The Theory of Faithfulness

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1 Introduction: Faithfulness with and without OT

1.1 A preliminary definition

The term 'faithfulness' has been introduced into phonology by Prince & Smolensky (1993) and McCarthy & Prince (1993), and it has become one of the cornerstones of Optimality-Theoretic analysis. It is usually assumed within Optimality Theory (OT) that grammars consist of two types of constraints: markedness constraints, requiring the output to have some 'optimal' shape and faithfulness constraints which require the outputs not to differ unnecessarily from the inputs. Faithfulness constraints keep the markedness constraints in balance; even though it can also happen that markedness constraints conflict

among themselves, the most common type of conflict is one between a markedness constraint and a faithfulness constraint. For instance if the input is /CVC/, the following three constraints are relevant:

(1) a. NOCODA: Syllables should not end in a consonant.
b. PARSE-C: Do not delete consonants.
c. FILL-V: Do not insert vowels.

NOCODA is an obvious markedness constraint, requiring outputs to have open syllables only. If it were on its own in the phonological universe, all languages would do anything to avoid consonants. Inputs /CVC/ would be turned into outputs [CVCV] or [CV] everywhere.

OT exists because constraints like NOCODA are not alone in the phonological universe. The faithfulness constraints PARSE-C and FILL-V serve two functions:

1. They are used in the description of languages in which words do not obey the universal markedness constraint.
2. They are used to describe which strategy is chosen if a language does obey the markedness constraint and underlying representations do not conform to it.

On the one hand faithfulness constraints make sure that NOCODA is counterbalanced in some languages, so that they have coda's. In this case we have PARSE-C, FILL-V ≫NOCODA:

(2)

/tat/	PARSE-C	FILL-V	NOCODA
ta	*!		
☞tat			*
ta.ta		*!	

The second function is to decide which strategy is chosen in a language which does not allow coda's: deletion of onsets or deletion of coda's. This strategy is famously dependent on the relative ordering of the faithfulness constraints which are involved. One ordering favours CVC → CV, the other CVC → CVCV:

(3) a.

/tat/	NOCODA	FILL-V	PARSE-C
☞ta			*
tat	*!		
ta.ta		*!	

b.

/tat/	NoCoda	Parse-C	Fill-V
ta		*!	
tat	*!		
☞ta.ta			*

The examples I have just given are standard examples of the way in which OT works, and you can find them in any textbook on this topic (Kager, 1999a). People therefore tend to think that faithfulness is a notion that is specific for OT. But in a sense the notion has been an important one for generative phonology during all of its history. The issue arises in every theory which has more than one level of representation, and in which a mapping has to occur.

Definition 1 (Faithfulness) *Suppose $<\mathscr{R}_1, \mathscr{R}_2>$ are linguistic representations, which are linguistically related.* Faithfulness *requirements are requirements that force $\mathscr{R}_1$ and $\mathscr{R}_2$ to be identical.*

This definition is very imprecise; it depends on two notions which are themselves in need of definition: *linguistically related* and *identical*. With respect to the former, we will assume for now that this is defined by a derivational relationship (one form is derived from the other); furthermore, in this class we will only consider pairs of representations where $\mathscr{R}_1$ is an underlying form, i.e. a lexical representation and $\mathscr{R}_2$ is the output of phonology, i.e. a phonetic representation. We will see in later chapters that there probably are no researchers who restrict faithfulness to this situation; but it nevertheless constitutes the core of the theory.

1.2 Faithfulness in SPE

If we restrict our theory in this way, it becomes immediately apparent that the notion 'identity'/'identical' is not without its problems. Lexical representations are presumably cognitive (phonological) objects and as such they are essentially different from the perceptual/articulatory objects which are found at the interface with the phonetics. This is also at the core of Noam Chomsky's criticism of OT, as he has formulated it e.g. in Chomsky (1995, p. 380, footnote 5):

> [McCarthy & Prince (1994)] recognize the need to add input-output relations of some kind ("faithfulness"). Traditional approaches, dating back to Pāṇini and revived in generative phonology from the late 1940s, spell out "faithfulness" in terms of the notion "possible phonological rule" (embodying assumptions about natural processes) and economy considerations on the system of

> rules (evaluation metrics, markedness considerations, etc.) McCarthy & Prince (1994) propose that "faithfulness" be restricted to input-output conditions, but what they suggest seems to have no relevance to the standard problem (e.g., "identity between input and output", a principle that is virtually never satisfied). The basic problem, long familiar, is the one mentioned earlier: crucial properties appear to hold not of input-output pairs but of intermediate stages, so that no input-output condition is formulable.

Two problems are mentioned in this quote. The first is the problem of *Opacity*: we need extra representations ('intermediate stages') beyond input and output. This is a problem specific to so-called parallel OT, which does not recognize these intermediate stages; we will return to this in chapters 7 and 6 below. The second issue I will call Chomsky's problem:

☞ *Chomsky's Problem*: Input and output of a phonological derivation are different objects by definition; therefore conditions on their identity cannot take effect.

In order to understand this line of reasoning, it is useful to go back to the *Sound Pattern of English* (Chomsky & Halle, 1968, § 4.2, p. 164-170), the culmination point of classical generative phonology. Within this theory, the phonological component of the grammar accepts something which is called the 'phonological matrix' and outputs something called the 'phonetic matrix'. Each of these matrices can be seen as a table, where the rows stand for features and the columns for individual segments. The following serves as an example of phonetic matrices for the English word *inn* and *algebra*:

(4)

inn	i	n
consonantal	-	+
vocalic	+	-
nasal	2	+
tense	-	-
stress	1	-
voice	+	+
continuant	+	-

algebra	a	l	g	e	b	r	a
	-	+	+	-	+	+	-
	+	+	-	+	-	+	+
	-	-	-	-	-	-	-
	-	-	-	-	-	-	-
	1	-	-	4	-	-	4
	+	+	+	+	+	+	+
	+	+	-	+	-	+	+

Chomsky & Halle (1968) write: "In the case of the phonetic matrix, each row corresponds to a phonetic feature, physically defined, from a predetermined initial set. The entry occupying a particular square of the matrix will be an integer specifying the degree to which the segment in question is characterized by the corresponding property." This means that the + and - in the above table are actually already abstractions from the real phonetic matrix. The number 2 for nasality in the vowel in *inn* (indicating partial nasality) as well

as the numbers for stress are more realistic.[1]

In the case of the phonological matrix, on the other hand, "each square represents simply a pair of opposed categories, to at most one of which the formative may belong. A + in this square indicates membership of the formative in one of these categories; a -, membership in the other, complementary category; a 0 indicates simply that no information is given for the formative in question concerning membership in these categories." Thus we will only find one of these three items in every cell, no numbers. Furthermore, as many cells as possible are assigned a 0 (indicated below by a blank). The words *inn* and *algebra* get the following matrices:

(5)

inn	i	n
consonantal	-	+
vocalic		
nasal		+
tense	-	
stress		
voice		
continuant		

algebra	a	l	g	e	b	r	a
	-	+	+	-	+	+	-
		+	-		-	+	+
			-		-		
	-			-			-
			+		+		
			-		-		

If we compare (5) to (4), we may observe that the latter is in some intuitive sense a 'submatrix' of the former (if we replace certain integers by + and others by -). Chomsky & Halle (1968) formulate a condition of invariance:

Definition 2 (Invariance) *Suppose that a certain formative meets the following condition: the phonological matrix given in its lexical entry is a submatrix of the phonetic matrix corresponding to it, in each context in which it occurs. In this case, we may say that the formative in question meets* the condition of "invariance." *(We can also extend the definition of invariance, in the obvious way, to the case of a particular segment of the formative.)*

Invariance is a weak version of faithfulness: it states that everything which is in the input should also be in the output. Nevertheless, "there is no hope for any condition on invariance that will relate phonological and phonetic matrices" (if it were true, the task of phonology would be a rather boring one, filling in the empty gaps in the phonological matrix). We can see this if we look at the word *algebraic*. The final vowel of *algebra* is [+tense] in this word, in spite of its being necessarily specified as [-tense] in (5). Thus we have the following rule:

[1] One could of course debate whether the values for phonetic matrices should be restricted to integers, or whether real numbers should also be allowed but that is beyond the present discussion.

(6) V → [+tense] / ___ V

Because this rule changes a feature value (rather than just adding one), the phonetic matrix of *algebra* in *algebraic* thus is substantially different from its phonological matrix. Invariance thus is not met.

Chomsky & Halle have another example which is more radical still, involving pairs such as *reciprocal-reciprocity - frivolous-frivolity - demon-demonic*. The last vowel of the stem is [ə] in the first part of the pair and [aː] in the second (in some American dialects of English). What is the underlying value of this vowel? According to Chomsky & Halle, even [aː] is derived, from /ɔ/, by a rule of unrounding:

(7) $\text{ɔ} \rightarrow \begin{bmatrix} \text{+tense} \\ \text{- round} \end{bmatrix}$

An argument in favour of this rule is dialectological: in this way, different varieties of English can be derived from the same underlying representation. Thus, no phonetic instance corresponds to the phonological matrix precisely. Chomsky & Halle conclude that "no doubt there are certain conditions on "possible phonological rules," and these will, derivatively, impose certain conditions on the relation of phonological and phonetic matrices. But it seems that there is no general condition that can be established apart from whatever effects these conditions may have." They also note that grammars that violate invariance more often, by necessity will possess more, and more complex, rules. Since there is an evaluation procedure which will always select the simplest grammar, invariance is still 'built in' to the grammar in some relativized way. Notice that all of this is exactly the line of reasoning Chomsky (1995) seems to follow in his remark quoted above.

