for their sisters. Thus, un- and -ic have the following subcategorisation:

\begin{align*}
(130) \text{a. } \text{un-} & \rightarrow (X^0) \\
\text{b. } \text{-ic} & \rightarrow (N^0) 
\end{align*}

This theory allows us to incorporate affixes into the general X bar system. Note that affixes behave like heads in at least two respects. They subcategorise for their sisters, and they determine the categorial features of their mothers. As pointed out earlier, both these properties follow from the X bar theory if affixes are $X^{-1}$. On the other hand, if words are $X^0$, and roots are $X^{-1}$, then roots should be the heads of words, and we would expect roots to subcategorise for affixes rather than vice versa, and for the roots to determine the category of the dominating node. In Selkirk, affixes are special entities that lie outside the X bar. Consequently, the properties of affixes with respect to their sisters and mothers become mere stipulations.

Another advantage of the theory implied in (129) and (130) is that it allows us to specify subcategorisation without violating the assumption that subcategorisations are defined on maximal projections (cf: Emonds (1976)). If we make the perfectly natural assumption
that \( X^0 \) is the maximal projection at the level of word formation, we can say that the condition of the maximality of projection on subcategorisation applies in word formation as well. In Selkirk's system, -\textit{ity} is subcategorised for \( A^{-1} \), and -\textit{ness} for \( A^0 \), and hence, no such restriction of maximality of projection can be made on subcategorisation.

Thus, Selkirk's use of the X bar theory in word formation does not crucially derive any explanatory power from the theory, such as those involving the notions of head and feature percolation from the head. The revised system suggested above, on the other hand, derives natural consequences from the theory for head, feature percolation, and subcategorisation. Now, a crucial feature of this alternative is that the X bar rules do not distinguish between class I and class II derivation (or between subcompounds and cocompounds) (e.g. (129)). In order to make the relevant distinction, it would be necessary in this system to supplement it with stratum ordering.

Thus, Selkirk argues that the use of the X bar theory in morphology eliminates the need for ordered strata, while we conclude that the maximal exploitation of the X bar theory in word formation requires the stratum theory to complement it by providing the relevant domain information.

One may still think of replacing the stratum theory with a node-domain theory, without demanding that the node labels be derived
from the X bar system. Such a theory can be constructed by assigning a numerical index corresponding to a stratum to each root node created at the stratum. One may, for example, propose the following grammar of word formation for Malayalam:

\[(131)\]
\[
\begin{align*}
\text{a. } & X_1 + X_1 \text{ affix (affix } X_1) \quad \text{(derivation)} \\
\text{b. } & X_2 + X_1 \\
\text{c. } & X_2 + X_2 X_2 \quad \text{(subcompounding)} \\
\text{d. } & X_3 + X_2 \\
\text{e. } & X_2 + X_3 \quad \text{(the loop)} \\
\text{f. } & X_3 + X_3 \quad \text{(cocompounding)} \\
\text{g. } & X_4 + X_3 \\
\text{h. } & X_4 + X_4 \text{ affix} \quad \text{(inflection)}
\end{align*}
\]

The grammar in (131) yields representations like the following:

\[(132)\]
\[
\begin{align*}
\text{a. } & \text{pašukkuttīkal} '\text{calves}' \quad \text{b. } \text{acchanammamaar} '\text{parents'} \\
\begin{array}{c}
\text{N}_4 \\
\text{N}_4 \quad \text{plur.} \\
\text{N}_3 \\
\text{N}_2 \\
\text{N}_2 \\
\text{N}_1 \quad \text{pasu kutti kal} \\
\text{cow child pl.} \\
\text{N}_4 \quad \text{plur.} \\
\text{N}_3 \\
\text{N}_2 \\
\text{N}_2 \\
\text{N}_1 \quad \text{acchan amma maar} \\
\text{father mother pl.} \\
\text{N}_4 \quad \text{(cf: (67a))} \\
\text{N}_3 \quad \text{(cf: (67b))}
\end{array}
\end{align*}
\]

pašukkutti is a subcompound, acchanamma is a cocompound. We can now specify the domain of gemination as \(X_2\), nasal deletion and
vowel lengthening as $X_2$ and $X_3$, and so on. Presented in this fashion, the node-domain theory is a notational variant of the stratum theory, except for one crucial difference. Given the stratum theory, it is imperative that the phonological rules associated with a stratum apply at that stratum in the lexicon, as the stratum information of a construction is not available at subsequent strata (2.2.1.). On the other hand, (131) preserves the stratum information in terms of an index, and therefore, in this theory, it is possible to postpone the application of phonological rules, as in SPE, to the output of morphological and subsequent syntactic operations.

The application of phonological rules in the lexicon in the stratum theory yields the level of lexical representation, which is the output of all the lexical operations. In Chapter 3, I shall show that this level of phonological representation makes important empirical predictions, which are not available to the node-domain theory, in which phonological rules do not apply in the lexicon.
Footnotes for Chapter II

1. Malayalam is a Dravidian language, with massive borrowings from Sanskrit. See Appendix 2 for a list of the Dravidian and Sanskrit stems used in this thesis.

2. The notation of subcompounds as $[\ldots]_2[\ldots]$, and of cocompounds as $[\ldots]_3[\ldots]$ is mnemonically related to their stratum structure (to be discussed), and have no theoretical significance. I am grateful to Douglas Pulleyblank for suggesting this notation.

3. What rule (7) does is to create a branching onset. I assume that the $\ddash$ in (3a) and the $k$ in (5b) are onsets. (See 4.1.3.)

   I follow Halle & Vergnaud (1980) in assuming that $\ddash$ is phonetically realised as $[\ddash\ddash]$, as opposed to $\ddash$, which is phonetically $[\ddash]$.

   Rule (7) uses the mirror image notation ($\%$), collapsing (i) and (ii), which are disjunctively ordered:

   (i) onset $\rightarrow \land / \#$

   (ii) onset $\rightarrow \land / \#$

   I should mention that the rule does not apply to sonorants:

   (i) $\ddash \text{poři} \rightarrow \ddash \text{tiippoři} (\ddash \text{Flame}; \text{poři} \ '\text{fragment'})$

   (ii) $\ddash \text{naałam} \rightarrow \ddash \text{tiınaałam} (\ddash \text{naałam} \ '\text{tongue'}(?))$

4. Gemination does not apply because the stems are not Dravidian, but derived from Sanskrit.

5. One may ask why the $\ddash$-$\ddash$ alternation cannot be handled in terms of a rule that shortens underlying long vowels in the word final position instead. The answer is that this move leads to complications, as vowels are long in compounds only when the second stem is of Sanskrit origin. Compare:

   (i) $[[\text{baařya}][\text{wiitɔ}] \rightarrow \text{baařyawiitɔ} (\text{wiitɔ} \ '\text{house'} [+\text{Drav}])$

   (ii) $[[\text{baařya}][\text{gɾham}] \rightarrow \text{baařyaagrɾham} (\text{gɾham} \ '\text{house'} [+\text{Sans}])$

6. All inflectional endings in Malayalam are of Dravidian origin, and vowel sandhi, like vowel lengthening, applies only when the following element is of Sanskrit origin. Thus, in Dravidian compounds like the following, vowel sandhi does not apply, and as a consequence, a glide is inserted between the two adjacent rimes:

   a. $\ddash \text{kaɾi} \# \ddash \text{ila} \ → \text{kaɾiyila} (\text{kaɾi} \ '\text{coal'}; \text{ila} \ '\text{leaf'}:'\text{dry leaf'})$

   b. $\ddash \text{mala} \# \ddash \text{ooɾam} \ → \text{malayooɾam} (\text{mala} \ '\text{hill'}; \text{ooɾam} \ '\text{side'}:'\text{hill side'})$

   Given these facts, the nonapplicability of the rule in inflectional endings may be attributed to the absence of [+Sans.] on inflections.
7. Nothing crucially hinges on the analysis proposed here. All that is important for us is the fact that the primary stressed vowel has a low tone, while the last vowel of the word, as well as all remaining long vowels, have high tones.

Observe that the remaining short vowels are unspecified for tone. Thus, the pitch track of paraati shows a low $F_0$ contour on the first syllable when utterance initial, but a transition from high to low when preceded by another word:

paraati paraññu vs kuṭṭi paraati paraññu
complaint said child complaint said

The same $F_0$ contour is observed in other unspecified short vowels as well:

maraṭakam vs paraṇayam

What this means is that the tone bearing unit in Malayalam is the foot, not the syllable. This is characteristic of intonational phenomena, as opposed to tonal phenomena.

It must be noted that final short vowels, unlike initial primary stressed vowels, undergo vowel reduction leading to the disappearance of the vowel in appropriate segmental environments (e.g. Ḟaamādaasan → Ḟaamāaasn). Therefore, the $F_0$ in (55) is not to be interpreted as secondary stress, but only as marking the location for tone spreading.

8. acchan appears to be an exception to stem final nasal deletion.

L H L H L H

9. cf: kutṭi 'child'; kutṭiyaye 'child-acc.'; kutṭiyute 'child-gen.'

L H
kutṭiyoota 'child-dat.2'.

10. The disjunction can be avoided by stipulating a hierarchy of boundary strength such as + ## # # ##. Rules which cannot apply across ## may also be assumed not to apply across the stronger boundaries # and ##.

11. The raised \[\breve{a}\] in \[\breve{V}\] represents a centralised onglide of the following vowel, as opposed to the \[a\] in, say, kaṭṭa, which is a full fledged central vowel.

12. (78) and (80) cannot be collapsed: cf: sampraḍaayaṃ → sam[b]raḍaayaṃ 'habit', but aprakaṛaṃ → *a[b]raκaṛaṃ 'likewise'. Also, arkan → *ar[g]an 'sun.
13. On the basis of the fact that class II derivation and compounding can be inputs to each other, Selkirk concludes that they belong to the same domain. Selkirk, like Allen, assumes a strict ordering hypothesis which can be stated as: if processes $P_i$ and $P_j$ are inputs to each other, then they define the same morphological domain (level in Allen). In contrast, I assume the looped ordering hypothesis which allows $P_i$ and $P_j$ to be inputs to each other and yet be associated with different domains.

14. This approach to stress is due to Siegel (1974).

15. It is not unlikely that this principle will be applicable in other areas as well (e.g., vowel harmony which proceeds from the stem to the affix).

16. All the Dakota facts are from C&S.

17. For further examples of such phonological processes, see C&S.

18. The rules DAR and CAR can be formulated in a simpler fashion in terms of the metrical framework, but I continue to use the segmental notation so as not to obscure the basic issues involved in the comparison between standard and lexical treatments.
Chapter III: THE LEXICAL REPRESENTATION

In Chapter II, I demonstrated the advantages of allowing a direct interaction between morphology and phonology, and assuming that this interaction is supervised by ordered strata. The focus of Chapter III is the levels of phonological representation resulting from these assumptions, in particular the level of representation between the underlying and the phonetic.

The principle of specifying the domains of phonological rules in terms of ordered strata yields a theory in which some rule applications take place at various lexical strata, and others outside the lexicon, at the post lexical stratum. In other words, some rule applications take place before lexical insertion, and others after it. I shall argue in this chapter that the stage in the derivation which is the output of the lexicon and the input to lexical insertion is not simply an accidental stage, but is an important level of linguistic representation at which various interesting phonological properties converge. I shall refer to this level as the level of lexical representation.

In 3.1., I shall make explicit the conceptual framework assumed in Chapter II, by answering questions like: what is the nature of the lexicon in Lexical Phonology? What are the levels of phonological representation assumed in this theory, and how are they related to the organisation of the lexicon?
In 3.2., I shall concentrate on lexical rule applications. The issues addressed will be: what are the criteria that separate lexical and post lexical rule applications? What are the predictions made by the assumption that lexical rule applications take place after every morphological operation?

In 3.3., which is the core of this chapter, and of the thesis as well, I identify the lexical representation as a significant level of representation in phonology, and demonstrate its consequences for a wide variety of phenomena such as speaker judgments, effect of pauses on phonological rules, secret code languages, speech errors, acquisition of phonology, speech recognition, and speech production. This section presents a brief glimpse of the potential application of Lexical Phonology for the better understanding of the phonological knowledge that human beings have, and the way they make use of this knowledge.

3.4. compares the level of lexical representation in this theory with two theories that postulate what looks like similar levels, namely, Taxonomic Phonemics and Natural Phonology, with the view of bringing out their empirical differences.

3.1. Underlying, Phonetic, and Lexical Representations

Following the lexicalist trend set by Chomsky (1970), I shall assume that lexical entries are entries of words, not morphemes. The list of unanalysable morphemes in the language constitute what I shall
refer to as the set of morphemic entries. (For the lexicalist approaches to morphology, see Zimmer (1964), Halle (1973), Aronoff (1976), Allen (1978), Siegel (1974), and Selkirk (to appear).) The word formation component which is conceived of as containing lexical redundancy rules maps the set of morphemic entries onto the set of lexical entries.¹

\[
(1) \quad \text{Morphemes} \rightarrow \text{Word Formation} \rightarrow \text{Words}
\]

Given the set of morphemes of the language, word formation predicts the potential words of the language, a subset of which constitutes the set of actual words of the language. The component of word formation tells us about the internal structure of words, in terms of the morphemes that constitute them, and the processes that have applied to them. Thus, a morphemic entry specifies the syntactic, semantic, and phonological properties of the morpheme; a lexical entry specifies the syntactic, semantic, and phonological properties of the word. What the component of word formation does is to predict the latter on the basis of the former.

To take an example, the morpheme strong will be listed as an adjective (syntactic property), and the morpheme -ly will be specified as one that makes adjectives adverbs. From these two entries, one may predict that strongly is an adverb. Similarly, the meanings of employer and employee (semantic property) can be predicted from the specifications on the morphemes employ, -er, and -ee: -er picks out
the subject of the verb as its meaning (an **employer** is an X that employs some Y), and -ee picks out the object (an **employee** is a Y such that some X employs Y). One can also predict that **child employer** is ambiguous ('a child who is an employer', or 'one who employs children'), but not **child employee** ('a child who is an employee', but not *'one whom children employ').

Just as the word formation component predicts the semantic and syntactic properties of words on the basis of the semantic and syntactic properties of their constituent morphemes, it also predicts the phonological properties of words on the basis of the phonological properties of their constituent morphemes. Thus, given that the phonological entries of the morphemes **divine** and -**ity** are /div₁n/ and /i₁/ respectively, we predict that the phonological entry for the word **divinity** is /div₁niti/. This makes rules like trisyllabic laxing and rules of word stress in English part of the component of word formation.

I use the term Underlying Representation to refer to the phonological representation of morphemes in the set of lexical entries. The phonological representation of words in the set of lexical entries is the Lexical Representation. The term Phonetic Representation is used in the standard sense, to refer to the output of all the phonological rules, given in some universal notation. The diagram given below relates the three levels of representation to the model of grammar:
To summarise: it has been recognised in linguistic theory since Chomsky (1970) that the principles responsible for putting morphemes together to form words are to be distinguished from the principles that put words together to form sentences. Most current theories have accepted this assumption with respect to both the structure of words and the meanings of words. What Lexical Phonology does is complete the set, and say that the principles governing the structure, meanings, as well as the phonology of words are to be distinguished from the principles governing the structure, meanings, and phonology of sentences. My proposal, therefore, is a logical consequence of the developments in linguistics triggered by Chomsky's Remarks on Nominalisation.
A note of explanation on the use of the term 'underlying representation' is in order. It is possible to think of a major difference between the model of phonology proposed in SPE and the model that I propose as being the addition of an intermediate level of representation in the latter:

(3)a. SPE

\[
\begin{array}{ccc}
\text{underlying representation} & \rightarrow & \text{phonological rules} \\
\downarrow & & \downarrow \\
\text{phonetic representation} & \rightarrow & \text{phonological rules}
\end{array}
\]

b. Lexical Phonology

\[
\begin{array}{ccc}
\text{underlying representation} & \rightarrow & \text{phonological rules} \\
\downarrow & & \uparrow \\
\text{lexical representation} & \rightarrow & \text{phonological rules}
\end{array}
\]

My use of the term 'underlying representation' is not, however, identical to the SPE use. This can be illustrated with words like presidential, the SPE underlying representation of which is /prezİd+ent+y+al/. Consider now the derivation of the word in the lexical theory (the derivation ignores stress):
I shall discuss at a later point why rules like trisyllabic laxing, \( t \rightarrow s \), etc. should be assumed to be lexical rules applying after every morphological operation. For the present, observe that the suffix \(-y\) is attached not to \[\text{prez\tilde{d}}\text{ent}\], but to \[\text{prez\tilde{d}}\text{ent}\], which is the output of laxing. Therefore, representations like \[\text{[prez\tilde{d}}\text{ent}] y\text{a1}\] do not exist in Lexical Phonology. Underlying representations are simply representations of morphemes, and lexical representations are representations of words, derived through lexical rules from the representations of morphemes.

