Chapter 1
Introduction

1.1 Introduction
This dissertation concerns issues surrounding the phonological realization of morphemes and develops a specific model dubbed "Realizational Morphology Theory" (RMT). Natural languages express the presence of a morpheme through some phonological manifestation, but the actually attested range of such phonological instantiations is wide. They can be roughly divided into two main classes: concatenative morphology and nonconcatenative morphology. Concatenative morphology depends upon affixation where the phonological material affiliated with distinct morphemes are sequentially agglutinated, as seen in the majority of cases involved in the plural formation in English (e.g., \textit{book=books}). Thus, concatenative morphology may roughly be equated with affixational morphology. On the other hand, nonconcatenative morphology does not employ sequential concatenation of morphemes, such that the morpheme information contained in the surface form cannot be sequentially defined. The most famous and well-known example is binyan systems observed in Semitic languages like Arabic and Hebrew. [\textit{katab} 'write, perfective active', for instance, has been analyzed in generative morphology and phonology such that the entire form consists of the consonantal root \textit{ktb} and a verbal affix \textit{a(a)} (McCarthy 1979, 1981). Assuming that this view of the binyan is on the right track, the two morphemes involved in [katab] cannot be separated in a clear-cut manner since the phonological content of the two morphemes is intermingled within the word.
Besides the binyan morphology exhibiting templatic effects, nonconcatenative morphology encompasses a wider range of a-templatic morphological phenomena. They include umlaut, subtractive morphology, morphological metathesis, suppletion, mutation, morphological haplology or fusion and so forth. Despite a great degree of different appearances on the surface, these phenomena share an essential property with the kind of nonconcatenative morphology observed in Semitic languages: phonological instantiations of the morphemes essentially cannot be demarcated in the output representation. For instance, umlaut as seen in the plural formation in German is phonologically parasitic upon a stem segment rather than being independent of stem segments (e.g., Mutter=Mütter 'mother(s)'). Furthermore, part of the phonological material of the base undergoes deletion in subtractive morphology, as in the nominative formation in Lardil (e.g., [yalulu]=[yalul] 'flame'). Thus, no tangible phonological substance appears to phonologize the abstract concept denoted by the nominative morpheme. Phonological realization in nonconcatenative morphology is therefore substantially different from that involved in concatenative morphology.

Despite the superficial difference, what is shared by concatenative and nonconcatenative morphology is the fact that some phonological change appears to express the presence of a morpheme contained in the underlying representation. Given the fact that the presence of morphemes is denoted phonologically, various issues surrounding morpheme realization invoke morphology-phonology interactions.

In this dissertation, I examine how the relevant interactions should be formally captured, taking Optimality Theory (OT; Prince and Smolensky 1993) as the analytical framework. The primary goal is to achieve a comprehensive understanding of realizational morphology under the heading of RMT. Some important questions
arise in this context. First of all, what does it mean that a morpheme has some phonological exponence on the surface? Adding new phonological material to the base (i.e., affixation) is of course one possibility, but it is not the only way attested in natural languages, as can be seen from a variety of nonconcatenative morphological processes such as those mentioned above. To capture the whole range of phonological exponence of morphemes attested in natural languages, concatenative and nonconcatenative morphology must receive a unified understanding. Given that some phonological substance associated with a given morpheme is attached to the base in concatenative morphology, morpheme realization in such cases is considered to be an issue of parsing the underlying material. But how are nonconcatenative morphological operations such as umlaut, subtractive morphology and so forth to be explained? In subtractive morphology, for example, some underlying element is elided rather than added, so no phonological substance can be recognized that is associated with the relevant morpheme. Thus, the central focus will be on the examination of nonconcatenative morphology, keeping a sharp eye on formal similarities and differences of concatenative and nonconcatenative morphology. In the subsequent study of nonconcatenative morphology, I especially focus on a-templatic nonconcatenative morphology which has attracted rather less attention in the earlier literature, but the ultimate goal is to propose a model to understand concatenative and nonconcatenative morphology in a unified fashion.

As will be argued in detail in chapter 2, my central claim is that a Realize Morpheme constraint (RM) proposed and employed in various contexts in the OT literature plays a pivotal role in RTM (for preceding works involving RM, see Samek-Lodovici 1993; Akinlabi 1996; Gnanadesikan 1997; Rose 1997; Walker 1998,

Another important issue is how the exact range of morpheme realization is to be accounted for. Given both concatenative and nonconcatenative morphology (especially, a variety of phenomena subsumed under nonconcatenative morphology), it might appear at first glance that the range of actually attested phonological exponence of morphemes is not restricted. But it turns out that the range of options is quite restricted. It is an important aspect in constructing a model of realizational morphology that it does not suffer from an over-generation problem. In this light, it is important to review two influential morphological models: Item-and-Arrangement and Item-and-Process. The role of OT adopted in this dissertation becomes significant in this light because it offers an appropriate analytical device to restrict the possible range of morphological operations in a reasonable way. As I will discuss in section 1.2, Item-and-Arrangement and Item-and-Process models suffer from serious empirical and/or conceptual problems. I argue that RTM couched in the framework of OT successfully eschews such problems, motivating the necessity to frame RTM in OT.