Chomsky & Halle also discuss the inverse position: if invariance is not met anyway, we could also argue that it is misleading to have the same labels for phonological and phonetic features. Alternatively, we might propose then that the phonetic features are labeled [consonantal], [vocalic], etc., but the phonological features get a more abstract label ([A], [B], etc.). This purely abstract position is rejected (cf. Fudge (1967)) by Chomsky & Halle, however, for two reasons. One reason is that we would need to introduce rules mapping e.g. [αA]→[αconsonantal] and [βB]→[βvocalic], but these would be redundant since every grammar would need them. Secondly, by restricting ourselves to those features which have a phonetic basis, our theory is more constrained (phonological rules may not refer to natural classes that are not phonetically motivated).[2]

In some sense, the representations for input and output thus are 'invariant'. Actually, Chomsky's problem partly is a problem for SPE just as well as

[2]Notice that a problem arises in the study of sign language phonology, at least if we assume that this is based on the same problems as spoken language phonology cf. (van der Hulst, 1993) among others.

for its successors. We have to assume that at some point in the derivation a feature such as [nasal] changes in character: +, - and blank are changed into integers (so we do not need a rule [αA]→[αconsonantal], but we do need a rule [αconsonantal]→[$\mathscr{A}$consonantal], where α is a variable ranging over +, -, and $\mathscr{A}$ a variable ranging over integers). It is not clear when exactly this point is (at the end of the derivation?) nor what exactly happens at this point. The point becomes even more complicated if we take into account markedness theory (Chapter Nine of SPE), for here it is assumed that underlyingly we do not have + or - values, but *u*(nmarked) and *m*arked; these have to be turned into + or -, so as to be available for manipulation by phonological rule, only later to be turned into integers. This means we now have two phases of transition with unknown properties.

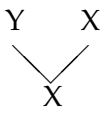
✓ In some sense this is less of a problem for Correspondence Theory (cf. chapter 3) than it is for SPE-phonology, since faithfulness is formalised here not in terms of identity (input and output are literally the same object), but in terms of correspondence (input and output are different, but one specific kind of mapping is favoured over the other).

1.3 Restricting the abstractness of phonology

We have seen that the relation between input and output was essentially unrestricted in SPE; there was no faithfulness at all. One of the first authors to propose some restrictions on this relation was Paul Kiparsky in an article that was adequately titled "How abstract is phonology?" (the article was circulated in 1968, but I am using the reprint in Kiparsky (1982a)).

Kiparsky (1982a) objected against the 'diacritic use' of phonological features. We have already seen above that in SPE there are cases were we can postulate underlying representations which never surface. This also allows for cases of 'absolute neutralisation'. For instance, if we assume a rule without a phonological context, X → Y, we can have two different X's on the surface: one underlying, and one the result of the rule (and Y will never surface in this language).

(8)



Chomsky & Halle (1968) actually argued for this type of process. For instance, they noted that Modern Hebrew does not have the feature of pharyngealisation on stops which Arabic uses for 'emphatic' consonants. Yet we need to refer to this feature in order to understand why certain [k]'s are sensitive to spirantisation, whereas others are not: if we assume that those which

are not sensitive have the pharyngealisation feature which is later lost. More generally, we can use this to describe lexical exceptions to general rules. Suppose we have the rule:

(9) A → B in the context C.

And suppose that the language have certain C's which do not seem to function as contexts for this rule, in spite of the fact that they are phonetically absolutely identical to the C's which can function as contexts. We can always simply state that these C's are actually D's 'underlyingly' (where D is something that does not surface in the language), and that we have a rule D → C, ordered after the one in (9).

An example mentioned by Kiparsky is vowel harmony in Hungarian. Compare for instance *kés-em* 'my knife' to ******héj-am*** 'my shell'; /eː/ triggers (backness) vowel harmony in the first case, but not in the second case (the rule would be approximately a→e and the context is 'after e'). We could now assume that the second word 'really' has a schwa in its underlying representation, in spite of the fact that Hungarian does not possess that vowel on the surface. The rule ə→e will then be applied after Vowel Harmony.

Even though Kiparsky does not mention this, the inverse can also happen: a rule does not apply even though its context seems to be met. This could be the case in French liaison, assuming that this is a deletion rule. The /t/ of the adjective disappears in *petit camerade* but it does not in *petit ami* because of a rule C→ ∅ / ___ ##C. Now we also have cases in which the deletion rule applies, in spite of the fact that there is no consonant on the surface; e.g. *petit héros*. We could now assume that there is an /h/ present in this case, accidentally corresponding to the orthography in this case (this is so-called *h aspiré*). Yet Modern French does not have [h] on the phonetic surface, so we have to assume a contextfree rule h→ ∅, which would apply after liaison.

Kiparsky notes that analyses like these use the phonological elements purely diacritically: we can always invent a segment that does not surface and hence can be postulated as underlying, just so that it can be neutralised. If French would have possessed a phonetic [h], or Hungarian a [ə], we could have come up with some other segment that would have played the right role in the analysis. (The question is what the value of this argument is, if our alternative is to have some purely morphological feature [-Vowel Harmony] stating that the form in question does not undergo a certain rule; the case of *h aspiré* is even more difficult to handle, because it involves a form which is subject to a rule, even though it does not satisfy the context of the rule; furthermore another rule would have to be sensitive to the same diacritic, viz. the allmorphy selection (or schwa deletion) between *le* and *l*: *l'ami - le héros*.)

An empirical objection is that rules of 'absolute neutralisation' do not have the same properties as context-sensitive neutralisation. (All of Kiparsky's examples are from historical grammar, which makes it a little hard to evalu-

ate.) Contextual neutralisation can be subject to 'reversion' or simplification, for instance. An example of reversion is is provided by Yiddish, which had a rule of syllable (or word) final devoicing just like German (turning d in *hund* 'dog' to t), but this rule was lost later (this is what we call reversion). An example of simplification can be found in German: in many dialects (possibly all, at a certain historical stage) the umlauted version of /a/ equaled [e]: *Nächte* ('nights', singular *Nacht*) rimes with *Rechte* ('rights', singular *Recht*). In some dialects was simplified later: the umlauted version became æ, and the words no longer sounded the same (*Næchte – Rechte*):

(10) a. $V \rightarrow \begin{bmatrix} \text{-back} \\ \text{-low} \end{bmatrix}$

b. V→ [-back]

Kiparsky claims that there are no cases of reversion or simplification of absolute neutralisation.

Similarly, absolute neutralisation rules are never really productive: loanwords in Hungarian never have a 'neutral' vowel, loanwords in French do not have a *h aspiré* (?). Context-sensitive neutralisation on the other hand is often very productive (final devoicing in German is applied to loanwords as well).

The conclusion Kiparsky draws from this is that absolute neutralisation rules do not exits, or are extremely costly. In order to do this, he postulates the so-called Alternation Condition. This condition has been formulated in many different ways, but one of these is the following:

Definition 3 (Alternation Condition) *An underlying form has to appear on the surface in at least one context. (There are no elements in the underlying representation which never surface.)*

The Alternation Condition clearly is a theory of faithfulness in the relevant sense: it restricts the differences that can exist between input and output. The relation works in the reverse order from what we know from 'normal' faitfulness constraints in OT, since it restricts possible inputs rather than possible outputs. In this sense it comes closer to the theory of Lexicon Optimisation, as we will see below (section 2.2).

It is also important to note that this line of reasoning only makes sense if we do not consider underspecification. In particular, note that we could assume for Hungarian that the underlying vowel is not 'schwa' per se, but it is a heavily underspecified vowel. In its strictest sense, the Alternation Condition prohibits all underspecification, since underspecified forms do not exist in the phonetics.

1.4 Natural Generative Phonology

Some phonologists in the 1970s thought that the relation between phonology should be even stricter; in their view it should be possible to completely deduce underlying representations from phonetic form and vice versa.

A concrete example is Natural Generative Phonology, developed by Theo Vennemann and his student Joan Hooper (later known as J. Bybee). A very strong condition on phonological generalisations was present in this system (Hooper, 1976):

(11) *True Generalization Condition*. All rules express transparent surface generalizations, generalizations that are true for all surface forms an that, furthermore, express the relation between surface forms in the most direct manner possible.

Even though the TGC is not in itself a faithfulness condition, it had strong implications for what constitutes a possible underlying form. For instance, it implies that we cannot have extrinsically ordered rules, hence no opacity. A well-known case of the latter is found in American English, where according to an SPE-school analysis we have a rule flapping /t/ in intervocalic context (12b) and another rule lengthening intervocalic vowels before voiced obstruents (12a) (both rules have been simplified here for ease of exposition).

(12) a. $\mathrm{V} \rightarrow \mathrm{V}\text{ː} \;/\; \_\_\_ \begin{bmatrix} +\text{cons} \\ +\text{voice} \end{bmatrix}$

b. $\begin{Bmatrix} \mathrm{t} \\ \mathrm{d} \end{Bmatrix} \rightarrow \text{ɾ} / \; \mathrm{V} \; \_\_\_ \; \mathrm{V}$

According to this analysis, the rules have to be applied in the order given here, since vowel length is opaque in cases such as *writer* [rajɾə] vs. *rider* [raːjɾə] (if we suppose that the flap is voiced, both forms should have undergone lengthening; if we suppose it is voiceless, neither should have lengthened if we just look at the surface). According to the TGC (12a) cannot be an active rule of English phonology anymore, at most the result of a historical development. The lexical forms for *write* and *ride* are [rajt] and [raːjd] respectively (so much closer to the phonetics than in SPE-style analyses). It is quite likely that an OT analyst would come to the generalisation, here.