3.2. Lexical and Post Lexical Rule Applications

3.2.1. Rules with lexical and Post Lexical Domains

The stratum theory I have developed so far allows for the application of the same rule in the lexical as well as post lexical strata. Rules of this kind do exist in natural languages. An example
of such a rule is the rhythm rule in English, first proposed in Liberman & Prince (1976). The rhythm rule relabels a tree of the form \( w \) as \( s \) as a tree of the form \( s' w s \). It applies at the phrasal level, changing thirteen men to thirteen men. As shown by Kiparsky (1979), it also applies at the word level as a cyclic rule, in words like artificiality (cf: artificial vs artificiality), anesthesiology, interchangeability, etc.

The vowel epenthesis in the past tense, plural, etc. is another rule with lexical and postlexical domains:

\[
(5) \emptyset \rightarrow \emptyset / [ + \text{coronal} \text{strident} ] \rightarrow [ + \text{coronal} \text{strident} ]
\]

Since the rule has to apply to the past tense (\([pæt \]d\) \(\rightarrow\) pæt\(\text{d}\) patted), present tense (\([wi\text{s}]z\) \(\rightarrow\) wi\(\text{s}\)z wishes), and plural (\([hors]z\) \(\rightarrow\) hors\(\text{z}\) horses), the inflectional stratum must be part of the domain of (5). Since the rule also applies in possessives (\([mij]z\) \(\rightarrow\) mij\(\text{z}\) Midge's), and auxiliary contraction (\([mij]z\)gow\(\text{i\text{n}}\) \(\rightarrow\) mij\(\text{z}\) gow\(\text{i\text{n}}\) Midge's going), it must apply at the postlexical stratum as well.3

3.2.2. Criteria for Identification

I shall now try to make explicit the criteria for distinguishing lexical and postlexical rule applications. An obvious property of lexical rule applications is that they have to be word internal,
as the output of the lexicon is the word, not the phrase. Therefore, no process that applies across words can be a lexical process. An immediate consequence is that external sandhi processes become post lexical operations. To give an example from English, the process that changes s to ñ in thï[ñ]year must be post lexical, as the sequence this + year is not available in the lexicon.

The second property of lexical rule applications hinges on their access to lexical information. If a rule is sensitive to word internal morphological information, it must apply in the lexicon. Recall that the Opacity Principle makes the internal structure at one stratum invisible at another stratum. This would mean that the internal structure at any of the lexical strata will be invisible to post lexical processes. It follows that post lexical processes do not have access to word internal structure, and that any rule that is sensitive to word internal structure must apply in the lexicon. We can now identify rules in English like trisyllabic laxing, velar softening, t → s, etc., as rules applying in the lexicon. These rules apply in class I derivations (stratum 1), but not, say, in compounds (stratum 3).

(6) Trisyllabic laxing

line drawing → * 1[i]n drawing (cf: 1[i]near)

(7) Velar softening

magic eye → * magi[s]eye (cf: magi[s]ian)
In order to guarantee that the rule applications in the environments given above are prevented, these rules must apply at stratum 1, and thereby, in the lexicon. Another example of a lexical rule is the compound stress rule, which applies only in compounds (stratum 3), and not across words.

In sum, we arrive at the following principles:

(9) Lexical processes cannot apply across words.

(10) Post lexical operations are blind to the internal structure of words.

It seems to me that there is a correlation between sensitivity to word internal structure and rule exceptionality. Rules which have lexical exceptions are also rules which are sensitive to word internal structure (cf: Pesetsky (1979)). If so, we may make the following stipulation:

(11) Post lexical operations are exceptionless. 4

3.2.3. The Issue of Cyclicity

All the rules discussed so far have been shown to apply
cyclically in the lexical domain. The cyclic application follows from
the model in which phonological rules apply after every morphological
operation (2.1.4.). The prediction that this model makes can be
stated as follows:

(12) All lexical rule applications are cyclic.

From the conjunct of (10) and (12), we derive the following
principle:

(13) All rules sensitive to word internal morphological
information are cyclic rules.

Current approaches to the cyclic application of phonological
rules hold that cyclic rules do not apply in the first cycle (Kean
(1974), Mascaro (1976), Halle (1978)). Halle (1978), for example,
formulates the principle of the cycle as follows:

(14) "A cyclic rule R applies properly on cycle j only if
either a) or b) is satisfied:

a) R makes specific use of information, part of which
is available on a prior pass through the cyclic rules,
and part of which becomes first available on cycle j.
There are three separate cases subsumed under a):

R refers specifically to some A and B in:

i) \([ j \ XAY \ldots[j_{-1} \ldots B\ldots] Z]\);
ii) \([ j \ Z \ldots[j_{-1} \ldots B\ldots] XAY]\);
iii) \([ j \ X \ldots[j_{-1} \ldots A\ldots] Y \ldots[j_{-1} \ldots B\ldots] Z]\).

b) R makes specific use of information assigned on
cycle j by a rule applying before R."
The effect of (14) is to disallow the application of a cyclic rule to an underlying string exhaustively contained in the innermost brackets. It has been argued that certain kinds of phenomena which were previously assumed to be irregular are in fact explained by this view of the cycle (Mascaro (1976), Rubach (1981), Kiparsky (class lectures)). An illustration can be given from Rubach (1981), who gives a detailed analysis of Polish phonology in favour of the cyclic principle cited above. Polish has a rule that tenses high vowels when followed by the Derived Imperfective aj (Yer tensing), and a rule that lowers a high vowel when followed by r (r lowering). Rubach gives the rules as follows:

(15) Yer tensing

\[ [+\text{syl}, +\text{high}, -\text{tense}] \rightarrow [+\text{tense}] / \quad \text{C}_{0}^{a} \text{j} \quad \text{DI} \]

(16) r lowering

\[ [+\text{syl}, +\text{high}, +\text{tense}, -\text{round}] \rightarrow [-\text{high}, -\text{back}] / \quad r \]

Rubach assumes that these are cyclic rules, and gives the following derivation:
Observe that the environment for r lowering is strictly contained in the first cycle [mir], and yet the rule applies in the second cycle, as the environment for r lowering is made available by the application of yer\textsuperscript{t}ening: mir is not an underlying string. In contrast, r lowering does not take place in words like wirowac 'rotate', and wiraz 'turning'. Rubach points out that the underlying sequence ir is properly contained in the first cycle, and therefore, the principle of cyclic application in (14) correctly predicts that r lowering will not apply to these cases. If r lowering were assumed to be a noncyclic rule, on the other hand, these forms will have to be listed as exceptions.

Similar accounts have been offered for English as well.
tion that trisyllabic laxing is a cyclic rule, will account for the fact that it does not apply to monomorphemic words like nightingale (cf: Kiparsky (1974)). /nˈɪtɪŋɡəl/ is an underlying string contained by the first cycle, and therefore, no cyclic rule can apply to it.

If the formulation of the cycle is as given in (14), (13) predicts that no lexical rule applications can take place in the first cycle. There are some problems that this prediction creates. Consider, for example, the rule of velar softening in SPE:

(18) Velar Softening
\[
k \to s/ \quad \begin{array}{c}
\check{V} \\
\text{-low}
\end{array}
\quad \begin{array}{c}
\check{V} \\
\text{-back}
\end{array}
\] (irrelevant details ignored)

The rule accounts for alternations like criti[k] ~ criti[s]ise, and electri[k] ~ electri[s]ity. SPE assumes that the rule applies in words like receive ([re[kev]]) as well. The voiceless s in these words is accounted for by ordering the voicing of s before velar softening.\footnote{5}

(19) [re [kev]] [re [sume]]
\[ \quad \begin{array}{c}
\text{voicing}
\end{array}\]
[re [sev]]
\[ \quad \begin{array}{c}
\text{velar softening}
\end{array}\]

Under this account, velar softening applies to an underlying string contained by the innermost brackets. Therefore, by (13) and (14), it cannot be a lexical rule. However, contradictorily, velar softening must be a lexical rule, as it does not apply at the compounding
Velar softening is not the only cyclic rule that applies to an underlying string contained by the first cycle. Consider the SPE account of the \( \eta \sim \eta g \) alternations in long \([l \eta]\), longer \([l \eta g \alpha r]\), and longing \([l \eta g i g]\) in terms of a rule that changes \( n \) to \( \eta \) before a velar consonant, followed by a rule that deletes the \( g \) in long and longing, but not in longer. I shall adopt the SPE solution and restate the rules as follows:

\[
(20) \begin{align*}
\text{a. } n & \rightarrow \eta/ - g, k \\
\text{b. } g & \rightarrow \emptyset/ [+\text{nasal}] - \\
\end{align*}
\]

domain: stratum 2

The derivations are given in (21):

\[
(21)
\begin{array}{ccc}
\text{long} & \text{longer} & \text{longing} \\
S_1 & [long] & [long] & [long] & \text{underlying} \\
& [(long)er] & & & \text{affixation} \\
S_2 & & & [(long)ing] & \text{affixation} \\
[log]\eta & [longer] & [(long)ing] & (20a) \\
[log]\eta & & [(long)ing] & (20b) \\
\end{array}
\]

(20b) does not apply to longer because the bracketing \([long]er\), by the Opacity Principle, is invisible at stratum 2. Now, it is crucial for this account of the \( \eta \sim \eta g \) alternation that rule (20b) applies at stratum 2: if the domain of the rule were, say, stratum 3 or 4, the bracketing in \([long]ing\) would be invisible.
to the rule, and the deletion would fail to apply in *longing* as well. Since (20b) must have stratum 2 as its domain, (20b) and the rule (20a) are lexical rules, and by (13), both are cyclic rules. Now, observe that (20a) and b apply to an underlying string contained in the innermost cycle, and are therefore, disallowed by (14).

In order to account for the fact that velar softening applies to *kev* in *receive*, Rubach assumes that it is a post cyclic rule. Presumably, a similar solution could be offered to the problem of g-deletion as well. Given the principle that rules which require word internal information must be cyclic rules, Rubach's move is not open to us.

The right solution lies in abandoning (14). Kiparsky (in preparation), for example, derives the desirable effects of (14) from the Elsewhere Condition (cf: Kiparsky (1973)). He proposes that all un-derived lexical entries are identity rules of the form $L \rightarrow L$, e.g.

(22) a. *nightingale* : $\tilde{n}i\tilde{t}i\tilde{g}\~\tilde{a}\tilde{l} \rightarrow n\tilde{t}i\tilde{n}g\~\tilde{a}\tilde{l}$

b. *divine* : $d\tilde{i}\tilde{v}\~\tilde{i}n \rightarrow d\tilde{v}\~\tilde{i}n$

Given the identity rule approach, (22a) and trisyllabic laxing are both rules which are applicable to the */i/* in *nightingale*, laxing being the more general of the two. By the Elsewhere Condition, (22a) applies, and laxing is inapplicable. In *divinity*, on the other hand, laxing applies, as there is no identity rule of the form $d\tilde{v}\~\tilde{i}\tilde{n}\~\tilde{i}t\~\tilde{i} \rightarrow d\tilde{v}\~\tilde{i}\tilde{n}\~\tilde{i}t\~\tilde{i}$.
The identity rule approach to lexical entries correctly predicts that velar softening can apply in receive. *receive* not being a word, there is no identity rule of the form \( \text{kev} \rightarrow \text{kev} \), and therefore, nothing prevents the rule from changing k to s in \([\text{re}[\text{kev}]\)\. The same explanation holds for g deletion as well. Since there is no identity rule of the form \( \text{long} \rightarrow \text{long} \), n \( \rightarrow \) n and g deletion are free to apply to long. 6

3.3. The Lexical Representation

The purpose of this section is to show that the intermediate level of representation that I have been calling Lexical Representation, constitutes a well defined level of linguistic representation. Given the stratum theory, Lexical Representation is the output of the lexicon, and the input to lexical insertion. I shall show that it has a number of other interesting properties as well: it is the input to the assignment of pauses, and to the application of the code in secret code languages, and plays a significant role in speaker judgments, speech errors, language acquisition, etc.

3.3.1. The Effect of Pauses on Phonological Rules

3.3.1.1. It was Rotenberg (1978) who drew the attention of phonologists to the fact that some phonological rules are blocked by intervening pauses, while others are not. As an example of a rule of the
first kind, consider the rule of intervocalic voicing of stops in Malayalam (2.2.2.):

(23) a. kutti ... (pause)... [k]a\bar{r}a\bar{n}\nu
    child        cried
b. ku\bar{t}ti[g]a\bar{r}a\bar{n}\nu

c. *ku\bar{t}ti... (pause)... [g]a\bar{r}a\bar{n}\nu

The voicing rule does not apply across words if there is an intervening pause; the same phenomenon is observed word internally as well. Though speakers do not normally pause word internally, they do so in careful and slow speech, as when they pause after every syllable. Thus, in answer to the question, "How many syllables does population have?", a perfectly natural answer is: "Four. Po..pu..la ..tion." The effect of word internal pauses on the voicing of stops in Malayalam is illustrated below:

(24) a. a...[p]a...[k]a...[\text{\t}]a\bar{m} 'danger'
    b. a[b]a[g]a[d]\bar{a}\bar{m}
    c. *a...[b]a...[g]a...[d]\bar{a}\bar{m}

We conclude that intervocalic voicing in Malayalam cannot apply across pauses. In contrast to voicing, the rule of gemination in subcompounds (2.1.1.) is not blocked by pauses:
(25) a. pašukkuttī 'calf' (from pašū 'cow', and kutti 'child')
   b. pa...šu...kku...tti
   c. *pa...šu... ku...tti

In order to explain the contrast, all that we need to do is to make
the perfectly natural assumption that pauses are assigned not in the lexicon, but after words are put together, i.e., after lexical
insertion:

(26)

The assignment of pauses creates units which have traditionally
been called 'phonological phrases', which are phonological strings
bounded by pauses. Just as the rules in the lexicon take place in
words, rules outside the lexicon take place in phonological phrases.
Intervocalic voicing applies at the post lexical domain (i.e. after lexical insertion)(2.2.2.), while gemination applies in the lexicon (i.e., before lexical insertion). Each of the syllables a, pa, ka, ram in (24) is a phonological phrase by itself. The environment for voicing (V — V) is not satisfied by any of the consonants in (24a), and therefore, the rule does not apply. In (25), on the other hand, the rule of gemination applies prior to pause assignment, and therefore, the insertion of the pause after the rule has applied does not affect the rule.

This contrast provides a major confirmation for lexical representation as a significant level of representation in phonological theory. The following properties identify this level:

(27) a. output of lexical rule applications;
    b. input to lexical insertion;
    c. input to pause assignment, which in turn yields
    d. input to post lexical rule applications.

The model in (26) makes the powerful prediction that no rule which is sensitive to word internal structure is blocked by the presence of an intervening pause. This prediction, to the best of my knowledge, is correct. The following examples from Malayalam show that the lexical rules of nasal deletion (2.1.1.2.), vowel lengthening (2.1.1.3.), and vowel sandhi (2.1.1.4.) are not blocked by pauses:
(28) Nasal Deletion
   a. ma...ra...kku...ti...ra 'wooden horse' (maram, kutira)
   b.*ma..ram..(k)ku..ti..ra (*ma..ra..m(k)ku..ti..ra)

(29) Vowel Lengthening
   a. taa..raa..kaa..ntan 'Tara's husband' (taara, kaantan)
   b.*taa..ra..kaa..ntan

(30) Vowel Sandhi
   a. ma..hee..swa..ran 'great god' (maha, iswaran)
   b.*ma..haa..ii..swa..ran

In English, lexical rules like trisyllabic laxing and CiV tensing (SPE: 180-81) are blind to pauses:

(31) Trisyllabic Laxing
   a. di..v[i]..ni..ty
   b.*di..v[ay]..ni..ty

(32) CiV Tensing
   a. ma..na..g[ëy]..ri..al
   b.*ma..na..g[e]..ri..al

3.3.1.2. Recall that Lexical Phonology allows the same rule to have both the lexical and post lexical strata as its domain. Given (26), we would predict the possibility of rules being insensitive to pauses when they apply in the lexicon, and being blocked by pauses when they
apply post lexically. An interesting example of such a rule is the r deletion in British English, responsible for alternations like the following:

(33) a. I know the actor.
   [ækta]

b. The actor acted hastily.
   [ækta:r]

c. The actor snored.
   [ækta]

The rule responsible for this alternation can be stated as follows:

(34) r deletion

\[ r \rightarrow \emptyset / R \]

Given below are the derivations for (33)a–c:

(35) a. actor  b. actor, acted ...  c. actor snored

\[ \begin{align*}
   \text{æk}\text{t}\text{o} & \quad \text{æk}\text{t}\text{o} \quad \text{æk...} \\
   \text{æk}\text{t}\text{o} & \quad \text{æk}\text{t}\text{o} \quad \text{æk...} \\
   \text{æk}\text{t}\text{o} & \\
   \emptyset & \quad \emptyset
\end{align*} \]

Resyllabification applies in (35b), linking r to the onset, and saving it from r deletion. No resyllabification is possible in (35) a and c, and hence r is deleted.
Consider now what happens when a pause is inserted:

(36) The actor ... acted hastily.