Furthermore, what is the formal difference between purely phonological alternations and morphologically motivated phonological changes? Obviously, the difference is that the latter is sensitive to some morphological information while the
former is not, descriptively speaking, but the question is how the grammar recognizes this distinction in a formal way. Under OT, as assumed throughout this dissertation, purely phonological alternations are motivated by markedness constraints ranked over competing faithfulness constraints. This has been already fairly established in the OT literature since Prince and Smolensky (1993). On the other hand, I will claim that morphologically conditioned phonological changes are governed by RM ranked over phonological faithfulness constraints. The idea is that the high ranked morphological faithfulness constraint forces violations of phonological faithfulness constraints. There has been a long-standing debate concerning whether morphology constitutes an independent module of the grammar separated from other modules such as syntax and phonology. This issue is not addressed in this dissertation, but it is true that a system must be developed which integrates morphology and phonology to achieve a satisfactory understanding of realizational morphology. RTM, embedded in OT, provides such a model since morphological and phonological constraints interact with one another within a single constraint hierarchy.

In addition to these fundamental questions, I address more advanced issues. First, a single morpheme often possesses various nonconcatenative allomorphs. For example, Upriver Halkomelem, a Salishan language, exhibits a complementary distribution of reduplication, prefixation, vowel lengthening, and stress shift to obtain phonological denotation of the continuative morpheme. This state of affairs is not surprising given the fact that affixational or concatenative morphology displays allomorphs. The only difference is that the relevant allomorphs depend on affixation or stem modifications. The parallelism is an area that has been understudied thus far. The central question is how the formal difference should be explained, still keeping
the similarity that both concatenative and nonconcatenative allomorphs are surface phonological manifestations of a single morpheme which appear in complementary distribution. This is the topic of chapter 4.

Second, natural languages exhibit cases where a single morpheme receives two phonological exponents cooccurring in the same form. German plural formation is one such example. In the plural formation, the suffix -e or -er (phonetically, [ə]) is productively employed (e.g., [kînt]Singular≈[kînd-ə]Plural ‘child(ren)’), but umlaut often takes place on top of suffixation (e.g., [buux]Singular≈[büüç-ə]Plural ‘book(s)’). I call such examples double morphemic exponence. The primary problem is how double morphemic exponence is to be accounted for. Given many cases where phonological realization of a morpheme is achieved solely by affixation (e.g., English plural formation), it is a mystery why an additional stem modification such as umlaut is called for. I address this question in chapter 5.

Addressing the issues raised above, I claim the following major points in this dissertation:

(i) Realizational morphology in general is successfully captured by OT. Given its basis to decide the optimal output form through constraint interactions, the intricate morphology-phonology interface in realizational morphology is explained by interactions of morphological and phonological constraints. (See section 1.2 for details.)

(ii) Nonconcatenative morphology exhibits anti-faithfulness effects, which crucially needs to be distinguished from faithfulness violations incurred in purely phonological alternations. Anti-faithfulness effects cannot be handled by phonological faithfulness and markedness constraints alone. RM plays a
key role as the driving force of various nonconcatenative stem modifications such as umlaut and morphological subtraction. They are motivated by RM ranked over some phonological faithfulness constraint (i.e., RM » Faith), the specific surface realization of a morpheme depending on the specific phonological faithfulness constraint. (See chapter 2 for details.)

(iii) Natural languages exhibit two types of morphological truncation: subtractive morphology and templatic truncation. They are remarkably different because what is deleted is phonologically invariable in subtractive morphology whereas the residue remaining after deletion is constant in templatic truncation. Nevertheless, they are governed by the same fundamental ranking: RM » Max. The difference is gained by the absence/presence of a set of prosodic markedness constraints that jointly require outputs to take a certain prosodic shape. If such constraints outrank Max, templatic truncation obtains while they do not dominate Max in subtractive morphology. (See chapter 3 for details.)

(iv) A single morpheme often shows allomorphs that are not affixational (e.g., metathesis and subtractive morphology are in complementary distribution). Such nonconcatenative allomorphs are best considered as languages' effort to minimize the markedness value of the overall word. Unlike affixational allomorphs, nonconcatenative allomorphs are more global since the overall word shape is taken into consideration. Nevertheless, they are governed by the same fundamental mechanism as affixational allomorphs in the sense that the least marked allomorph is chosen as the optimal one. (See chapter 4 for details.)
(v) Morphemes are often phonologically manifested by two surface exponents (double morphemic exponence), as in the plural formation in German. In double morphemic exponence, some stem change is invoked in addition to affixation. Sympathy theory, as proposed by McCarthy (1999), plays a central role in capturing those cases. Double morphemic exponence takes place because the affix is made invisible or opaque for the computation of RM satisfaction/violation, and therefore, some independent morpheme realization is called for, an effect dubbed here “morphological opacity”. This is formally implemented by establishing Stem≡PrWd as the selector constraint which demands the coextensiveness of a stem and the prosodic word. (See chapter 5 for details.)