Yet we loose the generalisation in (12a) (or it may be due to something outside of phonology proper, such as 'lexical redundancy'). We will see in the chapters to follow that this seems an inevitable result of building faithfulness constraints into our theory: because the underlying representations have to stay sufficiently close to the phonetic surface, the analysis sometimes has to be rather shallow. We therefore sometimes loose generalisations which are nevertheless real. (We will see however that OT has found its own ways of

massively violating the TGC, thereby allowing for analyses of at least some of these opaque phenomena.)

Another aspect of the introduction of faithfulness is that the underlying representations do not have very interesting properties on their own; underspecification theories have been largely abandoned with the advent of OT, and so have many of the more abstract aspects of phonological representations, which were immensely popular in the 1980s. Part of this may be due to the fact that faithfulness has been interpreted in one very specific way, however: the fact that underlying representation and phonetic form should be close has been taken to mean that the underlying representations should move in the direction of the phonetics. This is not a logical necessity, however, since it might also be the case that the outputs of the phonology should move closer to abstract cognitive representations, even if the upshot of that would be that we need a somewhat heavier phonetic component which could than turn the phonological outputs into their final form. We will see in the next chapter that this was actually the initial interpretation of faithfulness within OT.

2 Containment Theory

2.1 Containment and Invariance

As we have seen in the previous chapter, the notion 'faithfulness' was first introduced explicitly in the literature by Prince & Smolensky (1993). One of the central axioms on which this classical version of OT was based was *Containment*:

Definition 4 (Containment) *Every element of the phonological input representation is contained in the output. (There is no deletion.)*

This definition is exactly the definition of *Invariance* of Chomsky & Halle (1968) given above, modulo the fact that we no longer talk about phonological 'matrices', in other words, our theory of phonological representations has been developed. Given the fact that Chomsky & Halle (1968) had established that *Invariance* could not hold, this may explain why the wording of Chomsky (1995) is so close to that of SPE. Yet it is not immediately obvious that all of the results of the SPE carry over to theories that use different representations, as we will see below.

Containment conflicted heavily with another aspect of Classical OT, which actually was a far more radical departure of previous approaches, Richness of the Base:

Definition 5 (Richness of the Base) *There are no conditions on underlying representations. Anything can be input to the grammar of language and still give a grammatical output.*

While Containment gives us some very basic (but powerful) form of faithfulness, Richness of the Base runs against all faithfulness. Since inputs can be anything, including wildly ungrammatical forms — a series of three hundred clicks for English —, in some cases the phonetic output has to be completely different from the input. But how can we get from one to the other, if at the same time we are not allowed to delete anything?

The answer of Containment Theory (CT, this is how we will refer to the theory outlined in Prince & Smolensky (1993) from now on) is that the mapping from underlying representation to phonetics runs in two stages:

1. In the first stage, we have an OT system, not technically deleting elements which will not make it to the surface but marking them as somehow unpronouncable; the 'output' of this stage is still a fairly abstract representation.
2. In the second stage, we map the output of stage 1 to the phonetics. The way this mapping would work has never been worked out (as far as I am aware), but at least it should involve the deletion of the elements which were marked as unpronouncable before. Otherwise it should be fairly uninteresting and language-independent.

The system as a whole does not satisfy Containment, but the first stage does, and this is where the interest of the phonologist is supposed to be — the place where the important generalisations are. The output of the phonology thus is quite remote from phonetics. A priori this does not seem to be either a good thing or a bad thing, but something that could be verified by empirical study (even though this may be very hard).

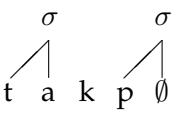
The way deletable elements are marked in CT is by 'not parsing' them. Segments that should not be pronounced are not incorporated into syllable structure, for instance, and features are not parsed into segments, i.e. not connected to them by association lines. It is clear that none of these options were available in SPE phonology for which syllable structure and autosegmental tiers did not exist; this is the reason why the results of Chomsky & Halle (1968) about Invariance do not carry over immediately to the new framework.

Faithfulness does not just prohibit deletion of material; it also prevents insertion. Again, the approach to this in CT was fairly abstract. One could insert material, but at the output of the phonology one could still see that it was inserted. Epenthetic vowels somehow looked differently from underlying vowels, and similarly for consonants. Constraints against insertion were constraints against segments that looked different. The way this was implemented was by making epenthetic segments completely empty, i.e. devoid

of any feature content. The features were then filled in at the second stage of the phonology (the 'phonetics').

This way of implementing deletion and insertion make CT into a purely monostratal theory; constraints do not need to refer to any phonological level of representation beyond the output. Also faithfulness constraints refer to this level — and there thus is no formal difference between faithfulness and markedness constraints. Unfaithful outputs are unwellformed outputs, since they contain unparsed or empty material.

The input thus was not just *contained* in the output, but it could actually be reconstructed from it. Consider the following phonological output representation for phonetic [tapə]:

(13)


From this, we know that the input must have been /takp/. The final vowel is empty — possibly pronounced as [ə] —, hence it must be epenthetic; the /k/ is not incorporated into syllable structure; hence it will not be pronounced.

One obvious problem with this implementation of the principle of Containment is that it uses aspects of representation that have been used to describe phenomena of purely faithful phonology as well. It has been argued that extraprosodic segments can stay outside syllable structure, and floating features have been part and parcel of many autosegmental analyses. However, we may still assume that extraprosodic segments are still associated to some higher-level structure (to the Phonological Word rather than the syllable), and it is not necessarily a problem that floating features are deleted in the phonetics, after they have enforced their phonological effect. The more serious problem lies in the representation of epenthetic material: it cannot be denied that epenthetic vowels and consonants often are the target of spreading, but this cannot be represented if they have to remain empty in order to be recognizable as potential violators of faithfulness constraints.

On the other hand, CT does not face all of the problems of Invariance. As we have noted above, the key reason for this is that our view of representations has changed. The key example for Chomsky & Halle (1968) was the fact that the final vowel of *algebra* is [-tense] if the word occurs in isolation, and [+tense] if the word occurs before the suffix *-ic*. We thus need to change a feature value. But if we assume that the relevant feature is monovalent [(+)lax] (van Oostendorp, 2000), there is no problem in analysing this in a way which satisfies Containment, viz. by letting [lax] float (it was always assumed that Containment did not apply to association lines):[3]

[3] A feature [lax] is associated to the second vowel here only to make the analysis more similar to the one in SPE. The vowel /ɪ/ probably also is lax, but this is not pictured here for

a l g e b r a (i c)
| | |
(14) [lax] [lax] [lax]

The second component will delete the floating feature [lax] and at the same time, mark all vowels which do not have such a feature as [tense].

Insertion of features again would be more problematic, since there is no device to mark inserted material as violators. We therefore cannot allow feature insertion at all – if it would be allowed, there would be no way to block random insertion of features, except for markednes. Furthermore, we would also be able to insert features into epenthetic segments, thus freeing them from their status of empty segments. Thus, Chomsky's Problem is not solved in a satisfactory way.

This also implies that the input representations of OT have to be rather different from those of SPE also in another respect: the heavily underspecified matrices of (5) could only be filled in at the second stage, and therefore anything interesting that could be said about them would fall beyond the scope of phonology proper. This basically means that we cannot have underspecification, as we will see in section 2.2. Thus, the underlying forms will have to be quite close to the output representations. This is true also in another respect. In this sense the faithfulness requirements may be too strong.

The main advantage of a CT approach to faithfulness is that it is parsimonious: it does not refer to any device which may not be needed independently. For instance, the PARSE and FILL families of constraint supposedly are necessary beyond the theory of faithfulness. This poses a problem for many of the proposed alternatives to be discussed in following chapters: we may stipulate that we no longer use PARSE-C or FILL-V, but then we will still need to say something about consonants that are not attached to syllable nodes on the surface or vowels that do not have any vowel content. In that sense, CT comes very close to the null hypothesis regarding faithfulness theory, given the other theoretical assumptions that were made in Prince & Smolensky (1993); McCarthy & Prince (1993).

2.2 Lexicon Optimization

The fact that CT is based on an assumption of Richness of the Base, does not imply that it does not recognize the existence of a lexicon, where the precise linguistic structure of individual items is stored, of course. It is clear that every language has a lexicon, and it is also clear that for instance a child acquiring a language should learn the arbitrary form-meaning pairs that are found in the lexicon. What Richness of the Base does say, however, is that

the sake of simplicity.

nothing interesting can be said about the structure of the lexicon. All generalisations (e.g. the fact that there are no English words starting with *rt-*) are epiphenomena from the constraints which operate on the output of the phonology (there is a constraint there forbidding **rt-*, so that words of this shape will never survive).