[æktə]
*[æktər]

Since resyllabification takes place across words, it must be post lexical, and applies after pause assignment:

(37) The actor ... acted hastily.

\[ \text{resyllabification} \]
\[ \text{r deletion} \]

The deletion of r applies word internally as well:

(38) a. bareness [bɛənəs]
b. barest [bɛərəst]

Unlike resyllabification across words, however, word internal resyllabification is blind to pauses, as predicted by (26):

(39) a. bɛə... rəst
b. *bɛə... əst

What is important for us is the fact that a pause makes the r disappear in the bear is, but there is no way a pause can make the r in the barest disappear. Resyllabification in the former follows lexical insertion (and hence pause assignment), while in the latter,
precedes it, and therefore, there is nothing that we need to say about the contrast.

It may be pointed out that the contrast between bear is and barest supports the assumption that inflections are attached in the lexicon (cf: Lieber (1980), Selkirk (to appear)). If the attachment of inflections takes place after lexical insertion, the two forms become identical, and we no longer have any explanation for the contrast. Therefore, the facts of r deletion in British English offer crucial evidence against syntactic rules such as affix hopping, which involve attaching the inflectional element to the stem in the syntactic component after lexical insertion. (Note that the behaviour of verbal inflections is identical to -est: e.g. storing: [stə ... riŋ], *[stə ... ɪŋ].)

Yet another rule that is blocked post lexically by pauses, but not lexically, is the rule of palatalisation of s. Following Hayes (1980), I state the essentials of the rule as follows:

(40) Palatalisation

\[ s \rightarrow ʃ/ \quad \text{y} \bar{y} \quad (\bar{y} = \text{unstressed vowel}) \]

The rule applies word internally, in words like racial
( ræs+yæl \rightarrow rēyəl ), and in some dialects, across words, in sequences like miss you (miss you \rightarrow miʃyə ). Speakers of English who do palatalise s across words cannot do so across a pause. Thus,
it is always [mis...ya], never *[miš...ya]. When the pause occurs word internally, however, it has no effect on palatalisation: it is always [rey...šal] (racial), never, *[rē̃ys..ɔ]. The palatalisation in racial is a lexical operation; in miss you, it is post lexical. Given that pauses are assigned post lexically, this is precisely what we expect. The pause is assigned after palatalisation in racial, but before it in miss you.

3.3.1.3. The behaviour of phonological rules with respect to pauses provides an important empirical distinction between the node-domain theory and the stratum theory. The essential character of the node-domain theory is that the components of word formation and syntax provide labelled trees, and phonological rules apply to these trees, identifying the domains of rules from the node labels. Observe that the node-domain theory has no intermediate level of representation between the underlying and the phonetic: all rules apply after lexical insertion, at the output stage of the syntactic component. The only way for accounting for the effects of pauses on phonological rules in the node-domain theory, as far as I can see, is to stipulate that the word and the subword domain rules are blind to pauses. Given a series of node labels $X^1, X^2, X^3, \ldots X^n$, what this stipulation does is to identify one of the nodes arbitrarily as marking the division between pause blind and pause sensitive rules. This arbitrary point, in principle, could have been, say, the noncompound word node, or an $X$.
The most important distinction between Lexical Phonology and the node-domain theory is that Lexical Phonology provides an intermediate level of representation between the underlying and the phonetic, while the node-domain theory does not. This intermediate level of representation, as we shall see, provides the input to secret code languages, to speech errors, and is the basis of speaker judgments. In the node-domain theory, all these would be unrelated stipulations on the output of the word domain rules.

3.3.1.4. In addition to predicting that lexical rule applications are blind to pauses, the model in (26) also makes the prediction that all post lexical rule applications will be blocked by intervening pauses. This phenomenon has some apparent counterexamples which fall into two classes. The first type of apparent exception is that of the assignment of intonation, which appears to ignore pauses, and even the segmental material of an appositive type. I give below Rotenberg's (1978) examples:

\[\text{(41) a. This is an example sentence.}\]
\[\text{b. This is... good lord!... an example sentence.}\]
\[\text{c. This is, as you can see, an example sentence.}\]
If intonation assignment is a rule that applies to segmental strings after pause assignment, (41) would constitute a counterexample to our claim that post lexical rule applications will be blocked by pauses. However, there is no reason to believe that intonation is handled by rules that operate on segmental material in this fashion at all. It has been shown by Liberman (1975) and Pierrehumbert (1980) that the correct approach to intonation is to have a module of grammar which generates 'intonation words', or tunes. These tunes have interesting internal structures, and are associated with semantic content, such as uncertainty, surprise, etc. (see Pierrehumbert (1980) for details). The tunes generated in this manner independently of segmental strings are then associated with the segments (via stress trees) in predictable ways.

We may incorporate the Liberman-Pierrehumbert model into (26):

(42) Intonation       'Syntax                 Lexicon

                      tunes                       syntactic representation
                      syntactic representation
                      lexical representation

                      lexical insertion
                      post lexical phonological rule applications

                      pause assignment

                      underlying representation

                      phonetic representation
In this approach, lexical insertion is seen as a merging together of the outputs of various components: the lexicon, syntax, and intonation. In this model, cases like (41) cease to be counterexamples.

The second type of apparent exception is seen in words like a and the, which have alternate forms before vowels and consonants: a book vs an old book; th[a] man vs th[i] old man. Rotenberg (1978) points out that alternations of this kind are blind to pauses:

(43) a. This is an old book.
   b. This is an ... (pause)... old book.
   c. This is a nice book.
   d. This is a ... (pause)... nice book.

If these alternations are handled by post lexical phonological rules, they falsify the claim that post lexical applications will be blocked by pauses. Note, however, that alternations like a~an are restricted to single lexical items. One way to look at them would be to say that a and an are different lexical items related by partial suppletion (cf: child~childen) (or perhaps an irregular phonological rule) in the lexicon. Associated with a will be a filter which says that the following word is consonant initial, and the opposite condition will be associated with an. These filters apply during lexical insertion, ruling out *an book and*a old book. Subsequent assignment of pauses would then have no effect on a and an.
Seen in this light, examples like (43) do not present a problem for our model. A true counterexample to the claim that postlexical rule applications cannot cross pauses will be an alternation that is not restricted to a small set of lexical items. If we found, for example, that in some language, all word final obstruents get voiced before a vowel initial word, and that this process applies across pauses, our claim would be falsified. To the best of my knowledge, such languages do not exist.

3.3.2. Speaker Judgments

Given that linguistics is concerned with the properties of the human mind, the intuitions of speakers become data that linguistic theory must account for. Thus, it is not enough for the theory to generate (44)a and b, and block (44c), but also account for the fact that the speaker finds that John and him in (44a), but not in (44b), can refer to the same person:

(44)  a. John believes that he is a fool.
       b. John believes him to be a fool.
       c.*John believes that him to be a fool.

Generative phonology has paid very little attention to speaker intuitions. Judgments on possible and impossible syllables and possible and impossible words have been acknowledged to constitute the data for phonology, but not speaker judgments about sameness and differentness of sounds.
Speakers of English judge the p in pit and spit to be the same, ignoring the [p]~[ph] distinction; the vowels in bit and bid are judged to be the same, ignoring durational and qualitative differences. Obviously, these judgments do not correspond to phonetic representations. At the other end of the spectrum, speakers judge the initial vowels of metric and met to be the same, oblivious of the underlying distinction: /\E/ ~ /e/. Similarly, the first consonant in sing, the fourth in criticism, and the last in presidency are judged to be the same, in spite of the underlying s~k~t distinction. Underlyingly identical segments are judged to be distinct, such as the initial vowels of meter and metric, or the second consonant in race and racial.

Given a theory of phonology with just the underlying and phonetic levels of representation, these judgments are unexplainable. Given the theory of Lexical Phonology, what corresponds to the speaker judgments is the lexical representation:

(45) underlying lexical phonetic

| a. spit | spit | spit | spit |
| b. pit  | pit  | pʰi t | pit  |
| c. bet  | bet  | bet  | bet  |
| d. bed  | bed  | beʰd | bed  |
| e. mėtr | mėytar | mėytar | metre |
| f. mėtr ik | metrik | metrik | metric |
| g. kritik ism | krítisim | krítisim | criticism |
| h. prezíd entsy | prézidënsi | pʰrezidënsi | presidency |
| i. rēs | reys | reys | race |
| j. rēs y æl | réyšal | réyʃal | racial |
Judgments of this kind also extend to the results of external sandhi rules and fast speech phenomena. The speaker who says thi[\text{s}]year thinks that he is saying thi[\text{s}]year (see Chapter I, footnote 4). Similarly, speakers think that they are saying div\text{initi} when they actually say dvini in fast speech. In short, we find that lexical representations correspond to the mental representations of the speaker, reflecting his intuitions of what constitutes his speech. Given that lexical representations are the representations of lexical entries, this is hardly surprising: what the speaker has conscious access to is the set of lexical entries.

3.3.3. Secret Code Languages

A secret code language is one in which one or more rules (the code) have been added to the grammar of a natural language so that the result becomes unintelligible to a speaker who doesn't know the code. A well known example is Pig Latin, in which the first onset of a word (if any) is moved to the end, and the diphthong \text{ey} added to it. Thus, the words \text{clean} (k\text{l}yn) and \text{ask} (a\text{s}k) in Pig Latin would be \text{lynkley} and \text{askey}. SPE gives the following rule for Pig Latin:

\begin{equation}
(46) \quad \#\#C_0VX## \rightarrow \#\#VXC_0\text{ey}##
\end{equation}

We may, in fact, think of Pig Latin in terms of the following equation:

\begin{equation}
(47) \quad \text{Pig Latin} = \text{Grammar of English} + \text{rule (46)}
\end{equation}
Consider what a secret code does. It creates new lexical items from existing ones so that an outsider does not identify the lexical items. Thus, Pig Latin picks up clean in English and changes it to iynkley:

\[(48) \text{Lexical entry}_{\text{Eng.}} \rightarrow \text{secret code} \rightarrow \text{Lexical entry}_{\text{Pig L.}}\]

Seen in this light, a secret code is an operation on lexical representations. This result gives rise to interesting predictions. To begin with, observe that all secret codes of this kind operate on words, not on morphemes. Thus, rules like (49)a and b are logically conceivable, but nonexistent:

\[(49)\]

- a. \$C_0\text{VX}\#
- b. \$C_0\text{VX}^+$

What this means is that secret codes are blind to the internal structure of words. Given the lexical theory, this is precisely the expected result. The input to the code is the lexical representation, and therefore, the code cannot be a lexical rule. It follows that the code cannot see the internal structure of words.

The model of the application of the secret code can be represented as follows:
Pig Latin is a language that is perfectly consistent with the model in (50), but since it does not interact with most of the rules in English phonology, it is also consistent with other possible approaches, and does not tell us anything revealing. However, there exist code languages which are more complex than Pig Latin, and show conclusively that the code applies only after the application of lexical rules and before the application of the post lexical rules. One such is the ayb language of English, the code of which is: insert ayb before every rime of the word. Thus, the word America would be aybamaybæraybikayba. (50) predicts that ayb insertion takes place after lexical rules like trisyllabic laxing, CIV tensing, velar soften-
ing, etc. The data confirms this prediction. Thus, the ayb versions of demon (díymān) and demonic (dimānīk) are daybīymaybān and daybimaybānaybik. Had trisyllabic laxing applied after ayb insertion, demon would have been *daybēmāyban. Similarly, Canada (kānēdā) and Canadian (kānéydnān) in ayb are kaybānaybdaybān and kaybānaybēydaiaybān. Had the CIV tensing applied after ayb insertion, it would have bled tensing, resulting in *kaybānaybēdaybīaybān for Canadian. The ayb forms of divider and division are daybivaybādaybār and daybivaybīdaybān.

The application of ayb insertion prior to the d → ẓ rule would have either blocked the rule in both cases, or allowed it in both, leading to bad consequences either way. Critical and criticism are kraybītaybikaybāl and kraybītaybisaybīzaybām, showing that velar softening also applies before ayb insertion.

All the above examples show that stress rules must apply before ayb insertion. If not, the stress would have been on ayb in most cases!

Additional examples like the following show that even secondary stress patterns remain unaffected by ayb insertion: redesign → raybēdaybesayb1ign (examples in English spelling); artificiality → aybartaybīfabic-1aybiaybalaybitayby.

There is no lexical rule application that takes place after ayb insertion in English. It now remains to show that all post lexical rule applications must follow ayb insertion. The only post lexical rule that interacts with ayb insertion is the aspiration of voiceless stops. The ayb version of painter is [paybēyntaybār], and not
*[pʰaybéyntaybær]*, which is what the application of aspiration before *ayb* insertion would result in. ¹²

The prediction made by the model in (50) is fulfilled by yet another code language I know of, namely, the *pa* language of Malayalam, which inserts the syllable *pa* before every syllable in the word. The code is illustrated by the following examples:

(51) Malayalam pa-language

a. moohanan 'a name' \(\rightarrow\) pamoopahapanan
b. kuṭṭi 'child' \(\rightarrow\) pakupaṭṭi

I shall select two of the rules discussed in 2.1., gemination and vowel sandhi, to demonstrate that *pa* insertion cannot precede lexical rule applications. The rules are repeated below in an informal fashion for convenient reference:

(52) a. Gemination: Obstruents geminate stem initially in subcompounds.

b. Vowel Sandhi: The final vowel at the end of the first stem and the vowel at the beginning of the second stem fuse together.

(53) Malayalam pa-language

a. kuṭiřa 'horse' pakupaṭipaṇa
b. kuṭṭi 'child' pakupaṭṭi

c. kutirakkutti 'baby horse' pakupaṭipaṇapakkupaṭṭi
Had pa insertion preceded gemination and vowel sandhi, the result would have been *pakupaṭipaṟapakupaṭṭi in (53c), and *pakapalaipayupalsapawam in (54c).

I shall now use the following post lexical processes to show that post lexical rule applications must follow pa insertion:

(55) Voicing: Intervocally, single stops are voiced. (see 2.2.2.)

(56) Onset shortening: Branching onsets are shortened after long vowels. (note: all intervocalic consonant sequences form onsets in Malayalam.)

The following examples illustrate the process of onset shortening:

(57) a. kuṭṭi 'child' but kuṭṭi 'increased'
     L(ong)                      S(hort)

b. kaṣṭam 'pity' but kaṣṭam 'excrement'
     L                        S
(58) a. kuutta → pa[gu]battti
     \L

b. kaastam → pa[ga][b]aštam
     \L

Clearly, if voicing applied before pa insertion, the k in
(58)a and b would fail to voice; if shortening applied before pa
insertion, it would incorrectly shorten the clusters. We must, there-
fore, assume that pa insertion takes place before these rules.

3.3.4. The Acquisition and Use of Phonological Knowledge

3.3.4.1. If the model of phonology with a three level system of
and underlying, lexical, phonetic representations is a more accurate
model of the phonological knowledge of the speaker, it would make
interesting predictions about the acquisition and use of this know-
ledge. In this section, I shall briefly speculate on the possible
directions that theories of the acquisition of phonology, speech re-
cognition and speech production based on Lexical Phonology may take.

It is likely, for example, that what the speaker internalises
during the acquisition of a new word is its lexical representation;
underlying representations of its constituent morphemes are establish-
ed as and when he comes across morphologically related words which
give evidence for these underlying representations. Words are not
presented to learners as sets of related items. A learner who comes across the word *presidential* may not have come across *preside* and *president*, and therefore, may not have arrived at the underlying representation involving /prezɪd/ and /ent/. He would store the word in the lexicon as something like /prezɪdɛnʃæl/, which is the lexical representation of the word. Similarly, post lexical rules would be acquired by the learner at a relatively early stage, as they do not require morphological evidence involving word internal structure which is hard to come by during the initial stages of learning.

The acquisition of lexical processes would follow at a leisurely pace in a random manner, and some speakers may never acquire some of the lexical rules at all.

It must be mentioned that knowledge of related forms is crucial for the acquisition of underlying representations. Thus, it is not enough that the learner guesses the structure of, say, [tinisiti] (nonsense form) in English to have the word structure [tinis+iti], on the basis of his familiarity with the suffix -*ity*. Even after the suffix has been identified, he will still have to choose between the underlying /tinɪk/, /tɪnɪk/, /tɪnit/, /tɪnit/, /tinɪs/, and /tɪnis/, and the correct choice is impossible unless he comes across the stem in some other context. It is this aspect of the underlying forms which makes them, and the lexical rules that derive lexical representations from them, slower to acquire.
3.3.4.2. It would not be unreasonable to assume that speech recognition involves the identification of the lexical representation of phonetic strings. The mapping between lexical representation and phonetic representation does not involve morphological information, and therefore, it would be possible to devise a bottom-up model of speech recognition which would arrive at lexical representations from phonetic representations without taking recourse to morphology. This would be a significant improvement on the top-to-bottom model proposed by Halle & Stevens (1962), which appears to be the only available model of speech recognition consistent with the assumptions of generative phonology. In the Halle-Stevens model, lexical access is conceived of as applying all the phonological rules to all the underlying forms listed in the lexicon, and comparing the output with the speech signal. Apart from the problem of computational complexity, the Halle-Stevens model suffers from a serious theoretical inadequacy in that it does not account for the fact that speakers are able to 'recognise' nonsense words, the entries for which do not exist in the lexicon. In an experiment conducted by Nakatani and Liberman, for example (personal communication), they found that speakers of English were able to assign unique 'phonemic transcriptions' to nonsense words with perfect agreement. If speech recognition is applying phonological rules to existing lexical entries, and matching the output with the speech signal, there is no explanation for the recognition and acquisition of new words, for which lexical entries do not exist,
The SPE model of phonology does not provide a level of representation which can be recovered from the phonetic representation without the use of morphological information. Consequently, it does not yield a bottom-up performance model. The model of Lexical Phonology offers precisely such a level.