(vi) Anti-faithfulness theory, as developed by (Alderete 1999), is seemingly attractive given the fact that nonconcatenative morphology exhibits anti-faithfulness effects. But it is not a viable theoretical device to capture the range of phenomena discussed here since it suffers from a number of empirical and conceptual problems while RTM overcomes them. (See the overall dissertation, section 2.5 in particular.)

In addition to these major claims, a number of theoretical questions and consequences are discussed in various portions of this dissertation. To close this section, I map out the organization of the rest of this chapter. In section 1.2, I review two morphological models proposed by structural linguists: Item-and-Arrangement and Item-and-Process. They are both concerned with how word formation should be viewed. I discuss strengths and weaknesses of each model, claiming that neither model is satisfactory as a general theory of realizational morphology. In this context,
I argue that OT provides an analytical tool suitable to understand it more plausibly. In section 1.3, I briefly review the framework of OT assumed throughout this dissertation. OT has undergone numerous development since the original proposal made by Prince and Smolensky (1993), but I restrict my review to three issues of relevance here: basic mechanisms to obtain outputs, correspondence theory (McCarthy and Prince 1995), and sympathy theory (McCarthy 1999). Finally, section 1.4 closes this chapter by discussing the overall organization and a brief synopsis of this dissertation, fleshing out what was discussed in this section more concretely.

1.2 Overview of Morphological Models

Affixation or additive morphology is undoubtedly the most productive, and therefore, the most widely attested morphological process across languages. This is because morphologically richer information is generally conveyed by the attachment of one or more affixes: the more complex the morphosyntactic information is, the more additional morphemes are employed. For example, in English, a singular noun is normally taken as the base of its plural form, and the latter is derived with an additional suffix -s. The principle that semantically more implies morphologically more is called *constructional iconicity* or *diagrammaticity* (Dressler 1987; Spencer 1991). Since Bloomfield (1933), it was a widely accepted view by structural linguists that word formation is agglutinating. This morphological model, called Item-and-Arrangement (henceforth, IA), has the following properties (Hockett 1954:214): (i) A linguistic form is either simple or composite, (ii) a simple form is monomorphemic, and (iii) a composite form consists of two or more immediate constituents, each of which occupies a certain position in the construction. Under the IA model, a
morpheme is viewed as a morphologically indivisible primitive atom, and every kind of word formation consists exclusively of concatenation of morphemes. Given that prefixation and suffixation are highly productive crosslinguistically, the IA theory would be a successful approach to predominant word formation processes.

But it is by no means the case that additive or concatenative morphology is the only morphological operation observed in human languages. A variety of problems flow from the principle of morphemic structure in IA when a full range of word formation phenomena attested in natural languages is considered. Root-and-pattern morphology advanced by McCarthy (1979, 1981) is one such example (cf. Harris 1941 for earlier insights, and Chomsky 1951 for a transformational account for the phenomenon). Semitic languages like Arabic and Hebrew exhibit interdigitation of more than one morpheme within a word. In the verbal morphology paradigm in Arabic, for instance, [katab] 'write, perfective active' consists of a root ktb and a verbal affix a(a). They are arranged in such a manner that the root consonants and the affixal vowels are intermingled with one another rather than being concatenated linearly. Because the segments of the two morphemes are interspersed, their precedence relation cannot be sequentially defined. This kind of word formation (so-called nonconcatenative morphology) poses a serious challenge to the IA theory.

A similar line of argument against IA can be provided by infixation, circumfixation, and probably also discontinuous morphemes at a phrasal or sentential level discussed by Harris (1945), because morphemes are not continuous in these cases. Another problem comes from truncation, a morphological phenomenon widely discussed since the emergence of prosodic morphology (McCarthy and Prince 1986 et seq.). This is a theory aimed at explaining how morphological and phonological
determinants of linguistic form interact with each other in a grammatical system. This theory made a significant contribution to morphology-phonology investigations in the sense that it offered an explicit theory of analyzing morphological operations in terms of prosodic units. Prosodic circumscription (McCarthy and Prince 1990), a further development of extrametricality and an important subcomponent of prosodic morphology, provided a powerful tool for analyzing morphological phenomena (e.g., infixation) from a prosodic perspective. Prosodic circumscription is of significant importance in the sense that it uncovered that morphological operations are often phonologically conditioned in a systematic way. Truncation is one such morphological phenomenon and invokes clipping of part of a base, so the idea of constructional iconicity or diagrammaticity is completely subverted here. These observations together seriously endanger the empirical plausibility of the IA model.