How do we select the shape of the lexical items? Although it is usually assumed that every input corresponds to exactly one output (so-called free variation aside), the inverse is not true. For instance, we know that English does not have the sound [ϴ]. Suppose we also know that underlying /ϴ/ is deleted (rather than turned into, say, [t]). This implies then that there are infinitely many possible inputs for the word [man]: /man, ϴman, ϴϴman, ϴϴϴman, . . . /. How does the child select the 'real' underlying form? Prince & Smolensky (1993) suggest that in this case a reverse optimisation takes place. We do not optimize the surface form, but the underlying representation; interestingly, this can be done using the same constraint ranking as for 'normal' output optimization. The following is Prince & Smolensky's first attempt:

Definition 6 (Lexicon Optimization) *Suppose that several different inputs I_1, I_2, . . . , I_n, when parsed by a grammar G lead to corresponding outputs O_1, O_2, . . . , O_n, all of which are realized as the same phonetic form Φ — these inputs are all* phonetically equivalent *with respect to G. Now one of these outputs must be the most harmonic, by virtue of incurring the least significant violation marks: suppose this optimal one is labelled O_k. Then the learner should choose, as the underlying form for Φ, the input I_k.*

It is easy to see what 'the most harmonic input' will be like, approximately. All inputs lead to the same output by definition, and therefore they will all incur exactly the same number of markedness violations. Hence the faithfulness constraints will decide, and they will pick the input which will give the smallest number of faithfulness violations. This will be the input that is closest to the output. And given Richness of the Base, there will be an input which is exactly identical to the output, so this will be selected. Lexical representations can thus be expected to be exactly the same as their pronounced form.

An obvious question arises at this point: how should we treat cases where segments alternate in different phonological contexts? To take one example out of many — any textbook on phonology is obviously full of them — consider Root Final Devoicing of stops in Turkish. The question is discussed by Prince & Smolensky (1993), but here we will rather follow the line of reasoning of Inkelas (1995). Consider the following data:

(15) a. Alternating root-final plosive:
kanat 'wing' *kanad-ı* 'wing-Acc'

kanat-lar 'wing-pl' *kanad-ım* 'wing-1sg.poss'

b. Nonalternating voiceless plosive:
sanat 'art' *sanat-ı* 'art-Acc'
sanat-lar 'art-pl' *sanat-ım* 'art-1sg.poss'

The problem is with the examples in (15a): the procedure for Lexicon Optimization cannot tell us about the voicing quality of the final plosive in the underlying representation (since it cannot satisfy faithfulness both with the nominative singular and the accusative singular). Therefore, Inkelas (1995) proposes an alternative definition:

Definition 7 (Alternation-sensitive restatement of L.O.) *Given a grammar G and a set* $S = \{S_1, S_2, \ldots S_i\}$ *of surface phonetic forms for a morpheme M, suppose that there is a set of inputs* $I = \{I_1, I_2, \ldots I_j\}$*, each of whose members has a set of surface realizations equivalent to S. There is some* $I_i \in I$ *such that the mapping between* I_i *and the members of S is the most harmonic with respect to G, i.e. incurs the fewest marks for the highest ranked constraints. The learner should choose* I_i *as the underlying representation for M.*

It is not specified how the calculation works, exactly, or what exactly are the members of S (if two suffixes trigger the same form of the stem, should this form be counted once or twice), but all of this could of course be worked out in a satisfactory way.

It is interesting to see (although this was not noted by by Inkelas) that this Alternation-sensitive L.O. effectively derives Kiparsky (1982a)'s Alternation Condition at least in the sense that underlying forms with feature values which conflict with all surface instances of the same morpheme are not allowed. (Recall that Kiparsky did not consider underspecification as an option.)

For the Turkish cases, we will now get the following Lexicon Optimisation tableaux, where D denotes a coronal stop that is not specified for voicing:

(16)

L.O.			PARSE-[+voice]
	a. /kanad/	[kanat]	*!
		[kanadı]	
	b. /kanaD/	[kanat]	
		[kanadı]	

In order to evaluate Lexicon Optimization, we thus need to evaluate several related forms (both with and without affixes) at the same time; as a matter of fact we need to compare all the environments in which a morpheme can occur. This involves something beyond the normal comparison of individual

forms; rather we need some form of output-output faithfulness, as will be discussed in chapter 5.

The relevant faithfulness constraint is a PARSE-constraint against deletion of features, presumably since there is no ban on inserting features in CT, as we have seen above. If a segment is underspecified, no feature has to be deleted. Note that it is actually essential that there is no constraint against insertion of features, since otherwise it would not be so clear which of these input forms would win. And note also that it is equally crucial that underspecified 'archisegments' such as /D/ should not be allowed to surface as such. This is the case of all underspecification theories, and it means that a force of antifaithfulness is as work as well: underlying representations have properties which surface representations do not have.

Turkish actually provides good empirical evidence for underlying underspecification, since it has a three-way contrast. Next to words which show alternation, and forms which are uniformly voiceless, there are also (loan)words which are uniformly voiced:

(17) Nonalternating voiced plosive:
etüd 'etude' *etüd-ü* 'etude-Acc'
etüd-ler 'etude-pl' *etüd-üm* 'etude-1sg.poss'

We can analyse this by assuming that *sanat* ends underlyingly in [-voice], *etüd* in [+voice] and *kanat* in [0 voice]. We can give these words the following analysis (FINDEV is a stand-in for whatever is responsible for Final Devoicing):

(18) a.

/etüd/	PARSE-[+voice]	FINDEV
☞[etüd]		*
[etüt]	*!	

b.

/sanat/	PARSE-[+voice]	FINDEV
☞[sanat]		
[sanad]		*!

c.

/kanaT/	PARSE-[+voice]	FINDEV
☞[kanat]		
[kanad]		*!

Notice that the ranking PARSE-[+voice]≫FINDEV is crucial to get the right result for *etüd*. In a language like German, which does not have exceptions of this kind, we need a ranking FINDEV≫PARSE-[+voice]. Lexicon Optimization then will mean in turn that there will be no words in German with an underlyingly voiced plosive, as the reader may verify.

Languages like English are somewhat problematic, however. The fact that English does not have final devoicing effects means that it has the ranking PARSE-[+voice]≫FINDEV, just like Turkish. But the question then is: why doesn't English have alternating forms of the type *kanat*? We cannot simply stipulate that English does not have the relevant archiphonemes, since this would violate Richness of the Base; but it is unclear how the problem should be solved in any other way.

The problem becomes even more complicated if we look at the analysis of the Turkish cases with a vowel-initial suffix. We have to make sure that the unspecified forms take the voiced alternative in this case (*kanadı*, **kanatı*). In order to do this, we may postulate a constraint causing intervocalic voicing; let us call it IV. A constraint PARSE-[-voice] must dominate it, in order to make sure that the plosive in *sanat* does not also voice:

(19) a.

/etüd/+/ı/	PARSE-[-voice]	IV
☞[etüdü]		
[etütü]		*!

b.

/sanat/+/ı/	PARSE-[-voice]	IV
☞[sanatı]		*
[sanadı]	*!	

c.

/kanaD/+/ı/	PARSE-[-voice]	IV
[kanatı]		*!
☞[kanadı]		

Again, the question arises why other languages which do not have Final Devoicing, also do not have the pattern here.

We can thus conclude that Lexicon Optimisation is not without its problems; as far as I am aware most of these problems have not been adressed, let alone answered in the literature. Later developments in faithfulness theories can be shown also not to really shed light on these matters.

2.3 Extreme unfaithfulness: The null parse and allomorphy

We have seen thus far that the faithfulness requirements imposed by CT are rather strict: for several reasons, underlying representation and phonological output have to be very close. Underspecification, if it exists at all, is restricted to those cases where there is an alternation.

Contrary to this is a principle within CT of the so-called *null parse*. One of the examples is Dyribal (McCarthy & Prince, 1993; Dixon, 1972). In this

language we have an ergative suffix -ŋgu which only goes with bisyllabic bases, not with longer stems:

(20) a. yaṭa-ŋgu 'man'
b. *yamani-ŋgu 'rainbow' *balagara-ŋgu 'they'

Intuitively it is clear why -ŋgu goes with bisyllabic stems only: it attaches to the foot with primary stress only, but it cannot function as an infix in Dyirbal (as similar suffixes can in other languages). In OT terms, there are two inviolable constraints on its distribution, viz. AFFIX-TO-FOOT and RIGHTMOSTNESS (the suffix has to occur at the very edge of the stem). Only in the case of bisyllabic words can both constraints be met at the same time.

(21)

Size	Example	AFFIX-TO-FOOT	RIGHTMOSTNESS
2σ	yaṭa-ŋgu	✓	✓
3σ	yamani-ŋgu	*	✓
	yama-ŋgu-ni	✓	*
4σ	balagara-ŋgu	*	✓
	balaga-ŋgu-ra	*	*
	bala-ŋgu-gara	✓	*

The problem is that we would expect at least some output for the three- and four-syllable cases, given the basic assumption that every input should render an output, even if it is not perfect. If we have to abandon that assumption, we will go outside Optimality Theory. There are basically two solutions to the problem, and both of them have implications for our view of faithfulness.

The first possible solution is proposed by McCarthy & Prince (1993). They suggest that in every candidate set there is also a so-called 'null parse'.

> The solution is to make the functional equivalent of *no output* a member of the candidate set and to rank the constraint prohibiting it below AFX-TO-FT and RIGHTMOSTNESS. This approach is developed by Prince and Smolensky (1993: § 4.3.4), who observe that the Null Parse, which supplies no analysis to the input, is uniquely unsuited to participate in linguistic structure. The idea is that, among the candidate output forms, there is one in which the affix is simply not joined with the base at all; the output form remains morphologically unparsed, identical to the input. Such an output is fatally flawed, because it cannot play any role in the syntax or higher morphology: unless an input {A, B} is analyzed structurally as [A B]$_{Cat}$, nothing that refers to Cat can deal with it. Intuitively, the productivity of –ŋgu where "productivity" refers to the extension of this affix over the entire nominal lexicon is subordinated to the interface requirement AFX-TO-FT

> and the linear ordering constraint RIGHTMOSTNESS. This possibility will emerge if the identity transformation is part of Gen, so the input {A, B} has, among its output candidates, the Null Parse {A, B}.