3.3.4.3. One may suggest that speech production also crucially makes use of the lexical level of representation. One may look for evidence for this hypothesis in speech errors which permute segments, as in *spin* and *spac* for *spic* and *span*. If speech errors of this sort are due to errors in the input to the speech production system, and the input to speech production is the lexical representation, one would predict that all lexical rule applications would precede the speech error, and all post lexical rule applications would follow it. The error, then, would be analogous to the application of the code in secret code languages (cf: (50)): 
The permutation of the vowels in the first syllable of *metrical grid* and *linear set* would produce the error *m[i]trical gr[e]d* and *l[e]near s[i]t*, never *m[i]trical gr[iy]d* and *l[e]near s[ay]t*. The correct output is possible only if the lexical process of laxing applies prior to the permutation:

(60)  \[
\begin{array}{c|cc}
\text{linear set} & \text{linear set} \\
\hline
\bar{I} & e \\
i & \text{laxing} & e & \bar{I} & \text{error} \\
e & i & \text{error} & \bar{I} & \text{laxing} \\
1[e]near s[i]t & \ast1[e]near s[ay]t \\
\end{array}
\]

Similarly, the permutation of the consonants in *electricity*
board may result in electri[b]ity [s]oard, but never *electri[b]iti [k]oard. Once again, the desired output demands the application of velar softening before the error.

In contrast, post lexical processes like aspiration apply after the application of the error. Thus, scotch tape becomes s[t]otch [kh]ape, never *s[th]otch [k]ape (example from Stampe (1972)).

\[
\begin{array}{c|c}
\text{scotch tape} & \text{scotch tape} \\
\hline
\text{k} & \text{k} \\
\text{t} & \text{t} \\
\text{t} & \text{t} \\
\text{kh aspiration} & \text{th} \\
\text{s[t]otch [kh]ape} & *s[th]otch [k]ape
\end{array}
\]

Bad men [bæd mən] may become [bed mæn], never *[bɛd mæn]: the nasalisation of the vowel, a post lexical process, also applies after the error.

Similarly, I face your miss for I miss your face ( mɪ[s] ) may be pronounced as I fa[s] your miss, but never *I face your mɪ[s]: the external sandhi process ( s → ʃ ) applies after the error.

3.4. Comparison with Similar Models

3.4.1. Taxonomic Phonemics

By now, the reader must have observed the similarity of lexical representations to taxonomic phonemic representations, A
crucial difference between Lexical Phonology and Taxonomic Phonemics on the one hand, and Standard Phonology on the other, is that the latter allows only two levels of phonological representation, the underlying and the phonetic, while the former incorporate an intermediate level of representation.

\[(62) \quad \text{Taxonomic Phonemics} \quad \text{Lexical Phonology} \]

\begin{align*}
\text{Morphophonemic} & \quad \text{I} \quad \text{Underlying} \\
\text{Phonemic} & \quad \text{II} \quad \text{Lexical} \\
\text{Phonetic} & \quad \text{III} \quad \text{Phonetic} \\
\end{align*}

The similarity ends here. Taxonomic Phonemics focussed on the restrictions on the mapping between levels II and III, while Lexical Phonology concentrates on the mapping between levels I and II. While Taxonomic Phonemics postulates several conditions on the phonemic-phonetic mapping, such as biuniqueness and invariance, the only condition in Lexical Phonology is that the lexical-phonetic mapping has no access to word internal morphological information. Therefore, a number of rules disallowed in Taxonomic Phonemics in the mapping from II to III are acceptable in Lexical Phonology. A typical example of such a rule would be one which changes one phoneme to another, like the voicing rule in Malayalam, which changes voiceless stops to voiced stops post nasally and intervocally (2.2.2.), and the palatalisation rule in English which changes s to š. The lexical representation for [màdān] in Malayalam is /màtān/, and for [ţišyə] (this year)
in English is /ðis yər/: these are not possible taxonomic phonemic representations. Similarly, rules which delete phonemes would be legitimate post lexical operations, but not legitimate 'allophonic' rules (e.g. list some \( \rightarrow \) lis some). What this means is that lexical representations are more abstract than taxonomic phonemic representations.

All the classical arguments against the taxonomic phonemic level of representation (Chomsky (1964), Halle (1959)) have been essentially arguments against a specific level of representation satisfying conditions like biuniqueness, local determinacy, invariance, and linearity. Since the level of lexical representations does not obey any of these conditions, the objections do not apply to the lexical level.

3.4.2. Natural Phonology

The distinction made by natural phonologists between rules and processes (Stampe (1973), Donegan (1978)) appears to have some correlation with the distinction I have identified as Lexical and Post lexical; it is, therefore, important to examine how the two theories match. A process is defined in Natural Phonology as "a mental operation that applies in speech, to substitute, for a class of sounds or sound sequences presenting a common difficulty to the speech capacity of the individual, an alternate class identical but
lacking the difficulty property" (Stampe (1973:1)). In other words, a process is motivated by the ease of articulation. One may say that \( ty \rightarrow c \) in \( \text{didn't you} \) is a process, but the \( t \rightarrow s \) change in \( \text{presidency} \) is a rule, and has no articulatory motivation.

Processes, according to natural phonologists, are universal: speakers do not have to acquire them. What has to be learnt is the inhibition of the process in a language that does not exemplify it. A speaker of English does not have to learn the \( ty \rightarrow c \) change, as the process is innate, but a speaker of Malayalam has to learn to inhibit or block the process, as Malayalam does not exhibit the alternation. Rules, on the other hand, have to be learnt.

Another property of processes is that they require special effort on the part of the adult speaker to violate them. Thus, velar softening, which is a rule, can be easily violated by a speaker to produce \( \text{criti[k]ism} \), but it is only with great effort that one can violate the process of aspiration in \( \text{pin} \), and say \( [p]in \) instead of \( [ph]in \).

Stampe observes that rules apply before the application of the code in secret code languages, while processes apply after them. Thus, the process that changes \( k \) to \( k' \) before a front vowel applies after the Pig Latin rule in English, giving the Pig Latin form \( ool[k']ey \) instead of \( *ool[k]ey \) for the word \( \text{cool} \). On the other hand, the rule of velar softening must apply before the insertion of \( ob \).
in the secret language of ob, since electricity in this language is obelobectrobi[s]obitoby: the insertion of ob destroys the environment for velar softening, and therefore, the softening must be assumed to take place prior to ob insertion (Stampe's examples).

Stampe also points out that processes apply to the result of slips of the tongue. "Such productions as [stačkhɛip] for scotch tape show that the slip /stač kɛip/ for /skač tɛip/ arose before the process aspirating initial stops applied, since otherwise [sňhačkɛip] would have been produced" (1973: 44).

The criteria for distinguishing between processes and rules can be summarised as follows:

<table>
<thead>
<tr>
<th>(63)</th>
<th>processes</th>
<th>rules</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>motivated by ease of articulation</td>
<td>(?)</td>
</tr>
<tr>
<td>b.</td>
<td>universal</td>
<td>(?)</td>
</tr>
<tr>
<td>c.</td>
<td>cannot be violated</td>
<td>can be violated</td>
</tr>
<tr>
<td>d.</td>
<td>follows the application of the code in secret code languages</td>
<td>precedes the application of the code in secret code languages</td>
</tr>
<tr>
<td>e.</td>
<td>follows slips of the tongue</td>
<td>precedes slips of the tongue</td>
</tr>
</tbody>
</table>

With respect to (63)d and e, Lexical Phonology and Natural Phonology make the same distinction, as lexical rule applications precede the application of the secret code and speech error, while
post lexical rule applications follow them. (63c) is not consistent
with the lexical model, as palatalisation across words ([thi[s] yea r])
is a post lexical operation, yet speakers experience no difficulty
in violating it.

The hypothesis that processes are universal ((63b)) and that
they are inhibited in languages which do not have them seems to me
to lack any empirical content. We may find a process that replaces
A by B in exactly one language, but nothing in principle would pre­
vent a natural phonologist from saying that A → B is inhibited in
all human languages except one. I therefore dismiss (63b) as a non­
falsifiable claim.

The claim that processes have articulatory motivation ((63a))
has the potentials of being an empirical claim, but only if it is
accompanied by a theory of phonetics from which we can derive the
notion 'articulatory ease'. Such a theory, given two sounds or sound
sequences, should tell us in unambiguous terms which of them is more
difficult to produce. In the absence of such a phonetic theory, (63a)
is a matter of opinion or intuition, and can hardly be argued with.

There is a crucial difference between the levels identified
by Natural Phonology and Lexical Phonology that has some empirical
consequence: while Natural Phonology makes a distinction between two
types of operations in terms of what they do (i.e. in terms of the
changes they effect), the distinction made in Lexical Phonology is in
terms of where the operations apply (i.e. in terms of their domains). To give an example, the rule of palatalisation in English applies both in the lexical and the post lexical domains. Since the distinction made in Natural Phonology is in terms of the intrinsic phonetic content of the operations, palatalisation should be either a rule or a process, but hardly both.

In sum, the level of lexical representation in Lexical Phonology is not identical to either the taxonomic phonemic level or the level between rules and processes in Natural Phonology.
Footnotes for Chapter II

1. The reason for assuming a morpheme based word formation rather than a word based word formation (cf: Aronoff (1976)) is that languages like Malayalam, Sanskrit, and Latin have several productive and regular forms of affixation on stems which are not independent words. Thus, the tense suffixes in Malayalam (um 'fut.', unnu 'pres', i/tu 'past') are attached to stems which are not independent words: e.g. dukkhikkum 'will grieve', ootum 'will run', but *dukkhiKK, *oot. The same observation applies to the formation of nouns, verbs, and adjectives. Thus, dukkhikk- (V), dukkham 'grief', and dukkhitam 'grieving person' are derived from the root dukkh which does not exist as a word. (This is a paradigm case in Malayalam word formation.) Except for the plural suffix, I cannot think of any affix in Malayalam which is attached to words'. On the basis of data of this kind common in various languages, I reject the model of word based word formation.

2. This contrast follows from Selkirk's (to appear) principle of semantic interpretation of compounds which forbids the interpretation of the left member as the subject of the predicate of the right member. The meaning "one whom children employ" interprets child as the subject of employ, which the principle disallows. Compounds like Ford employee may appear as counterexamples to this principle, but I would like to suggest that the meaning of Ford employee is "one who is employed at Ford, i.e., at the establishment referred to as Ford", rather than "one whom Ford (the person) employs". cf: *king employee, *president employee, *governor employee.

3. Unlike the past tense, present tense, and plural, the possessive in English is attached to a phrasal category, not a lexical category.

4. It seems intuitively correct to say that only lexical rules can have lexical exceptions (cf: Bresnan (1978), Baker (1979)).

5. Voicing applies only after vowels. cf: re[z]ume, but con[s]ume. (See SPE for the details.)

6. One may ask why there is an identity rule of the form nîtinge[l] → nîtinge[l], but none of the form long → long. Clearly, this is because lexical rules apply to the underlying form /long/ while no lexical rules apply to /nîtinge[l]/. If so, setting up nîtinge[l] → nîtinge[l] is another way of saying that no lexical rules can apply to /nîtinge[l]/.
7. The discussion in this section is about deliberate pauses, not the kind of accidental pauses created by, say, coughing or surprise.

8. I am grateful to Moira Yip for her help with this rule.

9. The rule is intended to account for the phenomenon of 'linking r', not 'intrusive r' (see Jones (1940), Gimson (1962)). The dialects with linking r have "The car is..." but "The idea is...". The dialects with intrusive r have "The idea is..." with an r at the end of idea as well. In the latter dialects, (34) is replaced by a rule that inserts r prevocally.

10. The transcriptions are from Jones (1977), 14th edition.

11. I am grateful to Joan Bresnan for the ayb data.

12. Ken Hale has pointed out to me that the nasal assimilation in fast speech in words like unclean $\rightarrow$ u[nk]lean applies in Pig Latin after the application of the code. e.g. clean $\rightarrow$ eanclay which becomes ea[nk]lay. Given that fast speech phenomena have to be post lexical, this is the predicted result.

13. Malayalam syllables do not allow codas. Words like kutti and kampi are syllabified as ku-ṛtti and ka-mpi (see 4.1.).

14. The rule that inserts a glide between two vowels is discussed in 4.2. (pa u... $\rightarrow$ payu... (54b)).
Chapter IV: A CASE STUDY: MALAYALAM PHONOLOGY

Having developed a theory of Lexical Phonology, and shown its consequences for the study of the phonological knowledge of human beings, I shall proceed to illustrate the application of the model through an extensive analysis of Malayalam phonology. This case study has two purposes: first, it provides the proper background for the phonology of compounding discussed in Chapter II, and highlights the details of the theory by examining a set of complex interactions of phonological phenomena; second, it provides additional supporting evidence for various assumptions made in the preceding chapters, such as the integration of phonology and morphology, the Opacity Principle, and the Stratum Ordering Hypothesis.

4.1. Syllable Structure

4.1.1. The Syllable Template

When asked to syllabify the words kampi 'metal rod', and kaappi 'coffee', native speakers of Malayalam break them up as ka-mpi and kaa-ppi. Odd though it may seem to those who are used to the Indo European syllabification, I shall argue that this untutored syllabification reflects a significant structural property of the language, namely, that it allows no codas.
Before going on to the details of the syllable in Malayalam, I should make explicit what I mean by 'coda', and my approach to syllable structure in general. I follow the theory of the syllable outlined in Halle & Vergnaud (1980), which sets up a three tier representation of the syllable, consisting of a tier of distinctive feature specifications called the 'melody', a skeletal tier of C's and V's, and a tier of onsets and rimes. (See McCarthy (1979) for the idea of C/V sequences as the prosodic skeleton.) An example of this kind of representation is given below:

(1) **Whistle**

\[
\begin{array}{cc}
\sigma & \sigma \\
\Lambda & \Lambda \\
O & R & O & R & \text{onsets and rimes} \\
\mid & \mid & \mid & \mid \\
C & V & C & V & \text{skeleton} \\
\mid & \mid & \mid & \mid \\
u & i & s & l & \text{melody}
\end{array}
\]

Observe that C's and V's are not to be identified with 'consonants' and 'vowels'. Thus, l in whistle is not a vowel, but is linked to V element in the skeleton. To use Pike's (1947) terminology, the melody tier consists of the phonetic categories of vocoids (e.g. u, i) and contoids (e.g. s, l), while the skeletal tier represents their syllabic (V) and nonsyllabic (C) functions.

Following this approach, I represent the syllable structure of **kampi** and **kaappi** as follows:
Observe that the distinction between a and aa is represented as V and VW at the skeletal tier, rather than at the melody tier, and the distinction between p and pp as C and CC.

The assumption that Malayalam has no codas (i.e., C elements in the rime) is consistent with the fact that words do not end in consonants in the language, with the exception of m and n in colloquial Malayalam, and m, n, ṇ, l, l, and r, in literary Malayalam. The contrast between the two varieties is illustrated in (3):

(3)  

<table>
<thead>
<tr>
<th>Literary</th>
<th>Colloquial</th>
</tr>
</thead>
<tbody>
<tr>
<td>marām</td>
<td>marām</td>
</tr>
<tr>
<td>awan</td>
<td>awan</td>
</tr>
<tr>
<td>aan</td>
<td>aanə</td>
</tr>
<tr>
<td>awal</td>
<td>awalə</td>
</tr>
<tr>
<td>paal</td>
<td>paalə</td>
</tr>
<tr>
<td>wayar</td>
<td>wayarə</td>
</tr>
</tbody>
</table>

These word final consonants may be analysed either as codas or as appendices (i.e. extrametrical syllable final segments directly dominated by the syllable node. See Halle & Vergnaud (1980)). We now have the following alternate analyses for the nasals in, say, kampam 'fascination':

(2) a. \( \sigma \sigma \) b. \( \sigma \sigma \)
(4.a) Syllabification: kam-pam; both nasals are codas.

b. Syllabification: ka-mpam; only the second nasal is a coda.

c. Syllabification: ka-mpam; neither of the nasals is a coda. The first one is part of the second onset, and the second one is an appendix.