Along the same lines, other morphological operations which crucially depend on non-affixation provide further rich empirical evidence against the IA theory. Such phenomena include subtractive morphology, metathesis, vowel changes (i.e., ablaut, umlaut, and suppletion), haplology (fusion), and suprasegmental changes (i.e., stress and tone shifts). These nonconcatenative phenomena do not contain a clearly identifiable morph, because they involve deformation of a base rather than any addition of phonological substance. Especially, subtractive morphology does the opposite of morpheme concatenation: deletion of part of a base. Compared with affixation, the nonconcatenative morphological processes are far less productive across languages, but they constitute strong empirical data against the IA view of structuralism that all morphemes are indivisible atomic units composed of phonological strings whose linear arrangement creates words.
The argument above indicates that morphological processes cannot be exclusively characterized in terms of concatenation, and has led a number of researchers to criticize IA (Nida 1948; Hockett 1947, 1950, 1954; Janda 1984; Anderson 1988, 1992). An alternative view regards word formation as consisting of a set of processes. This is a model known as Item-and-Process (henceforth, IP) theory. Its properties are encapsulated as follows (Hockett 1954:227): (i) A linguistic form is either simple or derived, (ii) a simple form is a root, and (iii) a derived form consists of one or more underlying forms to which a process has been applied. Under this approach, a certain morpheme does not have to contain any phonologically tangible substance, because word formation is considered as a set of transformations. In nonconcatenative morphology, the IP model applies a rule to a base to obtain the surface representation. In concatenative morphology, on the other hand, a rule attaches a morpheme to an already existing form. Thus, the IP theory can capture a wider scope of data than the IA theory.

This seems to strongly suggest the superiority of IP over IA. The IP model has its own potential problems, however. As pointed out by Anderson (1992:63), IP is potentially less restrictive than IA. He argues that we run the risk of weakening the whole theory if various morphological processes other than the limited class of rules of simple affixation are admitted. In other words, we expect that, without proper delimitation of the power of possible transformations, any kind of morphologically conditioned phonological operation is observed somewhere as long as they can be formulated as transformational rules. However, a language is unlikely to exist which, for example, metathesizes onset consonants and the rime regularly in all syllables to express a morphosyntactic category (e.g., /C_1V_1C_2C_3V_2/ → [V_1C_2C_1V_2C_3]), despite the
fact that the relevant transformational rule can be easily written. Similar unlikely morphological processes can be easily multiplied. This indicates that the IP model suffers from conceptual and empirical problems while the IA model has empirical difficulties. Hockett (1954) concludes that the two theories are both unsatisfactory.

This overview would suffice to highlight the fact that the nature of word formation has not received unanimous understanding. At a more fundamental level, the question is what morphemes are. It is evident from the controversy aroused between IA and IP that a satisfactory answer cannot be found by looking at additive or concatenative morphology alone. Thus, a comprehensive examination of the overall range of morphological phenomena needs to be done, crucially considering how nonconcatenative morphological operations are implemented.

The emergence of the derivational version of generative morphology and phonology has aroused debate concerning the formal treatment of nonconcatenative morphological processes. In the linear model originated by SPE (Chomsky and Halle 1968), reduplication was handled by a set of transformational rules to copy a string to the left, to the right, or in the middle of the base (Aronoff 1976; Carrier 1979; Lieber 1981). But this is again subject to the criticism of unrestrictiveness. Subsequently and alternatively, reduplication was seen as affixation where what is affixed is a CV skeleton or prosodic template (Marantz 1982). By reducing reduplication to affixation, the fear of permitting any random transformation would be avoided. Furthermore, umlaut as observed in German, for instance, was dealt with in such a way that there is a front vowel suffix /-i/ or a floating feature [-back] in the underlying representation as the trigger of the umlaut process. Various other morphological processes might receive a similar treatment potentially, but such
derivational accounts would not yet be able to handle subtractive morphology. Floating features are a very abstract and extremely powerful device as the trigger of phonological changes, but how would subtractive morphology be derived in a principled manner? Given deletion of part of the base, there would be no possible way to represent the relevant trigger in terms of an affix or floating feature. This shows that even fairly articulated derivational approaches are not satisfactory either.