We thus have the possibility that the morphology is completely inactive, and we get a result that is unpronounceable (i.e. which cannot be interpreted by the phonetics at all). Just like in the case of underspecification, this means that there are possible underlying representations which can never be possible surface representations, an extreme type of unfaithfulness. It also means that in some sense Richness of the Base does not hold for morphology: only unstructured sets of morphemes can be part of the base.

This may be the point to repeat that Richness of the Base — see the definition on 12 — can be interpreted in two different ways. A weak interpretation holds that no systematic differences between languages can be the result of differences in underlying representations. Under this weak interpretation, underlying forms can still be different in quality from phonetic forms. Most scholars however assume a stronger interpretation on Richness on the Base, viz. that 'no restrictions can be imposed on them'. Notice that nobody would take the most radical interpretation, which would have it that e.g. also a sigh, the number 54 and a pebble could be inputs to the grammar, because they would have to be ruled out by an infinity of constraints *BODYSOUNDS, *NUMBER and *PHYSICALOBJECT. It is usually assumed that Richness of the Base means that inputs are qualitatively the same as outputs, but there is no inherent reason why this should be the case.

There has been some debate in the literature about the type of 'ineffability' exemplified by Dyirbal; but many questions remain open, such as whether null parse analyses should always involve morphologically complex forms. The precise form of the faithfulness constraint — most often called MPARSE — has been discussed in Orgun & Sprouse (1999); Féry & Fanselow (2003); McCarthy & Wolf (2005). The latter authors propose an a formulation of this constraint within Correspondence Theory. We will return to this in section **??**.

An alternative option, at least in the case at hand, is that -ŋgu is not chosen in this case because there is another suffix, -gu, which does not necessarily meet these requirements. We will have to postulate in any case that AFX-TO-FT and RIGHTMOSTNESS are relevant for -ŋgu, but not for other Dyirbal suffixes, such as -gu. Let us do this in the most simple-minded way possible, viz. by postulating that at least the first of these is parametrized: AFX-TO-FT (ŋgu).

Now let us also assume that -ŋgu and -gu are allomorphs, i.e. they are alternative exponents of the same suffix. The function Gen can freely choose one or the other to express ergativity. Since -gu is not subject to AFX-TO-FT, it can serve as a perfect suffix for stems which are longer than two syllables. We also need to explain why -gu does not surface in the shorter words, i.e.

that it only functions if -ŋgu is not able to. In other words, we need to say that -ŋgu is the preferred allomorph. Again, let us take the most simple-minded formalisation that is available to us, just to illustrate the point, viz. a constraint PREFER-ŋgu. We then get the following derivations for words of two and three syllables:

(22) a.

ya‿ta+{ŋgu, gu}	RIGHTMOST	AFX-TO-FT (ŋgu)	PREFER-ŋgu
☞ya‿taŋgu			
ya‿tagu			*!
yaŋgu‿ta	*!	*	

b.

yamani+{ŋgu, gu}	RIGHTMOST	AFX-TO-FT (ŋgu)	PREFER-ŋgu
yamaniŋgu		*!	
☞yamanigu			*
yamaŋguni	*!		
yamaguni	*!		*

Notice that this approach also has implications for the theory of faithfulness, since it has implications for the theory of underlying structures. We now need to be able to say that a morpheme has multiple exponents and Gen can let one of them surface. But we cannot say this if we keep to the principle of Containment in an orthodox way: if we select the suffix *-gu*, the elements of *-Ngu*, which were present in the input are no longer present in the output. Therefore, theories of allomorphy seem to fit better in alternative theories of faithfulness, such as Correspondence Theory, which will be the topic of the next chapter.

3 Correspondence Theory

3.1 The Correspondence Relation and Constraints

It is no exaggeration to say that Correspondence Theory is the standard theory of faithfulness within Optimality Theory. In this chapter, we will discuss the standard version of the theory, as it was presented in McCarthy & Prince (1995a). Several extensions to Correspondence Theory will be discussed in the chapters to follow. Here, we will concentrate on the standard version of the theory.

The main motivation for replacing Containment with Correspondence was that some kind of faithfulness relation seems to hold between the two parts of a reduplicated form. Consider, for instance, the following examples from Javanese:

(23) Javanese intervocalic h deletion (Dudas, 1976; Horne, 1961)

	i. Stem	ii. +C	iii. +V	iv. Expected Red.	v. Gloss
a.	anɛh	anɛh-ku	anɛ-e		'strange'
b.	bədah	bədah-bədah	bəda-bəda-e	*bədah-bəda-e	'broken'
c.	dajɔh	dajɔh-dajɔh	dajɔ-dajɔ-e	*dajɔh-dajɔ-e	'guest'

The first row shows that Javanese deletes /h/ if it occurs between two vowels (for instance before the vowel-initial suffix *-e*). The second and third row (column iii) show that this also happens if a reduplicated word is followed by *-e*. Importantly, this happens to *both* halfs of the reduplicated word, even though the first half itself does not occur before a vowel and thus does not satisfy the relevant context. The reason for this seems to be that the 'reduplicant' needs to be as similar to the 'base' as possible: in other words a relation of faithfulness seems to hold between them.

Obviously, this type faithfulness cannot be expressed in terms of CT, since this requires absolute identity of the faithful objects (they are literally the same thing), yet the two [b]'s of [bəda-bəda-e] clearly represent different phonetic events, and similarly for the other segments. The faithfulness requirements of Correspondence Theory are more relaxed: it does not demand absolute identity, but merely that the two segments stand in a relation to one another. This relation is called 'correspondence':

Definition 8 (Correspondence) *Given two strings S_1 and S_2,* correspondence *is a relation $\mathscr{R}$ 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 $\alpha \mathscr{R} \beta$.*

It should be noted that here, as in the formulation of Containment we have seen, a special role in the transmission of faithfulness is awarded to the phonological segment (rather than features or syllables): the relation is defined in terms of strings, and in the practice of Correspondence Theory this has always remained to be the focus of attention. This is in line with the rather minimalist assumptions regarding representations that most OT practicioners follow.

The most important innovation of Correspondence Theory, however, is that also input-output pairs no longer have to be identical. Indeed, a segment in the input can be completely distinct from a segment in the output. This gives us a potential way of solving Chomsky's problem: we may assume in principle that the input representation is a purely cognitive object, whereas the output is a completely phonetic object. As long as we can establish a relation $\alpha \mathscr{R} \beta$, nothing forces us to assume that α and β have to be qualitatively the same thing (although obviously they are the same types of object in reduplication).

This also means that we can no longer see that something is inserted or deleted if we only look at the output. Instead of the singular representation

that appeared in the tableaux of Containment Theory (13) the following pair of representations, plus the correspondence relation between them, now has to be evaluated by the grammar:

(24)

Input	*Output*	*Correspondence*
$\mathrm{t}_\alpha\ \mathrm{a}_\beta\ \mathrm{k}_\gamma\ \mathrm{p}_\delta$	$\sigma \quad \sigma$ $\mathrm{t}_a\ \mathrm{a}_b \quad \mathrm{p}_d\ \mathrm{ə}_e$	$\mathscr{C}(t_\alpha, t_a)$ $\mathscr{C}(a_\beta, a_b)$ $\mathscr{C}(p_\delta, p_d)$

We know that $/\mathrm{k}_\gamma/$ has been deleted, because this segment is present in the underlying representation, and there is no segment x in the output such that $\mathscr{C}(k_\gamma, x)$. Similarily, [$\mathrm{ə}_e$] has been inserted because it is in the output, and there is no segment y in the input such that $\mathscr{C}(y,\mathrm{ə}_e)$.

The downside of this is that the objects on which our computations are based, have become quite complex. In OT tableaux using Correspondence Theory, most scholars still draw only the output representations, and this can be justified from a presentational point of view since the input is the same for all forms in a tableau. Yet this does not represent the real computational complexity of the problem involved. In reality, all candidates have a structure which is as complicated as (40). It is also fairly obvious that these representations are not pronounced as such, so that we still need a minimal rule component which takes out the 'output' representation and at least delete the indices which are necessary for the computation of correspondence relations.

In other words, correspondence has it that the analysis of every word in natural language involves reduplication, but where the base is silent. The two representations S_1 and S_2 have to be maximally similar because of a number of faithfulness constraints such as the following:

(25)
a. The MAX Constraint Family
Every segment of S_1 has a correspondent in S_2.
b. The DEP Constraint Family
Every segment of S_2 has a correspondent in S_2.
c. The IDENT Constraint Family
Let α be a segment in S_1 and β be any correspondent of α in S_2. If α is [γF], then β is [γF]. (Correspondent segments are identical in feature F).

These are constraint families rather than constraints, because there are different versions of them for input-output ('IO') correspondence and for base-reduplicant ('BR') correspondence (these have to be separate because they can have independent positions in the hierarchy (for instance BR faithfulness

has to be ranked higher than IO faithfulness, since similarity to the base can enforce dissimilarity to the input).