The syllabifications in (4)a-c are:

(5) a. σ σ b. σ σ c. σ σ

\[
\begin{array}{c}
\text{O} \hspace{0.5cm} \text{R} \hspace{0.5cm} \text{O} \hspace{0.5cm} \text{R} \hspace{0.5cm} \text{O} \hspace{0.5cm} \text{R} \hspace{0.5cm} \text{R} \hspace{0.5cm} \text{A} \\
\text{C} \hspace{0.5cm} \text{V} \hspace{0.5cm} \text{C} \hspace{0.5cm} \text{C} \hspace{0.5cm} \text{V} \hspace{0.5cm} \text{C} \hspace{0.5cm} \text{C} \hspace{0.5cm} \text{V} \hspace{0.5cm} \text{C} \\
\text{k} \hspace{0.5cm} \text{a} \hspace{0.5cm} \text{m} \hspace{0.5cm} \text{p} \hspace{0.5cm} \text{a} \hspace{0.5cm} \text{m} \hspace{0.5cm} \text{k} \hspace{0.5cm} \text{a} \hspace{0.5cm} \text{m} \hspace{0.5cm} \text{p} \hspace{0.5cm} \text{a} \hspace{0.5cm} \text{m}
\end{array}
\]

I shall argue for (5c), which illustrates the 'no coda' hypothesis. I propose the following syllable template for Malayalam:

(6) Syllable Template

\[
\begin{array}{c}
\text{σ} \\
\text{σ} \\
\text{σ} \\
\text{σ} \\
\text{σ} \\
\text{σ} \\
\text{σ}
\end{array}
\]

Appendices, it has been observed, have a restricted distribution in natural languages (Halle & Vergnaud (1980), Harris (forthcoming)). In Malayalam, they occur only in the morpheme final position.
4.1.2. The \( p_a \) Language

The \( p_a \) language, a secret code language of Malayalam (3.3.3.), confirms the \( V-C_0V \) analysis of the Malayalam syllable. I formulate the rule of \( p_a \) insertion as follows:

(7) Insert \( p_a \) before every syllable.

Thus, moohanan 'a name', in \( p_a \) language, is pamoopahapanan. Versions of the \( p_a \) language exist in most Indian languages, with minor dialectal differences. In some versions, the syllable inserted is \( ca \) or \( sa \) instead of \( p_a \): moohanan → camoocahacanan. In others, the inserted syllable copies the features of the following vowel: moohanan → pomoopahapanan; siima 'limit' → pipsiipama. What is common to all these versions is the insertion of a nonsense syllable before every syllable in the word.

Consider the \( p_a \) version of the following words:

(8) a. kāncan 'a name' → pakapañcan
    b. indiśa 'a name' → payipandipaśa
    c. susmita 'a name' → pasupasmipata

(9) a. ka-ñcan  b. i-ndi-śa  c. su-smi-ta

If the syllabification of (8) is as given in (9), the \( p_a \) versions are correctly accounted for by (7). An alternate syllabification, such as the one in (10), fails to account for (8):
Given the syllabification in (10), the rule of pa insertion would be unnecessarily complicated:

(11) Insert pa at the beginning of the word, and after every nucleus except the last one.

The syllabification in (10) does exist in the Indo European languages of India, giving the following pa versions:

(12) Hindi, Gujarati

a. kancan → cakancacan (or cakancacacan(a))

b. indira → cayincadicara

c. susmita → casuscamicaṭa

It is well known that languages in India share a number of common properties in vocabulary, phonology, and syntax, in spite of their genetic differences. This has, in fact, led to the notion of 'India as a linguistic area' (Emeneau (1956), Masica (1976)). Given rule (7), the differences between the pa versions of the Dravidial and the Indo European languages of India follow from the assumption that VCCV is syllabified in the former as V-CCV, and in the latter as VC-CV.

4.1.3. Gemination

Another source of evidence for the no coda hypothesis in
Malayalam comes from the rule of gemination (2.1.1.), repeated below:

(13) Gemination (Domain: Stratum 2)

\[ \text{Onset } \rightarrow \wedge \% \rightarrow ] [ \]

(14) Examples

a. \[[kaaṭ][maram]] \rightarrow kaaṭṭamaram \text{ (stem final gemination)}

b. \[[kūṭi̯a][kutṭi]] \rightarrow kūṭirakkutti \text{ (stem initial gemination)}

The application of (13) in (14b) is illustrated below:

(15) by (13)

What is interesting is that gemination does not take place if the onset is already branching, i.e., if the stem final/initial consonant is a geminate, or in a cluster:
Given the formulation in (13), nothing need be stated about the lack of gemination in (16) a and b. Since the onsets are already branching ($\frac{\text{CC}}{\text{pr}}$, $\frac{\text{CC}}{\text{t}}$), (13) applies vacuously, producing no difference in the output. Crucial to this solution, however, is the assumption that the pr in kutirapreemam and the tt in paattismaasa constitute onsets, and are not heterosyllabic. If VCCV is syllabified as VC–CV in Malayalam, the formulation of gemination will have to be complicated in undesirable ways.

The rules of stem final and stem initial geminations are disjunctively ordered, stem final gemination applying first. Thus, in kayattokaattila 'rope cot' (kayara, kaattila), stem initial k does not geminate, as stem final gemination applies to r (rr $\Rightarrow$ tt). In contrast, the k in marakkaattila 'wooden cot' (maram, kaattili) geminates. What is fascinating is that this disjunctivity is sensitive to the vacuous application of onset branching. If the preceding stem final onset is branching, the stem initial consonant does not geminate:

(17) a. [[cemp][paatram]] $\rightarrow$ cemp$\backslash$paatram *cemp$\backslash$paatram 'copper' 'vessel' 'copper vessel'

b. [[swarnam][paatram]] $\rightarrow$ swarnappaatram 'gold' 'vessel' 'golden vessel'
In (17a), (13) applies vacuously to \( \frac{\overline{a}}{cc} \), and therefore, does not apply to the stem initial p. In (17b), on the other hand, stem final gemination does not apply, therefore stem initial gemination applies to p.

4.1.4. The \( \overline{r} \sim r \) Alternation

The \( \overline{r} \sim r \) alternation in formal Malayalam appears to provide an argument against the no coda hypothesis.

Underlying \( \overline{r} \) becomes \( r \) before consonants and before pauses:

(18) \[
\begin{array}{ccc}
\text{Formal} & \text{Colloquial} \\
a. \text{aware} & \text{awar} & \text{'they'} \\
b. \text{aware} & \text{aware} & \text{'they-acc.'} \\
c. \text{awaroota} & \text{awaroota} & \text{'they-dat.2'} \\
d. \text{awarkka} & \text{awarakkha} & \text{'they-dat.'} \\
e. \text{aware ewife} & \text{awar ewife} & \text{'where are they'} \\
f. \text{aware ewife} & \text{awar ewife} & \text{'where are they'} \\
g. \text{awar wannu} & \text{awar wannu} & \text{'they came'}
\end{array}
\]

If \text{awarkka} is syllabified as \text{a-war-kka}, and the \( r \) in \text{awar} and \text{awarkka} is the coda, the rule would be stated as follows:

\[
(19) \quad \overline{r} \rightarrow r/
\]

The contrast between (18e) and (18f) (formal version) is accounted for by the syllabification in (20):
Steriade (1981) argues that the no coda hypothesis fails to unite the preconsonantal ((18d)) and the prepausal ((18f)) r's. I would like to suggest that the no coda hypothesis can handle the problem raised by (18) by allowing appendices (r, l, l) in the morpheme final position:

(21) a. \( \sigma \sigma \) b. \( \sigma \sigma \sigma \) c. \( \sigma \sigma \sigma \) d. \( \sigma \sigma \sigma \sigma \)

(21) would require an obligatory resyllabification rule such as (22):

(22) \( A \rightarrow 0/ \longrightarrow R \)

Given (21), the \( \tilde{r} \rightarrow r \) alternation can now be accounted for as follows:
4.1.5. The Voicing of Stops

I shall formulate the rule of voicing in Malayalam, tentatively presented in 2.2.2. as intervocalic voicing, in terms of the syllable structure. What is crucial about the voicing of stops is that it occurs only in noninitial nonbranching onsets:

(24) a. [kaaranam] 'reason'; [agaaranam] 'without reason'
b. [pawiaram] 'holy'; [abawitram] 'tainted'
c. [paatt] 'song'; [paadum] 'will sing'

(25) a. [kramam] 'order'; [akramam] 'disorder'
b. [tyaagam] 'sacrifice'; [parityaagam] 'giving up'

(26) a. akalca → [agalca] 'distance'
b. arkan → *[argan] 'sun'

Thus, the voicing of stops also takes place when nonbranching onsets are preceded by appendices in formal Malayalam:

(27) a. awal karannu → [awalgarannu] (NP-V)
she cried
b. ṭgamm kal танне → [mrząggall danne] (NP-Adv.)
animal pl. intens.
c. malar kont → [malargont] (NP-P)
flower with
d. awargal kal → [awargal] (N-pl.)
they pl. (honorific pronoun)
The rule of voicing can now be stated as follows:

(28) Stop Voicing

Nonbranching noninitial onsets are voiced.

The sequence rk constitutes a branching onset in (26b), but not in (27c); hence the difference in voicing:

(29) a. \[
\begin{array}{c}
\sigma \\
R \ O \ R \ A \\
V \ C \ C \\
\text{arkan}
\end{array}
\]

b. \[
\begin{array}{c}
\sigma \sigma \sigma \sigma \\
O \ R \ O \ A \ O \ R \ O \ R \\
C \ V \ C \ C \ C \ C \ C \ C \ C \\
\text{malarkonta}
\end{array}
\]

An important fact that must be mentioned at this point is that there are no morpheme internal cases of stop voicing after r, l, and l. Thus, monomorphemic alpam 'a little', kalpama 'order', walkalam 'blouse made of bark', karpuuram 'cam\'hor', wiirpa 'bloating', etc., have voiceless stops: this follows from the assumption that appendices in Malayalam are morpheme final.\(^5\)

4.1.6. Laghu and Guru

Another confirmation for the syllable template in (6) comes from the laghu-guru distinction in Malayalam poetry. 'Laghu' (light syllable) is a syllable with a short vowel not followed by a cluster; 'guru' (heavy syllable) is a syllable with a long vowel or one followed by a cluster. Thus, the initial syllable in kuṭi 'drinking' is a
laghu, while those in *kuti* 'child', *kuuti* 'increased-intr.', and *kuutta* 'increased-tr.' are guru's.

There are two ways in which the laghu~guru distinction can be characterised. Within the no coda hypothesis, the examples given above will be syllabified as in (30), and guru will be defined as in (31):


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(31) Guru: syllable which has a branching rime, or is followed by a branching onset.

Alternatively, one may allow codas, and assume the syllabification in (32), and the definition of guru in (33):

(32) a. *kuti* : as in (30a)  
b. *kuuti* : as in (30b)  
c. *kuutta*  
d. *kuutta*

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(33) Guru: syllable which has a branching rime.
Inelegant though (31) may seem, I shall demonstrate that (32) and (33) lead to incorrect predictions, and that (31) is, indeed, correct.

The first problem which (33) faces is the laghu/guru assignment in the case of word final vowels. The third syllable of kalpana 'order' is a guru in kalpana prakaaram 'according to the order', but a laghu in kalpana kaziinna 'after the order'. This contrast follows directly from (31), but for (33) to work, we would require an additional rule of resyllabification across words that changes kalpana prakaaram to kalpana prakaaram. This resyllabification will have to apply every time a word final vowel is followed by a branching onset.

The second problem is a little more complex. There is an interesting distinction in Malayalam versification referred to in the traditional literature (Rajarajavarma (1904)) as 'laghuprayaatnam' (light effort) and 'tiwarprayaatnam' (intense effort). Thus, one finds examples like the laghu in the second syllable in malarmaala 'garland of flowers' (malaar 'flower'; maala 'garland'), in contrast to the guru in the first syllable of marmaram 'murmur' (monomorphemic). Observe that the sequence -arm- is taken as a laghu in the former case (laghuprayaatnam), while the same sequence is a guru in the latter case (tiwarprayaatnam). Our assumptions regarding the syllable structure of Malayalam allow us to offer a principled account of the traditional distinction.
What we need to explain is why the second syllable in *malarmaala* is a laghu, even though the vowel is followed by a cluster. This can be accounted for by assuming that the r in this word is an appendix:

\[
(34) \quad \sigma \sigma \quad \sigma \sigma
\]

\[
\begin{array} {cccc}
\uparrow & \uparrow & \uparrow & \uparrow \\
O & R & A & O \ \\
\uparrow & \uparrow & \uparrow \ \\
C & V & C & V \\
\end{array}
\begin{array} {cccc}
\uparrow & \uparrow & \uparrow & \uparrow \\
O & R & O & R \\
\uparrow \uparrow \uparrow \uparrow \\
C & V & C & V \\
\end{array}
\]

*mal a r m a la* but *m a r m aram*

In *malarmaala*, the second syllable has a nonbranching rime followed by a nonbranching onset, and is therefore a laghu; in *marmaram*, on the other hand, the second syllable has a rime followed by a branching onset, and is therefore a guru.

Since appendices in Malayalam are restricted to the morpheme final position, this account correctly predicts that the sequence VC_i C_j results in a laghu only if C_i is an appendix, i.e., morpheme final r, l, or l.

\[
(35) \quad \begin{array} {ll}
a. \text{akalca 'distance'} & \text{muyal cattu 'hare died'} (\text{NP V}) \\
G & \text{L} \\
b. \text{markatan 'monkey'} & \text{malar konta 'with flowers'} (\text{NP P}) \\
G & \text{L} \\
c. \text{arkan 'sun'} & \text{awarkal 'honor. pronoun'} \\
G & \text{L} \\
\end{array}
\]

Though the second syllable in *malar konta 'with flowers'* is a laghu, it is a guru in *malar tyajiccu 'sacrificed flowers'*. Once again, the contrast is predicted by (31): ty is a branching onset,
k is not. This contrast becomes clearer with compounds in which
gemination occurs, such as malarppoti 'pollen' (poti 'powder'). Since
ar in this case is followed by pp, the second syllable is a guru,
in contrast to the phrase malar požinnu 'flowers fell', in which the
second syllable is a laghu.

Wherever we find laghuprayatnam, we also find the 'irregular'
voicing. Thus, awarka1 ((35c)) is phonetically [awargal], while arkan
is [arkan]. It is the nonbranching stop onsets which voice noninitially, and k in awarka1 is a nonbranching onset: the voicing is predict-
ed by the no coda hypothesis.

The behaviour of the pa language confirms our account of
laghuprayatnam. marmaram in the pa language is pamaparmaparam,
while malarmaala is pamapalarpamaapala.

It must be pointed out that nasals never give rise to laghu-
prayatnam. Thus, though the second syllable of malar konta is a laghu,
that of maram konta is a guru. The solution to this problem, I think,
lies in stipulating that nasal appendices are obligatorily attached
to the following onsets:

(36) A 0    →   0
     \   /  \\
    C   C
[+nasal]                  [+nasal]
(36) would change \textit{maram konta} to \textit{maram konta}, giving the desired results.

4.1.7. Malayalam Onsets and Universals of Syllable Structure

A consequence of the assumption that Malayalam has no codas is that all intervocalic consonant sequences, as pointed out earlier, are analysed as onsets: \textit{a-rkan}, \textit{ka-mpi}, and \textit{sa-mskaa-ram} 'culture'. Now, clusters like rk, mp, and msk do not occur word initially, and therefore, it is necessary to stipulate that only a subset of allowable onsets can occur as word initial onsets.

Steriade (1981), who argues for codas in Malayalam, points out that none of the word initial onsets in the language violate the universal principle of sonority hierarchy, given below:

(37) a. Segments belonging to the same onset occur in the order of increasing sonority.

b. Segments belonging to the same rime occur in the order of decreasing sonority.

Language surveys indicate that even though violations of (37) are observed at the beginning and end of words, they are not common word medially. Under the no coda hypothesis, the facts of
Malayalam syllable structure would be inconsistent with these observations. Even though word initial onsets do not violate (37a) (with the exception of onsets like sk, sp, etc. common in other languages as well), word medial onsets do (e.g. rk, mp). Steriade observes that it would be an accident, given the no coda hypothesis, that only word medial onsets violate (37a), and not word initial onsets. On the other hand, if we allow codas (ar-kan, kam-pi), all onsets would obey (37a).

In order to make Malayalam conform to the language survey results, Steriade is forced to complicate the grammar of Malayalam in uninsightful ways. In order to account for the pa language phenomenon, she sets up a late resyllabification rule which groups all consonants into onsets, thereby assuming, in effect, the no coda hypothesis at a late stage in the derivation. She accounts for laghu-prayatnam by setting up another resyllabification rule that changes a nonnasal sonorant into a syllabic consonant morpheme finally just in case it is followed by a single consonant (and not a cluster), and assuming that metrical scansion ignores these syllabic consonants. In short, practically every syllable related phenomenon requires a special rule of resyllabification and ad hoc assumptions.
4.2. Glide Insertion

4.2.1. The Facts and an Account

Malayalam has a rule that inserts a glide between two adjacent vowels, agreeing in roundness and backness with the preceding vowel:

\[(38)\]
\[
a. \text{[[karī]}_2[ila]] \rightarrow \text{kāriyila}
\]
coal leaf dry leaf
b. \text{[[pasu]in te]} \rightarrow \text{pasuwinte}
cow poss. cow's
c. \text{ṭaarā alari} \rightarrow \text{ṭaarāyalarī}
a name roared

Glide insertion can be looked upon as the insertion of an onset between two adjacent rimes:

\[(39)\]
\[
\text{RR} \rightarrow \text{ROR}
\]

The principle that is responsible for (39) is:

\[(40)\] Rimes and onsets must alternate (in Malayalam).