In this dissertation, I claim that OT offers an appropriate analytical vessel. Martin (1988) observes that the range of phonological changes involved in morphological phenomena is exactly the same as that found in purely phonological phenomena. This is a natural state of affairs given the fact that the presence of morphemes is denoted phonologically. As briefly mentioned in the preceding section and fleshed out in more detail later, nonconcatenative morphological effects are obtained through RM » Faith. As will be reviewed in section 1.3.2, the range of universal faithfulness constraints has been quite established since the emergence of correspondence theory (McCarthy and Prince 1995). Adopting correspondence theory embedded in OT thus provides a way to understand the parallelism between morphologically motivated phonological changes and purely phonologically defined ones. RTM couched in the framework of OT overcomes empirical and conceptual problems encountered by IA and IP. The specific phonological manifestation of a morpheme is the outcome resulting from constraint interactions.

An important implication is that whether morphemes are sequentially arranged or not does not matter for the grammar. Under the RMT model developed here, RM plays a central role, and its definition will be formulated in such a way that strict linear order of morphemes does not play any role. This means that the crucial
empirical problem of the IA model arising from the view that morphemes are sequentially divisible is avoided in RTM. Moreover, RTM eschews the serious over-generation problem of the IP model. While the kind of transformational operations postulated in the IP model is not constrained because the possible range of processes is not restricted, the range of possible morphological operations can be intrinsically limited in RTM by assuming exactly the phonological faithfulness constraints that seem to have been established in the OT literature. In effect, RTM provides a model of realizational morphology which encompasses exactly the range of phonological realization of morphemes attested in natural languages.

1.3 Theoretical Framework
As stated, RTM is framed in Optimality Theory (OT; Prince and Smolensky 1993). In this section, I provide a brief overview of this framework. This section consists of three portions. In section 1.3.1, I provide a description of some essential theoretical architecture of OT. The other two parts are concerned with two sub-theories: correspondence theory advanced by McCarthy and Prince (1995) (section 1.3.2) and sympathy theory proposed by McCarthy (1999) (section 1.3.3). Correspondence theory, a theory on faithfulness constraints, plays a central role throughout this dissertation whereas sympathy theory is of relevance in chapter 5.

1.3.1 Optimality Theory
The elementary theoretical design of OT (Prince and Smolensky 1993) consists in constraint interactions and constraint violability. Going back originally to SPE (Chomsky and Halle 1968), earlier generative phonological theories view the output
production as a result of applying a series of rules (and inviolable representational constraints such as the OCP and repair strategies) to a given input. Such derivational models maintain serialism from the input to the output, going through a number of intermediate representations, as schematized in (1).

(1)  Derivational Theory

\[
\begin{array}{c}
\downarrow & \downarrow & \downarrow & \downarrow \\
\text{Rule}_1 & \text{Rule}_2 & \text{Rule}_3 & \text{Rule}_n \\
/\text{Input}/ & \rightarrow & \text{Form}_i & \rightarrow \text{Form}_j & \rightarrow \text{Form}_k & \rightarrow \ldots \rightarrow [\text{Output}]
\end{array}
\]

OT departs from derivational models in a number of respects. First, the OT grammar contains no rules or repair strategies. Rather, the essential ingredient producing outputs is universal constraints. Second, the output production is parallel in the OT grammar, meaning that there is no intermediate representation between the input and the output. Third, constraints are potentially all violable, and even the eventual output may violate them.

The OT grammar consists of three components: Gen, Con, and Eval (Prince and Smolensky 1993). Gen is a function that generates a potentially unlimited number of output candidates. The candidates yielded by Gen differ in the degree of the similarity to the given input, and they may take any form as long as they conform to the primitive structural restrictions that are never infringed upon universally, the principle known as inclusiveness (McCarthy and Prince 1993b:1). Con is a pool containing a set of constraints. Constraints are considered to be universal, so no language-specific constraint is admitted. All systematic differences among languages are explained through different constraint rankings. Constraints are ranked with respect to their importance, and each language has its own constraint hierarchy distinct from all others. Finally, Eval is responsible for choosing an ultimate output
for a given input against the given constraint ranking. Eval evaluates comparative
well-formedness of all candidates, and the most harmonic one is selected as the
winner (i.e., the output). Since constraints are all violable, the best candidate does not
have to satisfy all. Rather, it must be the most harmonic with respect to the ranked
constraints. The OT grammar is schematically shown as in (2).

(2) **OT grammar**

\[
Gen(\text{Input}_i) \rightarrow \{\text{Cand}_1, \text{Cand}_2, \ldots, \text{Cand}_n\} \\
Eval(\{\text{Cand}_1, \text{Cand}_2, \ldots, \text{Cand}_n\}) = \text{Output}_{\text{Real}}
\]

The function of Eval is visually illustrated in the form of tableau, as in (3).