MAX-constraints ban deletion of segments (everything in the input needs to be in the output); DEP-constraints militate against insertion (everything in the output needs to be in the input). Both constraints only demand that there is *some* segment in the other level of representation, and do not care about the quality of the other segment. They are satisfied if underlying *a* corresponds to phonetic [t]. The latter configuration is prohibited by IDENT-constraints, since many of the features of /a/ are not found on its correspondent [t].

Notice that, just as in the case of Containment Theory, nothing in this formulation prohibits filling in underspecified features: if the underlying representation (S_1) does not have a feature value for [F], IDENT as it is formulated is vacuously satisfied. This also means that this formulation does not work satisfactorily with theories of unary features (cf. Blaho, 2004). The present formulation furthermore assumes that the underlying representation and the output representation are the same (so we do not work with phonological vs. phonetic features), but obviously a slight reformulation could be made to work under contrary assumptions.

3.2 Special faithfulness violations: Metathesis

The constraints mentioned above form the core of the faithfulness constraints. There also is a number of other constraints which regulate other types of faithfulness. Some of these could be formalized in Containment theory if we wanted to:

(i) a. The I-CONTIGUITY Constraint Family
The portion of S_1 standing in correspondence forms a contiguous string. (No deletion of elements internal to the input string.)

b. The O-CONTIGUITY Constraint Family
The portion of S_1 standing in correspondence forms a contiguous string. (No deletion of elements internal to the input string.)

In order to express this, we could prohibit empty and unparsed segments in the middle of a string. It is not obvious that this would be a more or a less plausible interpretation of the phenomenon at hand than what we have in Correspondence Theory. Something similar could be said about the Anchoring constraints:

(ii) a. The I-ANCHORING-(L/R) Constraint Family
The portion of S_1 standing in correspondence forms occurs on the left/right edge string. (No deletion of elements at the left/right to the input string.)

b. The O-ANCHORING-(L/R) Constraint Family
The portion of S_2 standing in correspondence forms occurs on the left/right edge string. (No insertion of elements at the left/right to the input string.)

We return briefly to this issue in section 8.2. Others however are impossible to formulate under Containment:

(26) a. The UNIFORMITY Constraint Family
"No Coalescence" No element of S_2 has multiple correspondents in S_1.

b. The INTEGRITY Constraint Family
"No Breaking" No element of S_1 has multiple correspondents in S_2.

c. The LINEARITY Constraint Family
"No Metathesis": S_1 is consistent with the precedence structure of S_2, and vice versa.

It is clear that LINEARITY could not be expressed within Containment Theory; there is no way to mark that two segments have changed their order. Similarly, we cannot tell from looking at the output alone whether two underlying segments are reversed or, inversely one underlying segment has been split up into two, so that UNIFORMITY and INTEGRITY also are impossible to express.

It is not immediately uncontroversial, however, that this should be counted as an advantage for Correspondence Theory. Clearly, it makes the theory much less restrictive than Containment. In the former theory, faithfulness was partly built into Gen, and the core of it was universal. Within Correspondence theory, *any* input can correspond to *any* output, hence all faithfulness is violable. This is a good thing if we see OT purely as a descriptive instrument which should be able to handle any phenomenon we encouter without any problem. Yet, from the point of view of explanatory adequacy, the theory does not fare very good at all. It is very hard to conceive logically possible but inattested phenomena that could be modelled perfectly in this theory of containment. For instance, suppose we have a language L, which has stems /ta/, /bo/, /at/, and two suffixes -/k/, and /i/. Suppose furthermore that the syllable structure constraints NOHIATUS and NOCLUSTER are very high ranked in this language, and so are all faithfulness constraints, except for (IO) LINEARITY. We then get as a result that words metathesize according to the suffix:

(27) a.

/ta/+/k/	NoCluster NoHiatus	Faith	Linearity
☞[tak]			
[atk]	*!		*

b.

/ta/+/i/	NoCluster NoHiatus	Faith	Linearity
[tai]	*!		
[ta?i]		*!	
☞[ati]			*

c.

/at/+/k/	NoCluster NoHiatus	Faith	Linearity
☞[tak]			*
[ak]		*!	
[atk]	*!		

d.

/at/+/i/	NoCluster NoHiatus	Faith	Linearity
[tai]	*!		*
☞[ati]			

Underlying /ta/ and /at/ thus give the same outputs. It is not difficult to see that this result applies also to longer words, so that /takepi/ and /atekip/ are also indistuinguishable. But languages of this type, where the order of consonants and vowels can be freely reversed according to the context, have never been attested. The problem is that the three constraint families which are difficult to handle for containment (Uniformity, Integrity, Linearity) do not seem as freely rankable as other constraints are. They are always lowly ranked. Even though the processes of metathesis, fusion and fission are well-known from historical phonology, and to some extent maybe also from reduplication, it is not clear that we cannot do without them in the synchronic phonology. In the absence of strong evidence in its favour (and such evidence can only consist of solidly analysed data, not just some random examples from languages which have not been carefully studied) there is no reason to assume the more permissive theory.

Interestingly, McCarthy (2000) gives precisely such an argument. He discusses the so-called 'incomplete phase' in Rotuman, a central Oceanic language spoken on an island about 500 kilometres north of Fiji (Churchward, 1940). The incomplete phase is, roughly, an environment in which the last two syllables of a word turn into one syllable. There are several ways of achieving this (not all of them listed here), but one of them is metathesis:

(28) Phase Differences in Rotuman

	Complete	Incomplete	
a. Deletion	tokiri	tokir	'to roll'
	tiʔu	tiʔ	'big'
b. Metathesis	iʔɑ	iɑʔ	'fish'
	sesevɑ	seseɑv	'erroneous'
	pure	puer	'to rule'
c. Diphthongization	pupui	pup͡ui	'floor'
	lelei	lel͡ei	'good'

McCarthy (2000) shows that in case the two vowels are separated by a consonant, metathesis is preferred over vowel deletion. The latter option is only chosen if the the former would result in a non-rising diphthong. Clearly, this implies that we somehow need to incorporate a device of metathesis into our theory, and McCarthy claims that this indeed provides us with an argument against Containment Theory:

> If input /pure/ must be "contained" in every candidate, then literal *puer* is not even in the candidate set, since /pure/ $\not\subset$ *puer*, stringwise. Under Containment, the real output form should be puEr<e>, with epenthetic E copying the unparsed final vowel. Yet how can this form, which violates both FILL and PARSE, ever compete with **pur*<*e*>, which violates only PARSE? To put the matter differently, if metathesis is copy+deletion, how will it ever be favored over straight deletion, since deletion receives a subset of the marks that metathesis receives? To escape this consequence of its core assumptions, the PARSE/FILL model would need to introduce considerable elaboration of the conception of what is PARSEd or FILLed, perhaps distinguishing effects on the Root nodes of the vowels from their Place nodes.

The latter remark (probably) means that we could save Containment Theory if we would be allowed to have independent faithfulness of Place nodes: the Place node of the deleted vowel could then be moved to the epenthetic vowel to preserve Place faithfulness. It is hard to decide whether the 'elaboration' this requires is really more 'considerable' than introducing the complicated machinery of metathesis into our theory, in particular since it seems clear that natural languages have processes of vowel copying, by which the full content of a vowel spreads across a consonant to another (epenthetic) vowel; the most well known example of this is Yawelmani.

McCarthy (2000) also mentions another possible analysis of this phenomenon, which would equally mean a more sophisticated theory of representations, viz. one which is based on 'tier segregation' — the idea that vowels and consonants occur on separate tiers underlyingly, and are not (totally) ordered on that level of representation with respect to each other, so that the incom-

plete phase does not really constitute a violation of faithfulness. McCarthy is highly critical of this analysis as well:

> With tier segregation, the possibility of metathesis is hard-wired into every phonological representation — in essence, it's a stipulated regularity of the Rotuman lexicon which has overt consequences in the incomplete phase. In Optimality Theory, on the other hand, there are no stipulated regularities in the lexicon; regularities must emerge from the constraints on output forms, possibly augmented with assumptions about language learning (Prince & Smolensky 1993: Chapt. 9). There are several reasons for pursuing this claim in OT: it is presupposed by another claim, that all interlinguistic differences are to be derived from constraint ranking; it is possible to obtain the effect of constraints on underlying representation from output constraints; and it is necessary to do so, in order to solve the "duplication problem" (on which see Kenstowicz & Kisseberth 1977). [...] More broadly, OT takes much of the burden of explanation off of representations (e.g., tier segregation) and places it on substantive constraints (e.g., LINEARITY), which are violable under domination. Thus, consonant-vowel tier segregation is completely superfluous in an Optimality Theoretic analysis of Rotuman, and in fact it is antithetical to fundamental premises of OT.

This argument is based on the implicit assumption that tier segregation is not available for languages which do not display its effect. If it would be a universal possibility in human language, it would not be a 'stipulated regularity of the Rotuman lexicon', nor would we need to abandon the claim that all language variation can be derived from constraint ranking. Furthermore, the duplication problem also would not arise, since this problem concerns only language-specific characteristics (which are duplicated since they are stated both in the lexicon and in the grammar).

Related to this is that this discussion is based on a specific interpretation of Richness of the Base, viz. one where we assume that nothing can be said about inputs at all. Another interpretation is different, however, viz. that we cannot use underlying representations as a way of marking systematic differences between languages. Under such an interpretation, Optimality Theory is a theory which mainly serves to describe (interlinguistic and intralinguistic) variation. Universals could be made to follow from a theory of representations, i.e. (partly) a theory of possible underlying representations.