In order to derive (40), we stipulate that onsets are obligatory in Malayalam except in the phrase initial position:

\[(41)\]
\[
a. \sigma
\]
\[
\text{0 R}
\]
\[
b. \sigma \quad \text{(condition: } \sigma \text{ is initial)}
\]
\[
\text{R}
\]
We can now account for glide insertion by the following general convention:

(42) Syllable Completion Convention (Domain: Strata 2 - 5, where 5 is the post lexical stratum)

Complete the syllable structure by providing the missing rimes and onsets. 8

The onset node provided by (42) is linked to the melody to its left:

(43) \[
\begin{array}{c}
\text{R} & \text{O} \\
\text{V} & \text{C} \\
\text{[-cons.]} & \text{[-cons.]} \\
\end{array}
\]

\[
\begin{array}{c}
\text{C} & \text{C} \\
\text{I} & \text{I} \\
\text{[-cons.]} & \text{[-cons.]} \\
\end{array}
\]

\[
\begin{array}{c}
\text{C} \\
\text{I} & \text{E} & \text{A} \\
\text{[-cons.]} & \text{[-cons.]} \\
\end{array}
\]

i, e, and a are phonetically realised as y by universal conventions, and \text{u} and \text{o} are realised as w.

The derivation of \text{taarayurapni} 'Tara slept' is given below by way of exemplification:
4.2.2. Lexical and Post Lexical Applications

The idea that the same phonological rule can apply both prior to and after lexical insertion makes interesting predictions regarding glide insertion. Recall that pauses are assigned after lexical insertion, and consequently, phonological operations prior to lexical insertion are sensitive to pauses, but not operations after lexical insertion. As predicted, the syllable completion principle is blocked by pauses across words, as (45), but not when it applies word internally, as in (46), (47), and (48):
(45) a. ewiće maalu? 'where is Malu?'
   b. maaluwewite? (scrambled version of a.)
   c. maalu... ewite?
   d. *maalu...wewite?

(46) Subcompounds

   a. ṭalayina, ṭala...yina, *tala...ina (tala, ina)
      pillow
      head
      mate
   b. kaśuwanti, kaśu...waṇṭi, *kaśu...aṇṭi (kaśu, aṇṭi)
      cashew
      nut
      cashew
      seed

(47) Cocompounds

   kuṭiFayaanayoṭṭakāṇjaḷa, kuṭiFa...yaana...yoṭṭakāṇjaḷa
   horses, elephants & camels
   *kuṭiFa...aana...oṭṭakāṇjaḷa
   (kuṭiFa, aana, oṭṭakam)
   horse
   elephant
   camel

(48) Inflection

   a. ṭaara 'a name'; ṭaaraye 'Tara-acc.'; ṭaar...ye
      *ṭaar...e
   b. paśu 'cow'; paśuwinte 'cow-gen'; paśu...winte
      *paśu...inte

Subcompounds, cocompounds, and inflected words come out of the lexicon with the glide in them; pause assignment does not alter the glide. On the other hand, words like maalu and ewiće come out of the lexicon without the glide, and when they are put together, pause assignment prevents glide insertion.
4.3. ə Insertion

4.3.1. Word Final ə Insertion

While glide insertion is the result of the syllable completion of unattached rimes, ə insertion is the syllable completion of unattached onsets. The rule is illustrated by the following examples:

(49) a. kattə ayaccu 'sent the letter'
    b. ayaccu kattə ((49a) scrambled)
    c. kattə kitti 'got the letter'

I assume that the ə in (49)b and c is an inserted one, rather than assuming that (49a) is a case of ə deletion. Other vowels do not delete in comparable environments:

(50) a. mettaayaccu 'sent the bed'
    b. ayaccu metta ((50a) scrambled)

(51) a. kattiyayaccu 'sent the knife'
    b. ayaccu katti ((51a) scrambled)

The occurrence of ə is restricted to the stem final position, and after syllabic r (4.3.5.). The solution that inserts the ə predicts such restrictions.

The generalisation regarding word final ə insertion is: ə is inserted word finally after any consonant except m and n (in colloquial Malayalam. In formal Malayalam, m, n, ɾ, r, ɾ, and ɾ)
when not followed by a vowel. The syllabification of maram 'tree' and katta 'letter' (underlying /katt/) are:

(52) a. \[\sigma \sigma\]  
\[
\begin{array}{c}
\text{OR R R A} \\
\text{C V C V C}
\end{array}
\]
\[
\text{ma ra m}
\]

(52) b. \[\sigma\]  
\[
\begin{array}{c}
\text{OR O} \\
\text{C V C C}
\end{array}
\]
\[
\text{k a t}
\]

\[\text{t}\] in (52b) is an unattached onset; by the syllable completion principle, it is assigned a rime:

(53) \[\sigma \sigma\]  
\[
\begin{array}{c}
\text{OR O} \longrightarrow \text{OR O R R}
\end{array}
\]
\[
\begin{array}{c}
\text{C V C C}
\end{array}
\]
\[
\text{k a t}
\]

The following rule gives the surface form kattā:

(54) Empty Rime Rule (Domain: Post Lexical)  
\[\text{Fill empty rimes with } \emptyset.\]

The derivation of (49)a and c are given below:

(55) \[\sigma \sigma \sigma\]  
\[
\begin{array}{c}
\text{OR O R R O R R O R R R}
\end{array}
\]
\[
\begin{array}{c}
\text{C V C V C V C C V C V C C V C}
\end{array}
\]
\[
\begin{array}{c}
\text{k a t a y a c u k a t a y a c u}
\end{array}
\]
4.3.2. θ Insertion in Compounds

Cocompounds behave exactly like phrases as far as θ insertion is concerned, inserting θ before consonants and not before vowels, when a stem ends in a consonant other than m and n:

(57) a. waal ulak'k'a parica kalə 'sword, pounding stick, & shields'
    (waalə 'sword'; ulak'k'a 'pounding stick; parica 'shield')

b. ulak'k'a waalə parica kalə (same as (57a))

θ appears after waal in (57b) because the stem final 1 is
followed by a consonant; in (57a), it is followed by a vowel.

\( \varepsilon \) insertion takes place in subcompounds as well, but with one crucial difference. If the stem final onset of the first stem and the stem initial onset of the second stem can be combined into a single onset, \( \varepsilon \) is not inserted. Compare (58) and (59):

(58) a. \( \text{waal} \text{tala} \) 'sword t' (\( \text{waal} \) 'sword'; \( \text{tala} \) 'head' (cf: \( \text{waal} \) \( \text{potti} \) 'sword broke')

b. \( \text{aaŋkutti} \) 'boy' (\( \text{aaŋŋa} \) 'male'; \( \text{kutti} \) 'child'

(\( \text{aaŋŋa} \) \( \text{kafannu} \) 'the man cried')

c. \( \text{paalppaatram} \) 'milk vessel' (\( \text{paal} \) 'milk'; \( \text{paatram} \) vessel. cf: \( \text{paal} \) \( \text{pirinnu} \) 'the milk split')

(59) a. \( \text{kaat} \text{puucca} \) 'Tom cat' (\( \text{kaat} \) 'forest'; \( \text{puucca} \) 'cat')

b. \( \text{paat} \text{maaaŋ} \) 'music tcher' (\( \text{paat} \) 'song'; \( \text{maaŋ} \) 'teacher'

(c. \( \text{cempa} \text{aatram} \) 'copper vessel' (\( \text{cempa} \) 'copper'; \( \text{paatram} \) 'vessel')

The sequence \( \text{ttm}, \text{ttp}, \text{mpp} \) (in (59)) are impossible morpheme internally in Malayalam. It is precisely such sequences which trigger \( \varepsilon \) insertion in (59), showing that these sequences are disallowed across morphemes as well. On the other hand, \( \text{tt}, \text{ŋk}, \text{1pp}, \text{etc.}, \) which are possible morpheme internal sequences, are the ones which do not require \( \varepsilon \) insertion (in (59)). What this means is that \( \text{ttm}, \)
пп, мпп are not possible onsets in Malayalam, and therefore, ə insertion must apply in order to avoid nonsyllabifiable strings, while sequences in (58) are possible onsets, and therefore, no re-adjustment is necessary.

A clearer contrast is provided by the following examples:

(60) a. paal-sakti 'strength from milk' (paal 'milk'; sakti 'strength')
    b. paal-sooppa 'milk shop' (sooppa 'shop')

ls is a possible onset in Malayalam, while lʂ is not: hence the ə in (60b).

In order to account for the absence of ə in (58) and (60a), I assume that adjacent onsets at the subcompounding stratum are resyllabified into a single onset:

(61) Onset Fusion (Domain : Stratum 2 )

0 0 → 0

(61) obeys the constraints on possible onsets: it applies only if the result is an allowable onset.

The derivation of (60) is given below:
Observe that onset fusion does not take place in cocompounds and phrases because the domain of the rule is restricted to the sub-compound stratum. Hence the contrast between, say, (57b) and (58a).

4.3.3. Lexical and Post Lexical Applications

The contrast between word internal and word external glide insertion is parallel to the contrast between word internal and word external \( \emptyset \) insertion. Though \( \emptyset \) is not inserted before a vowel, it
is, before a pause, word finally:

(63) \textit{kaatewite} 'where is the forest?' vs \textit{kaat\ldots ewite}

\(\emptyset\) is not, however, inserted before a pause, word internally:

(64)a. Subcompounds

\textit{kaatt\text{"a}ana} 'wild elephant'; but \textit{*kaatt\ldots aana}

\hspace{2cm} (cf: \textit{kaa\ldots t\text{"a}ana})

b. Cocompounds

\textit{waalulak'k'akal} 'swords & pounding sticks'; but \textit{*waal\ldots ulak'k'akal}

c. Inflected Words

\textit{rasiidinte} 'Rashid's'; but \textit{*rasiid\ldots inte}

Under the assumption that syllabification is cyclic (cf: Kiparsky (1979)), these results follow from Lexical Phonology.

4.3.4. \(\emptyset\) in Datives

My account of \(\emptyset\) essentially says that it appears after unattached onsets. Since \(m\) and \(n\) appear as appendices in both formal and colloquial Malayalam, they do not create unattached onsets, and the theory predicts that \(\emptyset\) will not appear after \(m\) and \(n\). This prediction is violated in a special instance, that of the dative case of nouns ending in \(n\). A sample list of case forms in Malayalam is:
It is clear that the stem for the nonnominative form in (65) c-f are mara-tt-in, pasu-in, waal-in, and baalan. In the dative case, ə is attached after n to these stems. If n is an appendix, how is the ə accounted for?

I suggest that the dative is a suffix of the form \(R\), with no segmental melody:

(66) \[
\begin{array}{cccc}
\sigma & \sigma & \sigma & \sigma \\
\text{OROR} & \text{OR} & \text{OR} & \text{R} \\
\text{CVVCVCV} & \text{CVVCVCV} & \text{CVVCVCV} & \text{CVVCVCV} \\
[b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] \\
\end{array}
\]

Dative suffixation

(66) \[
\begin{array}{cccc}
\sigma & \sigma & \sigma & \sigma \\
\text{OROROR} & \text{OROR} & \text{OROR} & \text{OROR} \\
\text{CVVCVCV} & \text{CVVCVCV} & \text{CVVCVCV} & \text{CVVCVCV} \\
[b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] \\
\end{array}
\]

Resyllabification

(66) \[
\begin{array}{cccc}
\sigma & \sigma & \sigma & \sigma \\
\text{OROROROR} & \text{OROROR} & \text{OROROR} & \text{OROROR} \\
\text{CVVCVCV} & \text{CVVCVCV} & \text{CVVCVCV} & \text{CVVCVCV} \\
[b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] & [b\ a\ l\ a\ n] \\
\end{array}
\]

Empty Rime Rule
4.3.5. Syllabic r

Another context in which empty rime filling applies is after syllabic r. That it is necessary to postulate a distinction between syllabic and nonsyllabic r in Malayalam, though the distinction is neutralised on the surface, has been amply argued for in Warrier (1976). Her arguments are summarised as follows:

(67) a. Morpheme internally, a can occur only after r, in words like rāsi 'sage'. This fact can be accounted for by assuming an underlying /ṛsi/ (to distinguish it from examples like /raṇi/ 'queen'), and a rule that inserts a after r.

b. The rule of intervocalic voicing of stops (4.1.5.) applies in the environment of V₁ r, but not V₁ r:
[sugṛādi] 'good deed' (from /sukṛti/), but [sukriya] 'good deed' (from /sukriya/).

c. The postulation of syllabic r, along with the independently required vowel sandhi rule (2.1.1.4.), explains the contrast between a and aa in mahāṛsi 'great sage' (from mahaa 'great', and ṛsi 'sage') and mahaaraṇi 'great queen').

One can account for the insertion in rāsi by adding the following rule to the grammar:

(68) Desyllabification (Domain : Post Lexical Stratum)

\[ V \rightarrow C/ r \]
(68) detaches r from the rime node and attaches it to an existing or newly formed onset node. Consider the derivations of rasi and maharsi:

\[
\begin{array}{c}
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\sigma \sigma \sigma \sigma \\
\end{array}
\]

\[
\begin{array}{c}
\text{Compounding} \\
\text{Onset fusion} \\
\text{Syll. completion} \\
\text{Vowel Sandhi} \\
\text{Desyllabification} \\
\text{Empty Rime Rule}
\end{array}
\]

\[
\begin{array}{c}
\text{ra} \tilde{s} \text{i} \\
\text{mah} \text{a} \text{r} \text{s} \text{i}
\end{array}
\]

\[
\begin{array}{c}
\text{ra} \tilde{s} \text{i} \\
\text{mah} \text{a} \text{r} \text{s} \text{i}
\end{array}
\]
stage in the derivation (the post lexical stratum), the former has an empty rime but not the latter.

It is important to note that desyllabification does not apply at stratum 2. If it did, and the application of vowel sandhi followed desyllabification, we would have unacceptable forms like *mahaarsi. Evidence from a different area forces us, in fact, to conclude that desyllabification is a post lexical rule. Observe that, in order to account for forms like [sugardi] (/sukrti/), we must assume that desyllabification takes place after stop voicing (2.2.2.). If not, the contrast between /sukrti/ and /sukriya/ would be lost, and voicing would not take place. We know that voicing is a post lexical rule, and since desyllabification follows voicing, it also must be post lexical.

An advantage of the metrical treatment of a insertion is that it provides a unified account of the insertion at the end of words, at the end of stems in subcompounds and cocompounds, and after syllabic r. Within a segmental treatment, the fact that it is the same vowel that is inserted in these environments would be an accident.

Other Dravidian languages like Tamil and Telugu offer strong support for the assumption that the vowel insertion after syllabic r and word finally are, in fact, the same process. In Telugu, the English word belt is pronounced [beltu] as a consequence of syllable completion and empty rime filling: the empty rime filling vowel in Telugu is u. It is the same vowel that appears after syllabic r also: /rasi/ in Telugu is
[rusi]. In Tamil, belt and /r̥si/ are belt and [r̥si].

4.4. Vowel Sandhi

4.4.1. Derivations

Recall that vowel sandhi has the derivational, subcompounding, and cocompounding strata as its domain. There is a derivational process (2.1.4.) in Malayalam, restricted to words of Sanskrit origin, which inserts a to the left of the first rime in the word:

(70) a. alasam 'lazy' ; aalasyam 'laziness' : a~aa
    b. kumaarān 'boy' ; kaumārayam 'boyhood' : u~au
    c. wikalam 'distorted' ; waikalyam 'distortion': i~ai
    d. dīnām 'illness' ; dainyam 'ill-looking': iī~ai
    e. kruurām 'cruel' ; krauryam 'cruelty' : uu~au
    f. kr̥si 'farming' ; karsakan 'farmer' : r~ar

What is inserted, I suggest, is the melody a at the melodic tier: given the assumptions regarding the linking of the melody to the skeleton, the desired consequences follow. In the case of nonbranching rimes, it creates a new branch ((70)a-c):

(71)  σ  σ
    \  / \  /
    O R O R
    | | | | | |
    C V C V \ V
    u i u i → u a i

    wikalam waikalyam

In the case of rimes which are already branching ((70)d, e),
the addition of the new melody does not create a new branch, since a rime can have at the most two branches in Malayalam. Consequently, the linking of the a to the V results in a delinking, once again, following from general principles:

\[
\begin{array}{c}
\text{\textbf{(72)}} \\
\text{\textbf{(73)}}
\end{array}
\]

The solution sketched above accounts for (70f) as well:

\[
\text{\textbf{(73)}}
\]

The insertion of \( \ddot{a} \) in \textit{kra}ṣ\(i \) is a consequence of the desyllabification of \( r \), which creates an empty rime node, as in \textit{rā}ṣ\(i \) ((69)). The absence of \( \ddot{a} \) in \textit{kara}ṣ\(k\)an is similar to that in \textit{maharṣi}: the desyllabification does not result in an empty rime node, and hence there is no \( \ddot{a} \) insertion.