(3)

<table>
<thead>
<tr>
<th>/Input/</th>
<th>Constraint$_1$</th>
<th>Constraint$_2$</th>
<th>Constraint$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Candidate$_1$</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b.</td>
<td>Candidate$_2$</td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Candidate$_3$</td>
<td>*!</td>
<td></td>
</tr>
</tbody>
</table>

Suppose that Candidate$_1$ through Candidate$_3$ are generated by Gen, and the job
of Eval is to select the optimal form. In (3), constraints are ranked in the order of
importance from left to right, meaning that Constraint$_1$ and Constraint$_3$ are the most
and the least important, Constraint$_2$ in-between. First, Candidate$_3$ violates the most
important constraint, and therefore, it is ruled out from the competition first of all.
Between the remaining two candidates, Candidate$_1$ is more harmonic since it violates
only Constraint$_3$ which is ranked beneath Constraint$_2$ violated by Candidate$_2$.
Constraints are violable, and indeed, the best form violates a constraint here. But the
ranking is strict in the sense that any number of violations of lower ranking
constraints does not make up for a violation of a higher ranking constraint. The set of
constraints is universal, but their ranking is not. Thus, the failed candidates in (3) can be chosen as the optimal form in other languages depending upon a permutation of the ranking. In this simple example, any of the three candidates appears as the winning form depending on which constraint is ranked the lowest. If Constraint$_2$ is ranked below Constraint$_1$ and Constraint$_3$, Candidate$_2$ emerges, while Candidate$_3$ is opted for if Constraint$_1$ is dominated by Constraint$_2$ and Constraint$_3$. The winner expected by Eval is indicated by a pointing finger. Stars indicate constraint violations, and exclamation marks show that the relevant constraint violations are fatal. Finally, shading shows that the satisfaction/violation in the cell is irrelevant to the selection of the eventual output form.

### 1.3.2 Correspondence Theory

Throughout this dissertation, correspondence theory, as proposed by McCarthy and Prince (1995), plays an essential role. OT constraints are largely grouped into two classes: markedness constraints and faithfulness constraints, and correspondence theory concerns the latter. Markedness constraints solely penalize phonologically marked structures or representations, but faithfulness constraints demand two corresponding structures or representations to be identical. Any conceivable elements (i.e., segmental, subsegmental, and suprasegmental) stand in correspondence, and identity of those elements is computed in various dimensions, including input-output (Faith-IO), output-output (Faith-OO), base-reduplicant (Faith-BR), and base-truncatum (Faith-BT). Following McCarthy and Prince (1995:262), correspondence of strings is defined as in (4), where $S_1$ and $S_2$ refer to an element belonging to two dimensions. The idea of correspondence is applied to subsegmental (featural) and
suprasegmental (prosodic) elements as well, indicating that $S_1$ and $S_2$ in (4) may be any phonological element.

(4) Given two strings $S_1$ and $S_2$, correspondence is a relation $\mathcal{R}$ from the elements of $S_1$ to those of $S_2$. Elements $\alpha \in S_1$ and $\beta \in S_2$ are referred to as correspondents of one another when $\alpha \mathcal{R} \beta$.

Specific faithfulness constraints in correspondence theory are listed in (5) (McCarthy and Prince 1995:370-372). They prohibit divergence of correspondents in various dimensions.

(5) a. Max
   Every element of $S_1$ has a correspondent in $S_2$.

b. Dep
   Every element of $S_2$ has a correspondent in $S_1$.

c. Ident-[F]
   Correspondent segments have identical values for the feature F.

d. Contiguity
   The portion of $S_2$ standing in correspondence forms a contiguous string.

e. {Left/Right}-Anchor($S_1, S_2$)
   Any element at the designated periphery of $S_1$ has a correspondent at the designated periphery of $S_2$.

f. Linearity
   $S_1$ is consistent with the precedence structure of $S_2$, and vice versa.

g. Uniformity
   No element of $S_2$ has multiple correspondents in $S_1$.

h. Integrity
   No element of $S_1$ has multiple correspondents in $S_2$.

Max and Dep are constraints which militate against deletion and epenthesis respectively. Thus, given /pit/ as the input, for instance, [pi] violates Max because the final segment /t/ is deleted in the output whereas [pitu] violates Dep by virtue of the fact that the final segment [u] has no correspondent in the input.
Ident-[F] demands complete identity of featural values of correspondents. [F] is a variable replaced by various concrete features such as [voice] and [coronal]. For example, [pid] violates Ident-IO-[voice] given that /pit/ is the input and that the final output segment [d] is the correspondent of /t/ in the input.

Contiguity requires that the linear order of input elements be preserved in the output representation. McCarthy and Prince (1995) distinguish two types of Contiguity constraints (i.e., I-Contiguity against skipping and O-Contiguity militating against intrusion), but this distinction is not important in the subsequent discussion. Contiguity defined in (5d) corresponds to O-Contiguity in McCarthy and Prince's (1995) terms, and this is what is relevant in this dissertation. It militates against any intrusion and is violated by forms such as [piat] for the input /pit/ since /i/ and /t/ contiguous in the input are not contiguous in the output because of the presence of an intervening segment [a].