Under such a theory, it is not clear at all, whether we need LINEARITY. This becomes even more apparent if we consider the following concession McCarthy makes:

> While V-C metathesis is not uncommon, to my knowledge processes of V-V metathesis have been proposed on just three occasions [...]. All three involve very abstract analyses, in which

> the underlying representations and/or the consequences of metathesis are by no means apparent, and all except Latvian have been reanalyzed in ways that do not involve V-V metathesis at all. It therefore seems reasonable to prohibit V-V metathesis outright, perhaps universally [...].

If we want to distinguish between V-C metathesis on the one hand, and V-V metathesis on the other, we need to take recourse to some theory of representations. We could wonder whether this could then not take care of the other aspects of metathesis as well.

More in general, we need very strong arguments in order to convince us that we should make the step from Containment Theory to Correspondence Theory. The strongest argument seems to be the fact that reduplication obbeys the same patterns. If it can be shown that we need the correspondence machinery independently to describe reduplication, there may be no real extra 'cost' to adapting it for input-output relations as well.

3.3 Faithfulness in reduplication

Let us now see how correspondence relations behave in reduplication. We have already seen one example above, from Javanese, in which an /h/ had disappeared on the surface in the reduplicant only because it also disappeared from the base (example (23) on p. 22). This is traditionally called 'overapplication', since it would be described in rule-based terms by a rule (*h* deletion) which would apply in a form which does not meet its condition. Another example is from Tagalog. In this language there is a process of 'nasal substitution'. After a prefix ending in a velar nasal, a stem initial plosive turns into a nasal (e.g. /p/→[m]).

(29) a. *putul* 'cut (n.)'
b. *pang-putul* 'that used for cutting' >[pamutul]
c. *pa-mu-mutul* 'a cutting in quantity' (reduplication; **pa-mu-putul*)

Nasal substitution overapplies in the reduplicated form: the first consonant in the base is not preceded by a velar nasal, but still it turns into a nasal. The reason for this apparently is that in this way it is more similar to the reduplicant.

Overapplication is a good argument for faithfulness within reduplicated forms, since there seems to be no other reason why it would happen. Another good argument is its reverse, *underapplication*: cases where some phonological rule does not seem to apply even though its phonological condition is met. An example for this may come from Japanse (as has been observed in Kager (1999a), based on data from Mester & Itô (1989)). In Tokyo Japanse,

[g] and [ŋ] are famously in complementary distribution. The former occurs at the beginning of the word, whereas the latter occurs in other positions:

(30) Complementary distribution of [g], [ŋ] in Japanese

#g	VŋV
geta 'clogs'	*kaŋi* 'key'
giri 'duty'	*oyuŋu* 'to swim'
gai-koku 'foreign coutry'	*koku-ŋai* 'abroad'

Complementary (allophonic) distributions like this in general pose some puzzles for faithfulness theories (cf. section 6.2); but one way of seeing this certainly is that that /g/ turns into [ŋ] in the middle of the word. Assuming that we have a constraint against velar nasals in word-initial position (*[$_w$ŋ) and another constraint against velar voiced stops (*g), and assuming that all the relevant IO faithfulness constraints are low ranked, we get the right result:

(31) a.

/geta/ or /ŋeta/	*[$_w$ŋ	*g
☞[geta]		*
[ŋeta]	*!	

b.

/kagi/ or /kaŋi/	*[$_w$ŋ	*g
[kagi]		*!
☞[kaŋi]		

Now this process does not apply in so-called 'mimetic' reduplication:

(32) a. *gara-gara* 'rattle' (*garaŋara, *ŋaraŋara)
b. *geji-geji* 'centipede' (*gejiŋeji, *ŋejiŋeji)
c. *gera-gera* 'laughing' (*geraŋera, *ŋeraŋera)

'Normal' application of the nasalisation process would lead to *garaŋara, etc. Overapplication would lead to *ŋaraŋara, etc. The form we find, however, are cases of underapplication: the process does not apply, even though it could in principle. BR Faithfulness is able to describe this:

(33)

/gara/+red or /ŋara/+red	BR FAITH	*[$_w$ŋ	*g
☞[garagara]			**
[ŋaraŋara]		*!	
[garaŋara]	*!		*

Obviously, this is dependent on many other assumptions we make. For instance, if we assume that the two parts of the reduplication both constitute a

domain D which is relevant to the constraint *[$_D$ŋ, we do not need to refer to BR Faithfulness at all:

(34)

/gara/+red or /ŋara/+red	*[$_D$ŋ	*g
☞[gara-gara]		**
[ŋara-ŋara]	*!*	
[gara-ŋara]	*!	*

An important question now is whether the Japanese example just happens to be an unfortunate one, or whether other purported examples would also be subject to alternative analyses (we will return to a different type of reduplication in Tokyo Japanese in sections 6.2 and 7.2). There is at least one attempt at giving an alternative to the BR Faithfulness account within OT: this is Inkelas & Zoll (2005). They discuss the Javanese case mentioned above; the analysis is fairly complicated, but the general idea is that the reduplication is not a prefix, as would be assumed under a BR Faithfulness analysis, but rather an infix. This means that there is some level at which the stem is next to the prefix:

(35)

putul
↓ + pang
pang-mutul
↓ + RED
pang-mu-mutul

The way the analysis is represented here, shows that this analysis requires a faithfulness theory for the morphology - phonology interface which is more complicated than a simple input consisting of a stem plus a set of suffixes. We need to incorporate a notion of *cyclicity*, i.e. we need faithfulness between several levels which are defined by the addition of one single affix at a time. (We will return to the issue of cyclicity in section 5.1.) The Javanese example presented above could be analysed in a similar way. (See Keenan (2002); Frampton (2001) for a formal criticism of Correspondence Theory as a theory of reduplication and Raimy (2000); Zoll (2002); Frampton (2004) for empirical arguments and alternative analyses.)

We thus have to conclude that we need some type of faithfulness to understand reduplication, and that for this we cannot use the simplest form of faithfulness theory. It is not so clear, however, that it means we have to abandon Containment. In the model presented in (35), we could use Containment in principle.

3.4 Distinctions between faithfulness and markedness

There is yet another potential advantage of Correspondence Theory over Containment Theory. We have seen that Containment Theory used markedness constraints (against empty and unparsed segments) to express faithfulness. On the other hand, Correspondence Theory uses a separate formalism for faithfulness constraints. (To be precise, McCarthy & Prince (1995a) suggest that Correspondence could be used also for autosegmental association, and for ALIGNMENT, but neither of these suggestions have been taken up in full detail.)

Dividing up the set of constraints formally in this way has certain implications, and these actually seem to be very favourable for Correspondence Theory. The reason is that certain subtheories actually refer to the difference between faithfulness and markedness.

The most well-known example of this is language acquisition. It is a standard assumption in the OT acquisition literature that in the initial stage all children have a grammar in which all markedness constraints outrank all faithfulness constraints (cf. the contributions to Kager *et al.*, 2004, for an overview). One argument for this is that in this way we can explain the so-called *Jakobsonian Generalisation* (Jakobson, 1942; Smolensky, 1996):

Definition 9 (Jakobson's Generalisation) *Structures which are avoided via phonological 'processes' within adult languages, and excluded from some inventories across adult languages, also tend to be structures which are later-acquired by children.*

The avoidance or exclusion of structures in adult languages can only be accomplished by markedness constraints dominating faithfulness in OT. If we assume that this is the initial state, Jakobson's Generalisation follows trivially.

Another argument for this assumption is that it allows for a solution of the so-called Subset Problem of language acquisition. Smolensky (1996) gives the following example of this. Suppose we have a language L which has CV Syllables only (so all words are CV, CVCV, CVCVCV, ...). Every grammar (i.e. every permutation of the set of universal constraints) can generate words with CV syllables. The question arises: what is the grammar that the language learner acquire when it is confronted with the evidence of language L? A priori it is in no position to decide that closed syllables should be excluded from the language, given the lack of negative evidence. In other words, it does not know whether it is learning the $\{CV\}^*$ language L, or some $\{CVC\}^*$ language L_c. (The former language is a subset of the latter, this is why this is called the Subset Problem.) Yet all the available evidence seems to show that children who learn a language such as L, will assume that closed syllables are disallowed: the subset language is assumed, unless we find (positive) evidence that we need to assume the superset.

Within OT, there is an obvious way of handling this, viz. by assuming that initially the markedness constraint NOCODA dominates the faithfulness constraints MAX-C and DEP-V. More generally, we may assume, once again, that the initial state is one in which all faithfulness constraints are outranked by all markedness constraints. This will give a grammar which has precisely one output for all inputs, viz. the most unmarked form of the language (say [ta] or [ti] or something similar). Only if we find positive evidence that something more marked is possible, we can rerank one markedness constraint and one faithfulness constraint to get the desired result.

We thus see that two problems of language acquisition (the Jakobsonian Generalisation and the Subset Problem) can be solved at the same time by the same assumption, viz. that initially markedness dominates faithfulness. But this assumption only makes sense if we can really distinguish the two types of constraints. The distinction between faithfulness and markedness constraints also plays a role in the analysis of other phonological phenomena as well. Itô & Mester (1995, 2001) have argued that we can use this distinction also to understand the 'stratal' organisation of the lexicon in natural language. In many languages, there is a distinction between native words and loanwords, for instance. Rougly, loanwords are more exceptional than native words. We can understand this in the following way: for loanwords some faithfulness constraints are higher-ranked than for native words.