4.4.2. Compounds

The kinds of alternations in derivational morphology sketched in 4.4.1. are found in compounding as well, with a few additional complications. Given below are examples of subcompounds which illustrate
the phenomena (cocompounds exhibit identical alternations):

(74)a. a]a → aa : niila]̯mbaram → niilaambaram
   blue sky

   b. a]aa → aa : niila]aakaasam → niilaakaasam
   sky

   c. aa]a → aa : maha]atbhum → mahaatbhum
   great wonder

   d. aa]aa → aa : maha]anandam → mahaanandam
   pleasure

(75)a. i]i → ii : ravi]indran → raviindran
   sun god sun god

   b. i]ii → ii : rati]iswaran → ratiiswaran
   a name god Cupid

(76)a. a]au → au : warksam]ausadham → warkausadham
   tree medicine

   b. aa]au → au : maha]ausadham → mahausadham

   c. a]ai → ai : jana]aikyam → janaikyam
   people unity people's unity

   d. aa]ai → ai : maha]aiwaryam → mahaiwaryam
   godliness

(77)a. a]r → ar : saptam]rsi → saptarsi
   seven sage the seven sages

   b. aa]r → ar : maha]rsi → maharsi

Consider what happens to the syllable trees:
If we look at the change in (78) as one involving the erasure of the rime node, leaving the melody tier intact, the facts illustrated in (74) - (77) become identical to (70).

I propose a rule that erases a rime node when followed by another in Sanskrit compounds:

(79) Rime Erasure (Domain: Strata 2, 3)

\[ R \rightarrow \emptyset / \longrightarrow R \]

+skt.

Since a rime node can have at the most two V's, the left over melodies which do not get linked do not surface.\(^{12}\) The derivations for (74a), (76)a, d, and (77b) are given below:

(80)a. niilaamba\~ram

\[
\begin{align*}
& R R \rightarrow R R \\
& \downarrow \downarrow \rightarrow \downarrow \downarrow \\
& a a \ a a \ a a \\
& \end{align*}
\]

b. wrksausadham

\[
\begin{align*}
& R R \rightarrow R R \rightarrow R R \\
& \downarrow \downarrow \rightarrow \downarrow \downarrow \rightarrow \downarrow \downarrow \\
& a a u a a u a u \\
& \end{align*}
\]
Now, both rime erasure and glide insertion apply to adjacent rimes, and one bleeds the other. Rime erasure is a less general rule, applying at strata 2-3 to words of Sanskrit origin, while glide insertion (resulting from the principle of syllable completion) applies at all strata, and it applies to both Sanskrit and Dravidian words. I shall assume that rime erasure is a rule, and that syllable completion is a general convention. In nīlaambāram (74a), rime erasure reduces the two rimes to a single rime, eliminating the need for syllable completion. In the Dravidian compound panayoolla 'palm leaf' (from pana 'palm'; oola 'leaf'), rime erasure does not apply, and syllable completion, therefore, does apply, resulting in glide insertion.

We are now ready to tackle vowel combinations of a more complicated sort. To begin with, i and u become glides when followed by a vowel.
These examples can be accounted for by assuming that a high vowel becomes nonsyllabic (i.e. linked to a C element in the skeleton) when followed by another vowel.

(82) Glide Formation

\[ V \rightarrow C / \begin{array}{c}
[+\text{high}] \\
[-\text{cons.}]
\end{array} \]

(82) creates a new C element and links the vowel to it. The following derivation illustrates the application of (82):
It is crucial that ty in (83) is seen as a branching onset (\( \overline{O} \) \( C \) \( C \)), rather than as a nonbranching onset (\( \overline{O} \) \( C \)). Recall that nonbranching onsets voice noninitially in Malayalam, while branching onsets do not (4.1.5.). Since voicing does not apply to ty in (83) (*\( \overline{r}a[d]yausa2ham \)), we must conclude that ty is a branching onset.

As stated earlier, i is realised phonetically as y when linked to a C element. The linking of \( \overline{i} \) to an appropriate onset node follows from general principles.

I now turn to the phenomenon of mid formation. If the second element in vowel sandhi is a high vowel, the result is a mid vowel agreeing in other features with this vowel:
The process of mid formation can be characterised as a rule that applies at the melody tier, changing a sequence of a vowel melody and another high vowel melody into a single mid melody. The rule is stated as follows:

(86) Mid Formation (Domain: Strata 2, 3)  

\[
[-\text{cons.}] \begin{bmatrix} +\text{high} \\ \kappa\text{back} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{high} \\ -\text{low} \\ \kappa\text{back} \end{bmatrix}
\]

The application of the rule is illustrated in (87):
It is important to note that the skeletal tier remains undisturbed by the application of the rule, and the rime structure remains independent of the changes at the melody tier.

Recall that sequences like i][a and u][a result in ya and wa: the vowel after a glide is a short one, which is an automatic result of the desyllabification of i and u. The surface forms of sequences like i][u, u][i, and u][u, however, are yoo and woo, with a long vowel after the glide:

(88)a. i][u → yoo : pat{i}[utsawam → patyootsawam
husband festival festival of husbands

b. u][u → woo : sīs{u}[utsawam → sīswootsawam
child

c. u][i → wee : sīs{u}[indr{an → sīse{wendran
 god
d. u][ii \rightarrow wee : \text{sisu}] \rightarrow \text{sisweeswaran}

\text{god}

e. u][uu \rightarrow woo : \text{sisu}] \rightarrow \text{siswoosmaalam}

\text{warmth warmth of children}

We saw that vowel sandhi applies only to words of Sanskrit origin. Now, it is a fact of Sanskrit phonology that it has no short mid vowels, even though it has short as well as long high and low vowels. Clearly, it is this property of Sanskrit which carries over to (88). Thus, there are no short e and o in words of Sanskrit origin in Malayalam; we need to stipulate a rule that lengthens mid vowels in these words.

\begin{align*}
(89) \quad &\begin{bmatrix} -\text{high} \\ -\text{low} \end{bmatrix} \rightarrow V V \\
\text{in Skt. words}
\end{align*}

The derivation of (88c) is:

\begin{align*}
(90) \quad &\text{sisweendran} \\
&\text{O R R} \\
&\text{C V V} \\
&\text{sis u indran} \\
&\text{O} \quad \text{R} \\
&\text{C} \quad \text{C} \quad \text{V} \\
&\text{S u i} \quad \text{Glide Formation} \\
&\text{R} \quad \text{V} \\
&\text{e} \quad \text{Mid Formation} \\
&\text{O R} \\
&\text{C C V V} \\
&\text{sis u e endran} \quad (89)
\end{align*}
Mid formation and glide formation do not apply in sequences involving \[1][i\] as in (75), in contrast to the sequences in (88)b and e. In order to prevent the application of mid formation, it is necessary to stipulate that \[1][i\] is an exception to mid formation. \[1][i\] does not undergo glide formation because there are no sequences of the form \(\text{Cyt}\) or \(\text{Cwu}\) in Malayalam. In order to account for the absence of these sequences, I set up the following filter:

\[(91) \star \begin{array}{c} * \ C \ C \ V \\ \hline \hline \hline \end{array} \]

4.5. Causatives

4.5.1. The Phonology of Causativisation

A causativised verb in Malayalam can be causativised further, thereby creating several 'layers' of causativisation:

\[(92)a. \ \text{t\texttt{i}n\texttt{u}m} ; \ \text{t\texttt{i}t\texttt{t}um} ; \ \text{t\texttt{i}t\texttt{t}ik'\texttt{u}m} \]
\[\text{will eat} \quad \text{will feed} \quad \text{will cause to feed} \]

\[b. \ \text{o\texttt{oot}um} ; \ \text{o\texttt{ot}ik'\texttt{k}'\texttt{u}m} ; \ \text{o\texttt{ot}ippik'\texttt{k}'\texttt{u}m} \]
\[\text{will run} \quad \text{will run} \quad \text{will cause \textit{X} to run \textit{Y}} \quad \text{intr.} \quad \text{tr.} \]

The devices used to express causation fall into two categories:
(93) Type A

   a. Denasalisation

          (i) uraggum 'will sleep' ; urakkum 'will put to sleep'

          (ii) kuumpum 'will fold ; kuuppum 'will fold instr.

          (iii) unnum 'will eat' ; uuttum 'will feed'

   b. Gemination

          (i) aatum 'will swing intr.' ; aattum 'will swing tr.'

          (ii) murukum 'will tighten; murukkum 'will tighten intr.'

          (iii) maarum 'will change intr.' ; maattum 'will change tr.'

   c. Suffixation of -utt

          (i) warum 'will come' ; waruttum 'will make X come'

          (ii) coorum 'will leak' ; coorttum 'will cause to leak'

          (iii) ketum 'will go off' ; ketuttum 'will put off'

(94) Type B

   a. Suffixation of -ikk

          (i) ootum 'will run intr.' ; ootik'k'um 'will run tr.'

          (ii) parayum 'will say' ; parayik'k'um 'will make X say'

          (iii) ceerum 'will join intr.' ; ceerkkum 'will join tr.'

   b. Infixation of -ipp-

          (i) ootik'k'um 'will run ; ootippik'k'um 'will make tr.' X run Y'
(ii) pathikk'um 'will study'; pathippikk'um 'will teach'.

(iii) dukkhhikk'um 'will grieve'; dukkhippikk'um 'will cause X to grieve'.

How do we formally relate the processes of gemination and nasalisation to causativisation?

I assume that a word formation process can consist of a set of operations which specify semantic, syntactic, and phonological changes. This idea is inherent in the treatments of lexical rules like passivisation in the Lexical Functional Grammar. Thus, Bresnan (in press: a) formulates the passive rule for English as follows:

(95) Passive

a. \( (\text{SUBJ}) \rightarrow \emptyset / (\text{BY OBJ}) \)
\( (\text{OBJ}) \rightarrow (\text{SUBJ}) \)

b. \( V \rightarrow V \text{ part.} \)

(95a) gives the syntactic changes in the lexical entry of the word; (95b) gives the morphological change. This format can be extended to derivational processes as well. Thus, the effect of -er attachment (employ...employer) can be characterised as:

(96) The Agent Rule

a. \( [V] \rightarrow [V \text{ er}]_N \)

b. \( \text{Pred '}(\text{SUBJ})..' \rightarrow \text{Pred '}X \text{ such that } \exists x \cdot F(\langle \text{SUBJ} \rangle..) \text{ is true} ' \)
(96a) specifies the morphological and syntactic change, (96b) specifies the semantic change.

We can now formalise the causativisation in (93)a-c as:

(97) Type A Causativisation

a. (SUBJ) \(\rightarrow\) (OBJ)
   \(\emptyset \rightarrow\) (SUBJ)
   agent

b. Pred 'F' \(\rightarrow\) Pred 'cause F'

c. Onset \(\rightarrow\) \(\wedge/\rightarrow\) \(l_{\text{v}}\) (gemination)
   or
   Onset \(\rightarrow\) \([-\text{nasal}]//\rightarrow\) \(l_{\text{v}}\) (denasalisation)
   or
   \(l_{\text{v}} \rightarrow l_{\text{v}}\text{utt}l_{\text{v}}\) (\(-\text{utt}\) suffixation)

(97a) specifies the syntactic change: the existing subject becomes an object, and an agent subject is inserted into the lexical form. (97b) specifies the semantic change. (97c) corresponds to the phonological and morphological changes, the choice of which is determined idiosyncratically by the verb.

Alternately, one may assume that processes like gemination and denasalisation are triggered by an abstract 'cause' morpheme suffixed to the verb:

(98) a. Onset \(\rightarrow\) \(\wedge/\rightarrow\) \(l_{\text{v}}\) 'cause'\(l_{\text{v}}\)

b. Onset \(\rightarrow\) \([-\text{nasal}]//\rightarrow\) \(l_{\text{v}}\) 'cause'\(l_{\text{v}}\)
(98) is strictly within the assumption that all morphological operations are cases of affixation or compounding (McCarthy (1979), Lieber (1980)). That this assumption is too strong, and that the richer mechanism illustrated by (97) is needed in morphology, is shown by the derivation in alternations like anukuulam 'supporting -Adj.' ~ aanukuulyam 'support -N', and cancalam 'fickle' ~ caancalyam 'fickleness' (for more examples, see 4.4.1.: (70)). The derivational change from A to N is accompanied by two phonological operations: a is inserted at the beginning of the first rime, and y is inserted at the end of the last onset:

(99) A → N Rule

a. \[ A \rightarrow N \]

b. \[ \emptyset \rightarrow a / [ a \bar{g} \]

\[ \emptyset \rightarrow i / \bar{a} \]

\[ \emptyset \rightarrow c / \bar{a} \]

If the categorial change from A to N, and the phonological changes of a and y insertion were not directly associated, and the phonological rules applied to the output of the syntactic or morphological component, the facts would become less amenable to description. We would have to postulate an abstract morpheme which changes A to N, and triggers the rules of a and y insertion. The disadvantage of this solution is that we would have to allow the abstract
The only way to formulate such a rule is by resorting to the use of variables (Q), which is unmotivated in phonology.

4.5.2. The Two Strata of Causativisation

Type A causativisation and type B causativisation take place at two different strata. Stratum A (=type A) causativisation is less productive, and applies to intransitive verbs only. Among the intransitive verbs, it applies only to some; the choice between gemination, nasalisation, and -ụtụ suffixation is determined by the verb idiosyncratically. In contrast, stratum B (=type B) causativisation is quite general, applies to both transitive and intransitive verbs, and the choice between the two kinds of suffixation is not arbitrary. This difference in productivity is not unlike the difference in productivity between stratum I affixation and stratum II affixation in English (Allen (1978)).

There is also a semantic distinction between A and B. Causatives derived through A are unambiguously of the 'direct causative' type, while those belonging to B could have either the direct or the indirect reading of causation. A direct causative is one in which the
causer is the agent of the action (e.g. eat ~ feed, in English), while an indirect causative is one in which the causer is not the agent, and gets the action performed in an indirect fashion (e.g. eat ~ cause to eat, in English) (see Masica (1976) for a discussion of direct and indirect causatives in Indian languages).

Causatives derived through A can undergo further causativisation through B, but the reverse is not true:

(101) a. tinn ; tiitt ; tiittik'k'
et ; feed ; cause to feed
b. war ; warutt ; waruttik'k'
come ; make X come ; cause to make X come

(102) a. tinn ; tinnik'k' ; *tinnik'k'utt
et ; cause to eat
b. oot ; ootik'k' ; *ootik'k'utt
run ; run -tr.

These results would follow from the ordering of stratum A before stratum B.

In sum, differences in morphological productivity, semantic properties, and distributional criteria distinguish type A causatives from type B causatives, and justify the decision to assign the two processes to two different strata.

4.5.3. Opacity vs Bracket Erasure

The facts of causativisation are of particular interest because
they provide crucial evidence in favour of the Opacity Principle. A characteristic of -ikk is that it can be attached to any verb which does not have a branching structure \( \text{[[X]Y]} \). Thus, from the simple verb \text{wilakk } (\text{'to weld'})\), and from the derived verb \text{mayakk } (\text{'to hypnotise'}) (from \text{mayann } (\text{'to doze'})), neither of which contain any suffixes, we get \text{wilakkik'k } (\text{'to cause to weld'})\), and \text{mayakkik'k } (\text{'to cause to hypnotise'}). However, -ikk causativisation is impossible in (103)-(106)b:

\[(103)\]
\[\text{a. } \text{[[dukkh]ik'k] 'to grieve' (cf: dukkham 'grief')}\]
\[\text{b. } * \text{ dukhkik'k'ikk}\]
\[\text{c. dukkhippik'k 'to make X grieve'}\]

\[(104)\]
\[\text{a. } \text{[[path]ik'k] 'to study' (cf: paatham 'lesson')}\]
\[\text{b. } * \text{ pathik'k'ikk}\]
\[\text{c. pathippik'k 'to teach'}\]

\[(105)\]
\[\text{a. } \text{[[mara]kk] 'to forget' (cf: marawi 'forgetfulness')}\]
\[\text{b. } * \text{ marakkik'k'}\]
\[\text{c. marappik'k 'to cause to forget'}\]

\[(106)\]
\[\text{a. } \text{[[oot]ik'k] 'to make X run'}\]
\[\text{b. } * \text{ ootik'k'ikk}\]
\[\text{c. ootippik'k 'to cause X to run Y'}\]

What (103)-(106) show is that -ikk suffixation must necessarily see the internal structure of the stem. The -ikk in (103)-(105)a is
the stem forming -ikk, and that in (106a) is the causative -ikk.
The stipulation that -ikk cannot be attached to a branching structure rules out the unacceptable examples above, while allowing wilakkik'k' and mayakkik'k', which do not have branching structures.