Anchor requires that the element occupying either edge appear at the same edge in the output. Given prefixal monosyllabic reduplication and the input /pit/, [pi-pit] satisfies Anchor-L in the base-reduplicant dimension because the left edge segment in the reduplicant (i.e., [p]) occupies the left edge of the base as well. But [i-pit] violates Anchor-L since the left edge segments of the reduplicant and the base are not the correspondents of each other.

Linearity is a constraint which bans metathesis since it dictates that precedence relations in the input must be preserved in the output. Thus, for the input /pit/, forms such as [ipt] and [pti] infringe on Linearity since the sequential relations holding among the three input segments are not completely preserved.
Finally, Uniformity and Integrity are mirror-imaged constraints. Uniformity bans a configuration where a single output element has more than one correspondent in the input (i.e., no coalescence) whereas Integrity prohibits more than one output element from corresponding to one and the same input element (i.e., no breaking). For example, for /pi,a,t/, [pe,a,t] violates Uniformity since two input vowels share a single segment as their correspondent. By contrast, Integrity is violated by [pi,a,t] for the input /pe,t/ because two output segments have one and the same input segment as their input correspondent.

1.3.3 Sympathy Theory

Finally, I review sympathy theory which will play a central role in chapter 5. It is a sub-theory of OT advocated by McCarthy (1999) to handle phonological opacity (Kiparsky 1971, 1973). In this section, I review the fundamental mechanism of the theory and introduce technical terms employed in chapter 5. Among others, McCarthy discusses Tiberian Hebrew in which the interaction of -epenthesis and -deletion exhibits phonological opacity (Malone 1993). The former operates to epenthesize a vowel e between word-final consonants whereas a glottal stop undergoes deletion in the syllable coda. In derivational terms, this is illustrated in (6).

(6) a.  
\[ \emptyset \rightarrow V/C\_C\# \]  
(e.g., /melk/ \(\rightarrow\) [melek] 'king')

b.  
\[ ? \rightarrow \emptyset /_\]  
(e.g., /qara?/ \(\rightarrow\) [qara] 'he called')

These rules potentially interact with each other in a counter-bleeding manner, as shown in (7). The rule relation is counter-bleeding since -deletion, if applied first, destroys the environment of -epenthesization. Under parallel OT, this is problematic.
because the surface representation does not have any justification to have the
epenthized vowel by virtue of the fact that it does not contain a consonant cluster
word-finally. In McCarthy's terms, this state of affairs is called "non-surface-
apparency".

(7) Underlying representation: /deʃʔ/
e-epenthesis: deʃɛ
-epenthesis: deʃ
Surface representation: [deʃe]

The problem here becomes clearer given the following consideration. The
fact that e-epenthesis occurs to break up a consonant cluster motivates *Complex »
Dep-V. Furthermore, a syllable-final glottal stop is prohibited, and therefore,
CodaCond (i.e., *ʔ) is assumed to be ranked over Max-C. As demonstrated in (8),
this ranking provides a surface transparent candidate (i.e., [deʃ]) as the winner,
contrary to fact. This form is better than [deʃe] (the desired winner marked by §)
since the latter incurs an excrescent constraint violation in Dep-V. Comparing (8b)
and (8d), the latter is harmonically bounded by the former in the sense of Prince and
Smolensky (1993:176-178), and no ranking permutation ameliorates the situation.

<table>
<thead>
<tr>
<th></th>
<th>/deʃʔ/</th>
<th>CodaCond</th>
<th>*Complex</th>
<th>Max-C</th>
<th>Dep-V</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>deʃʔ</td>
<td>*!</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>☞</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>deʃɛʔ</td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>☉</td>
<td></td>
<td></td>
<td>*</td>
<td>*!</td>
</tr>
</tbody>
</table>

The innovative proposal made by McCarthy (1999) is that OT has a system to
evaluate correspondence between candidates (inter-candidate correspondence) in
addition to other various correspondence relations such as input-output, base-reduplicant and so forth. Descriptively, the fact that epenthesis takes place in the eventual output is motivated by the fact that it imitates the epenthetic property of *de/ea*, an intermediate representation in the derivational sense. On the other hand, *de/ea* does not share this property with *de/ea*, and this is exactly the fatal fault of the transparent candidate. This intuitive idea is formally implemented through the notion of sympathy.

The initial step is to grant special status to *de/ea* (called sympathy candidate) although it loses the competition because of its violation of CodaCond. The sympathy candidate is chosen by a designated constraint called selector constraint. The sympathy candidate is selected among the candidates which satisfy the selector constraint. Among those forms, the most harmonic one with respect to other constraints is selected as the sympathy candidate. In Tiberian Hebrew, Max-C serves as the selector constraint, which is marked by ❀. Considering (8), only (8a) and (8c) satisfy Max-C, and the latter is more harmonic with respect to other constraints since (8a) violates *Complex which is satisfied by (8c). Since all other candidates violate the selector constraint, the violation of high ranked CodaCond does not matter for the purpose of choosing the sympathy candidate.