This solution has interesting consequences for the choice between the Bracket Erasure Convention (2.1.7.) and the Opacity Principle. According to the Bracket Erasure Convention, the last rule in the cycle of \([\text{marak}kk]\) \((105)\) will erase the internal brackets, giving \(\text{marakk}\), thereby making it identical to mayakk in structure. If these are the forms to which -ikk causativisation is applicable, there is no reason why it should apply to one and not to the other.

The Bracket Erasure Convention thus destroys valuable morphological information, and is too strong an empirical hypothesis. Given the principle of Opacity, on the other hand, the right consequences follow. All that the Opacity Principle demands is that the internal brackets at one stratum be invisible to the processes at another stratum, not to the processes at the same stratum. If the attachment of the verb forming -ikk and the causativising -ikk take place at the same stratum, -ikk suffixation can see the internal structure of both dukkhik'k' and ootik'k'.

It is interesting that -ikk causativisation can apply to verb forms which contain the causative suffix -utt: \([\text{war} utt]ikk\) 'cause
X to make Y come; [[walar tt]ikk] 'cause X to grow Y'. Note that these are branching forms, and yet -ikk can be attached to them, because -utt is attached at a stratum prior to the attachment of -ikk. Therefore, the internal structure of, say, waftt, is, by Opacity, invisible to -ikk attachment, which treats it as a nonbranching form.

Similar conclusions can be drawn from the facts of -ipp- infixation, the restriction regarding which can be stated as: -ipp- is inserted only in branching structures, preceding the last branch (as shown by (103)-(106)). The following examples show that (i) -ipp- cannot be attached at the end of a stem, and (ii) it cannot be inserted into a nonbranching structure.

(107) a. *dukkhipp (cf: (103c))
   b. *pathipp (cf: (104c))
   c. *marapp (cf: (105c))
   d. *ootipp (cf: (106c))

(108) a. wilakk 'weld'; *wilappik'k'
   b. mayakk 'hypnotise'; *mayappik'k'
   c. murukk 'tighten-tr'; *muruppik'k'

(107) shows that -ipp- is an infix, not a suffix. (108) shows that it cannot be infixed into underived structures ((108a)), structures derived through denasalisation ((108b)), or structures derived through gemination ((108c)): none of these are branching structures,
Since -utt is attached at stratum A, and -ipp- at stratum B, the bracketing assigned by -utt suffixation is, by the Opacity Principle, invisible to -ipp- infixation, and thus, -ipp- cannot be inserted in -utt stems:

(109) a. * waripputt (cf: war ; warutt )
    b. * talaripputt (cf: talar ; talartt )

Thus, the facts of -ikk and -ipp affixations show that these affixes must be sensitive to the presence or absence of prior suffixations at that stratum, but not affixation at a previous stratum. These results are consistent with the Opacity Principle, but not the Bracket Erasure Convention.

4.5.4. The Place of Causatives in the Grammar

The question that now arises is: where/the two strata of causativisation, which I called strata A and B, fit in with the rest of the grammar?

We can either assume that the two strata of causativisation constitute two strata of derivational morphology, similar to the two strata of derivation in English, or assume that type A causativisation belongs to stratum 1 (Derivational stratum), and type B causativisation belongs to stratum 2 (Subcompounding stratum). The first
solution would entail adding an extra stratum to the set we already have:

(110) \[ \begin{align*}
\text{Stratum 1} & : \text{Derivations (A)} \\
\text{Stratum 2} & : \text{Derivations (B)} \\
\text{Stratum 3} & : \text{Subcompounding} \\
\text{Stratum 4} & : \text{Cocompounding} \\
\text{Stratum 5} & : \text{Inflections}
\end{align*} \]

The second solution is less elegant in that it puts affixation and compounding in the same stratum:

(111) \[ \begin{align*}
\text{Stratum 1} & : \text{Type A Causativisation and other Derivations} \\
\text{Stratum 2} & : \text{Type B Causativisation and Subcompounding} \\
\text{Stratum 3} & : \text{Cocompounding} \\
\text{Stratum 4} & : \text{Inflections}
\end{align*} \]

I shall reserve the choice between the two solutions for the next section.

Type B causativisation cannot be associated with either the cocompounding or the inflectional strata, because of the facts of tone assignment. The word melody LH is assigned to the output of the subcompounding stratum (2.1.3.). If cocompounding and type B causativisation belonged to the same stratum, the high tone would incorrectly occur at the end of the stem to which the suffix is attached, not at the end of the suffix itself,
Tone assignment ignores inflectional endings, but is sensitive to causative endings. This contrast follows from the assumption that type B causativisation takes place prior to tone assignment, and inflectional suffixation, after it. Thus, type B causativisation must be associated with a stratum prior to cocompounding and inflection.

4.6. Verbal Compounds

4.6.1. The Morphology of Verbal Compounds

Malayalam has a verbal compound construction similar to constructions like slave driver, movie goer in English:

(113) a. ambaracumbi 'sky-craper' (ambaṟam; cumbikk; cumbanam) sky to kiss kiss
     b. kutiṟapreemi 'horse lover'(kutiṟa; preemikk; preemam) horse to love love
     c. gaganacaari 'sky traveller' (gaganam; caṟikk ) sky to travel

I shall assume that these words have the structure in (114), and are generated by (115):
The ternary branching construction is chosen in preference to the possible binary branching structures in (116), because neither [N V] nor [V -i] ((117)) are possible words in Malayalam:

(116)

(117) a. * ambaracumb (ikk); * cumbi
b. * kuṭirapreem (ikk); * preemi
c. * gaganaca(a)ći (ikk); * caari

4.6.2. Nasal Deletion

Verbal compounds crucially differ from subcompounds and co-compounds. In verbal compounds ([N+V+-i]), the stem final nasal of the first stem deletes only if the second stem is of Sanskrit origin; in subcompounds and cocompounds ([N+N]), the nasal deletes irrespective of the etymology of the second stem. Nasal deletion takes place in ambaracumbi ((113a)), because cumb is of Sanskrit origin, but not in maṛaṇcaati 'tree swinger' (maṛam 'tree'; caat 'jump'), because
caat is a Dravidian verb. In contrast, deletion takes place in the [N+N] compound maraccannala 'wooden chain', even though cannala 'rope' is Dravidian. Given below are more examples which bring out the Dravidian vs Sanskrit contrast in verbal compounds:

(118) Dravidian second element

a. ṛasaṅkollī 'kill joy' (rasam ; koll )
   interest to kill
b. waĩramwizunggi 'diamond swallower' (waĩram ; wizung )
   diamond swallow
c. maanamnookki 'sky gazer' (maanam ; nookk )
   sky look

(119) Sanskrit second element

a. janadṛooḥī 'enemy of the people' (janam ; dṛooḥikk)
   people harm
b. maargadarśī 'path shower' (maargam ; darśikk )
   path see
c. matawidweesī 'religion hater' (matam ; widweesikk)
   religion hate

The nasal deletion in verbal compounds can be stated as follows:

(120) [+nasal] → Ø / —— ] [+ skt.]

Whether the nasal deletion in [N+N] compounds and in verbal compounds should be collapsed into a single rule is an issue that I will not go into. If necessary, it can be done as follows:

(121) [+nasal] → Ø / —— ] ＜+＞＜skt＞
4.6.3. The Branchingness Condition

An interesting property of verbal compounds is that the verb has to be nonbranching. Thus, i can be attached to dFrooh and cumb, but not to [[dFrooh]ikk] and [[cumb]ikk]: *janadFoohikki, *ambaFacumbikki. The verb can be a causativised one as long as the process does not create new brackets:

(122) a. Sakunammuṭakki 'ill omen' (Sakunam ; muṭaṇṇ) omen be prevented
b. piṇimurukki 'thread tightener' (piṇī; muruk) thread tighten-intr.
c. *kuppiyuṭakki (kuppi; uṭa; uṭakk) bottle break-intr. break-tr.

The restriction on the branchingness of the stem in verbal compounds parallels that in -ikk and -ipp- affixation. As in the case of -i, -ikk cannot be attached to branching structures. Now, if the attachment of -i is to treat [[dFrooh]ikk] and [[uṭa]kk] as branching structures, it follows that verbal compounding must belong to the same stratum as type B causativisation. At other strata, the internal structure of type B causativised verbs will, by the Opacity Principle, be invisible to verbal compounding, and hence, dFroohikk will not be seen as a branching structure. Given that verbal compounding and type B causativisation belong to the same stratum, our theory predicts that the brackets created at a previous stratum, such as that of type A causativisation, will be invisible to verbal compounding. This prediction is fulfilled by compounds such as kaṭamwaṛtti.
'debt bringer', in which the verb is derived through -utt suffixation: war, warutt.

Recall that we found that type B causativisation must precede tone assignment. Since verbal compounding and type B causativisation belong to the same stratum, verbal compounding must necessarily precede tone assignment. The facts confirm this prediction:

(123) a. ambaFacumbi
    L H H

b. kutiFapreemi
    L H

c. waifamwizunni

If verbal compounding, like cocompounding, followed tone assignment, we would derive the unacceptable results *ambaFacumbi, L H L H
*L H L H
*kutiFapreemi, and *waifamwizunni. There is no dialect of Malayalam in which these forms are acceptable. If there were such a dialect, Lexical Phonology would not be able to account for the facts. Thus, the actual facts are the only facts allowed by Lexical Phonology, and therefore, they confirm the validity of the theory, particularly that of the Opacity Principle.

4.6.4. The Stratum of Verbal Compounding

As observed earlier(4.5.4.), the data from type B causativisation is consistent with either (110) or (111):
Given that type B causativisation and verbal compounding must belong to the same stratum, (111) predicts that the N in \([N+V+i]\) can be a subcompound. By transitivity, subcompounding and verbal compounding must belong to the same stratum, which would predict the possibility of one being inside the other. On the other hand, (110) predicts that subcompounds cannot occur inside verbal compounds, as verbal compounds are formed at a previous stratum.

The examples in (124) show that (111) makes the right predictions for Malayalam:

(124) a. [[[paṣu]₂[kkuṭṭi]][preem]₁] 'lover of calves'
   cow child love -er

b. [[[mahaa]₂[nagāra]][waas]₁] 'dweller of a great city'
   great city dwell-er

If the N in a verbal compound can be a subcompound, it follows that it can also be a cocompound, as subcompounds and cocompounds are inputs to each other:
(125) a. [[[jaati]₃] [mat[a] [pœem]i] 'lover of caste and religion'

b. [[[striri]₃] [puɾuṣa] [widweeq]i] 'hater of man and woman'

On the basis of these facts, I conclude that Malayalam has the following stratum organisation:

(126) Stratum 1: Derivations, including type A Causativisation
    ↓
Stratum 2: Subcompounding, Verbal Compounding, and type B Causativisation
    ↓
Stratum 3: Cocompounding
    ↓
Stratum 4: Inflections
Footnotes for Chapter IV

1. In some versions of the pa language, a vowel is added to the word final consonant. Thus, bhaaskar 'a name', in this dialect, is cabhaas caka cara.

2. It must be pointed out that the \( \overline{r} \to r \) rule cannot be reversed as a \( r \to \overline{r} \) rule which applies prevocally: underlying \( r \) never becomes \( \overline{r} \).

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3. An inadequacy of this solution is that it does not explain why, in single morphemes, \( \overline{r}C \) is possible only when the \( C \) is \( y \). Thus, arkan 'sun', and bhaarya 'wife' are possible, but not \( *\)arkan and \( *\)bhaarya. One may think that this constitutes an argument against the no coda hypothesis, as (19), and not (23), accounts for both morpheme final and morpheme internal \( r \). I do not take this as a serious objection, as there exist independent restrictions on the distribution of \( \overline{r} \) and \( r \): \( dr/*dr, tr/*tr, jr/*jr, dr/*dr, \) etc. require special morpheme structure or onset structure conditions.

4. Examples with morpheme final \( r \), \( l \), and \( l \) are used because stops voice in Malayalam when they are preceded by nasals whether they are appendices or not (2.2.2.).

5. Observe that the correct stipulation on these appendices is that they are morpheme final, not word final or phrase final. The \( r \) in awarkaj ((27d)) is morpheme final, but not word or phrase final.

6. Words like nalki 'gave' and pulki 'embraced' pose a problem. The \( l \) in these examples cannot be an appendix, if appendices occur only morpheme finally ( [[nalk] i] ; [[pulk] i] ). As expected, the initial syllable in these words constitutes a guru; yet, \( k \) gets voiced. One way of explaining this would be to say that the segment is underlyingly voiced. However, the final \( i \) in these examples does not exhibit the \( \partial \) onglide which follows underlying voiced stops (see 2.2.2.). Examples like these are extremely rare, while examples in which the voicing does not apply are numerous: alpam 'a little', kalpana 'order', taalpa fryam 'interest'. Since voicing is a post lexical rule, nalki and pulki cannot be exceptions: post lexical rules do not allow exceptions. I reserve this problem for future research.
7. Appendices are ignored here for convenience of presentation.

8. See Vergnaud & Halle (1979), for the original proposal to treat epenthetic segments in Berber and Hanan in terms of the conventions of syllabification.

9. I have not done a thorough dictionary search to check my statements about possible and impossible morpheme internal consonant sequences in Malayalam, but have depended on my intuitions.

10. Since Syllable Completion would destroy the environment for Onset Fusion, it must be ordered after Onset Fusion.

11. Since syllabic r is restricted to the environment \( \{C\} \rightarrow C \), it would not be necessary to set up an underlying distinction between /r/ and /\( \tilde{r} \)/. r is assigned to the rime node just in case it occurs in the environment mentioned above.

   It may be pointed out that the ə in rəgi is phonetically [\( \ddot{a} \)], a high central vowel. This is a consequence of a late rule that raises ə when followed by a consonant: cf: [kaa\( \ddot{a} \)] 'forest', but [kaat\( \ddot{a} \)tii] 'forest fire'; [kaar\( \ddot{a} \)] 'car', [kaari\( \ddot{a} \)wannya] 'the car came', [kaar\( \ddot{a} \)... wannu].

The early stages of generative linguistics had no provision for morphology. The grammar was conceived of as a device that maps a finite set of morphemes onto an infinite set of sentences (Chomsky (1957)). Morphemes were directly mapped onto sentences: the traditional notion 'word' played no role in linguistic theory, except by way of an accidental stage in the derivation of the sentence. The basic assumption was that the principles that determine the way morphemes are put together to form words were in no way distinct from the principles that determine the way words are put together to form sentences. Consequently, word structure and sentence structure were handled by the same module of the grammar.

During this period, the lexicon was viewed as an unstructured collection of whatever was idiosyncratic and unpredictable. All phenomena which were regular and were worthy of the linguist's attention were the burden of the nonlexical components of syntax and phonology. As a result, little attention was paid to the nature of the lexicon.

With Chomsky's seminal paper, 'Remarks on Nominalization' (1970), the traditional notion 'word' came back to linguistics. Chomsky proposed that certain regular relationships between words could be expressed in terms of 'lexical rules', and that these rules were of a different nature from the syntactic rules which determined
sentence structure. A lexical rule was a redundancy rule which captured the regularities in the lexical entries, such as the relation between *destroy* and *destruction*. This was the beginning of the recognition that word structure and phrasal structure were not governed by the same set of principles, and that they belonged to different modules of grammar. The lexical entry was no longer the morpheme; it was the word.

The second significant work in this direction was Halle's 'Prologomena to a Theory of Word Formation' (1973). Halle undertook to investigate the principles governing word structure in depth, and added a new module to the grammar as part of the lexicon, namely, the word formation component. These works attributed a far richer structure to the lexicon, and focussed on the nature of lexical operations. Ever since, there has been an increasing awareness of the role of the lexicon in linguistic theory. Halle was followed by several linguists who undertook to study the organisation of the lexicon and the rules which characterise word structure: Aronoff (1974), Siegel (1974), Allen (1978), Hust (1978), Amritavalli (1980), Lieber (1980), and Selkirk (to appear), to mention a few. Several linguists recognised that the mechanism of lexical rules could be extended to handle phenomena which were previously handled in terms of syntactic transformations, such as passivisation and raising (Bresnan (1978), Brame (1978), Baker (1979)). As a result, the lexicon, and the lexical
rules, became the appropriate device for the characterisation of a great number of syntactic and semantic regularities, thereby reducing the power of the nonlexical syntactic component to a minimum.

This thesis may be viewed as an extension of the lexical approach to phonology as well, almost as a logical step in the course of the developments sparked off by Chomsky's Remarks.

Subham
### Appendix 1: Phonetic Chart for Malayalam

#### Pure Vowels

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#### Consonants

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Appendix 2: INDEX OF DRAVIDIAN AND SANSKRIT STEMS

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<td></td>
</tr>
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