The next step is to determine the constraint which forces correspondence of all candidates with the designated sympathy candidate, again marked by ❀. Because (8b) and (8d) are discriminated by whether an epenthetic vowel is present or not, the relevant constraint is Max-❖O-V. This constraint requires all candidates to possess correspondents of all vowels of the sympathy candidate. This constraint is satisfied by (8d) but is violated by (8b). As demonstrated in (9), this sympathy proposal
succeeds in selecting the desired candidate as the optimal form, eschewing the problem caused by harmonic bounding. In effect, the actual output is made optimal by virtue of the fact that it is sympathetic for a particular failed candidate through an inter-candidate correspondence constraint.

<table>
<thead>
<tr>
<th></th>
<th>/deʃ?/</th>
<th>CodaCond</th>
<th>*Complex</th>
<th>Max-ØO-V</th>
<th>*Max-C</th>
<th>Dep-V</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>def?</td>
<td>!</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>def</td>
<td></td>
<td></td>
<td>!</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>deʃe?</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>d.</td>
<td>deʃe</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

1.4 Organization

The rest of this dissertation consists of five chapters. Chapter 2 outlines Realizational Morphology Theory (RMT). RMT accounts for the mechanism behind phonological realization of morphemes in general. Putting special focus on a-templatic nonconcatenative morphological processes, I argue that they exhibit anti-faithfulness effects (cf. Alderete 1999) and show that regular faithfulness and markedness constraints are not sufficient to explain them in OT. I develop a model in which RM plays an essential role. Although RM has been used in various contexts in the earlier literature, I significantly expand the role of the constraint and provide a formal definition. I argue that interactions of RM and faithfulness constraints are of central importance in understanding realizational morphology. Furthermore, I discuss anti-faithfulness theory (Alderete 1999) as an alternative possibility. I will claim that it is not a viable possibility for various empirical and conceptual reasons.
Chapter 3 is devoted to the implementation of RTM in truncatory morphology. Natural languages exhibit two types of morphological truncation: subtractive morphology and templatic truncation. The most significant difference is what remains constant. In subtractive morphology, what is deleted is constant, and therefore, the phonological size of the residue varies depending of the length of the base, but the residue remains prosodically constant in templatic truncation. I will claim that both types of truncation are governed by the same underlying principle (i.e., RM » Max). The only difference is whether Max is dominated by a set of prosodic constraints restricting the phonological size of the entire output. If such constraints exist, templatic truncation emerges while subtractive morphology obtains otherwise. Concerning subtractive morphology, I examine a number of examples which have received various different analyses in derivational and constraint-based terms. I demonstrate that they are all explained by the same ranking schema (i.e., RM » Max) and discuss its superiority to earlier approaches.

Chapter 4 deals with multiple nonconcatenative allomorphs, cases where allomorphs are nonconcatenative rather than affixational. I maintain that they are governed by the same driving force as affixational allomorphs. The plural morpheme -s in English, for instance, takes three allomorphs, but their distribution is regulated by phonological conditions. In OT terms, this is because some relevant markedness constraint is ranked over relevant faithfulness constraints. I propose that the same holds of nonconcatenative allomorphs: the choice of a particular nonconcatenative allomorph is languages' effort to optimize the overall harmony of the word, decreasing phonological markedness. However, the phonological environment to be considered is more global than affixational allomorphs in the sense that the overall
word shape affects the selection of nonconcatenative allomorphs. This is not true of the allomorphemic alternation of the plural morpheme -s, since only the stem-final segment is pertinent.

Chapter 5 is devoted to the investigation of cases where a single morpheme enjoys two phonological exponents (i.e., double morphemic exponence). More specifically, I address why and how some stem modification (e.g., umlaut) is required in addition to affixation given the crosslinguistic fact that affixation is frequently enough to denote the concept of the idea of a morpheme in the surface representation. I propose that sympathy theory plays a pivotal role in this context and develop the idea that I call morphological opacity. The idea is that the affix contained in the underlying representation is made invisible for the purpose of satisfying RM through Stem≡PrWd (the stem domain must coincide with a prosodic word domain) that serves as the selector constraint. The net effect is that the whole affixational category is made opaque. The sympathy candidate is the one which undergoes some stem modification under duress of RM. The stem modificational property is inherited by the ultimate output form through a relevant Faith-ราม. Parsing of the affixal element is required by high ranked Max-IO, obtaining two phonological exponents for a single morpheme.

Throughout these chapters, RM plays a pivotal role. Finally, this dissertation is closed by a brief summary of the main results of the investigation carried out in this dissertation (Chapter 6).