Itô & Mester study languages such as Japanese and Korean in which the structure of the lexicon is more refined than a mere distinction between loanwords and native words. Their theory of lexical strata is roughly as follows. All the markedness constraints in a given language have a fixed ranking $M_1 \gg M_2 \gg \ldots \gg M_n$. The faithfulness constraints can be reordered with respect to this fixed ranking. In the more 'native' parts of the lexicon, we will have lower-ranked faithfulness, in the more 'foreign' (or learned) part of the lexicon, we will have higher faithfulness.

An example from Jamaican Creole (Meade, 2001; Itô & Mester, 2001) may illustrate this point. This is an English-based creole in which several phonological processes apply optionally to acrolectal forms. Thus we have a process of cluster simplification (e.g., [st]ick → [t]ick) and a process of hardening of voiced interdentals (e.g., [ð]at → [d]at). Acrolectal [ðat stik] (*that stick*) thus appears as basilectal [dat tik]. Interestingly, we also find the mesolectal form pronunciation [dat stɪk] (with hardening but without simplification) but the fourth logical possibility *[ðat tɪk] (i.e., with simplification but without hardening) is not attested.

Meade (2001) and Itô & Mester (2001) view this as evidence that there is a fixed ranking of the markedness constraints (36a), and ranking faithfulness relative to this gives us exactly the three attested varieties (36c):

(36) a. *ð≫*CLUSTER
b. not attested: *[ðat tik]

c.	← Faith-C (acrolect)	no hardening no simplification	[ðat stik]
|			
*ð			
|	← Faith-B (mesolect)	hardening no simplification	[dat stik]
|			
*CLUSTER			
|	← Faith-A (basilect)	hardening simplification	[dat tik]
|			

The only way in which we could get the unattested form in (36b) would be by reranking the markedness constraints, but apparently this option is not available to us. We thus need to be able to refer to the difference between markedness and faithfulness constraints in order to describe this.

There is a third way in which the distinction between the two types of constraints is relevant, but this is very close to what we have just seen. In van Oostendorp (1997) it is argued that differences between styles of speech (i.e. between more formal and more informal speech levels) within a language can be understood by reference to this distinction. E.g., in Dutch, we can distinguish between at least three styles of speech with respect to the behaviour of vowel reduction. In the most formal variety the word *fonologie* 'phonology' is pronounced as [fònoloɣí] without reduction; in a slightly less formal variety we find [fònəloɣí], with the posttonic vowel reduced; in the most informal variety we find [fònələɣí], with all unstressed vowels reduced. Unattested is the form [fònoləɣí], with only the pretonic unstressed vowel reduced. We can understand this, again, by assuming there is a fixed ranking of markedness constraints, and that faithfulness constraints can be reranked with respect to these constraints according to the (possibly universal) principle in

(37) a. The more formal the style of speech, the higher ranked faithfulness constraints are.

b.	← Faith-C (formal)	no reduction	[fonoloɣi]
|			
*POSTTONICFULL			
|	← Faith-B (informal)	reduction of post-tonic	[fonəloɣi]
|			
*UNSTRESSEDFULL			
|	← Faith-A (very informal)	full reduction	[fonələɣi]
|			

The principle in (37a) also applies to the Jamaican Creole case, if we assume that the acrolect is the more 'formal' variety and the basilect the more 'informal'. This shows the conceptual similarity between the difference between (learned) loanwords vs. native words on the one hand, and formal vs. infor-

mal speech on the other. These differences can both be described in terms of the relative ranking of faithfulness vis à vis markedness.

In the ideal case, this would be reflected in a formal distinction between the two types of constraints. Correspondence Theory allows us to do this:

- *Faithfulness constraints* refer to correspondence relations between input and output.[4]
- *Markedness constraints* refer to output representations.

Even though it was customary to refer to faithfulness vs. markedness constraints already in the Containment literature, it is not clear how we could make a sharp formal distinction between the two types of constraints there. We will see later on, however, that the distinction sometimes becomes blurred in further developments of Correspondence Theory as well.

3.5 String-based correspondence

McCarthy & Wolf (2005) propose a formalization of Correspondence Theory which is based on a slightly different conception of phonological representations. In their view the correspondence relation does not hold over segments, but over strings and substrings, including the empty string $\varnothing$.

Every string (e.g. every string of segments) can be decomposed in an infinite number of substrings, if we include the empty string. E.g. the string abc can be decomposed as:

(38) $< abc >, < ab, c >, < a, bc >, < a, b, c >, < abc, \varnothing >, < ab, \varnothing, c >, < ab, \varnothing, c, \varnothing >, \ldots$

Because we can add an unbounded number of $\varnothing$'s anywhere, there is actually an infinite number of decompositions for any given string. We can decompose both the input and the output in this way, and input-output correspondence can then be established on substrings in stead of on segments. To take the following (nonsensical) example:

(39)

input	ab	$\varnothing$	c
	|	|	|
output	a	b	c

In this example input ab thus corresponds to output a, and the empty string in the input corresponds to b in the output. This candidate will probably

[4]Strictly speaking, this makes only MAX and DEP constraints into real faithfulness constraints within Correspondence Theory, because only they can be understood by reference to the existence of correspondence relations alone. In order to check, e.g. IDENT or LINEARITY constraints, we also need to look at the content of the input and output representations. We will ignore this technical problem.

never win under any circumstances since there is a simpler input pair where a corresponds to a, b to b, etc., but this is a possible candidate nevertheless. In the typical case, every substring will correspond to exactly one segment, because of faithfulness constraints such as UNIFORMITY and INTEGRITY requiring this.

Deletion is now defined as correspondence of an input segment x to a $\varnothing$ in the output; insertion is defined as correspondence of input $\varnothing$ to an output y. A candidate looks as follows:

(40)

Input	*Output*	*Correspondence*
$\mathrm{t}_\alpha\ \mathrm{a}_\beta\ \mathrm{k}_\gamma\ \mathrm{p}_\delta\ \varnothing_\epsilon$	$\mathrm{t}_a\ \mathrm{a}_b\ \varnothing_c\,\mathrm{p}_d\ \mathrm{ə}_e$	$\mathscr{C}(t_\alpha, t_a)$ $\mathscr{C}(a_\beta, a_b)$ $\mathscr{C}(k_\gamma, \varnothing_c)$ $\mathscr{C}(p_\delta, p_d)$ $\mathscr{C}(\varnothing_\epsilon, \mathrm{ə}_e)$

The correspondence relation is a *bijective function* in this case, roughly because everything in the input corresponds to something in the output and vice versa. This is different from the representation in segment-based correspondence (40) where the deleted and inserted segments have no correspondents in the other representation.

This also means that the constraints against insertion and deletion no longer refer to the correspondence relation. MAX and DEP are now formalized as follows (the notation has been simplified slightly):[5]

(41) a. MAX
Given a candidate $< i, o, \mathscr{R} >$ (i an input, o an output representation and $\mathscr{R}$ a correspondence relation)
for every string S in o where $S = \varnothing$: assign a violation mark.

b. DEP
Given a candidate $< i, o, \mathscr{R} >$ (i an input, o an output representation and $\mathscr{R}$ a correspondence relation)
for every string S in i where $S = \varnothing$: assign a violation mark

[5] In McCarthy & Wolf (2005), these constraints are actually not defined on the strings themselves, but on the segments in the strings corresponding to them. So in the definitions given here, every empty element in the decomposition of the output gives exactly one violation mark. In McCarthy & Wolf (2005)'s definition, it would give two violation marks if it corresponded to an input string which itself corresponded to one violation mark. McCarthy & Wolf (2005) has as a problem that for every input, there will be an infinite number of winning candidates. Suppose for instance that the input output pair /ab/ - [ab] is winning; this will correspond to the candidates $< i =< a, b >, o =< a, b >, \mathscr{R} =<< a, a >, < b, b >>>$, $< i =< a, \varnothing, b >, o =< a, \varnothing, b >, \mathscr{R} =<< a, a >, < \varnothing, \varnothing, >, < b, b >>>$, $< i =< a, \varnothing, b >, o =< a, \varnothing, \varnothing, b >, \mathscr{R} =<< a, a >, < \varnothing, \varnothing, >, < \varnothing, \varnothing, >, < b, b >>>$, ... None of these will violate any more faithfulness constraints than the original form.

It is of some interest that in this case, the constraint MAX is again a markedness constraint in some sense: it refers to a decomposition of the output alone. We have seen above that also in the Containment formulation of the constraint against deletion this is formally a markedness constraint.

The main reason for proposing this reformulation of Correspondence is that it allows us to define the notion *null parse* (section 2.3): it is a candidate for which $\mathscr{R}$ is not a bijective function. The relevant constraint reads as follows:

(42) MPARSE Given a candidate $< i, o, \mathscr{R} >$
if $\mathscr{R}$ is not a total bijective function from i to o,
assign a violation mark.

In particular, the candidate $< i =< a, b >, o =<>, \mathscr{R} =<>>$ will violate MPARSE, but no other constraints. It violates MPARSE because $\mathscr{R}$ is empty, hence it does not contain any counterparts for the input substrings a and b. It violates no faithfulness constraints, because there are no $\varnothing$s in either i or o; but it also violates no markedness constraints, since there is nothing in the output, and markedness constraints can only penalize structure in the output.[6] Furthermore, McCarthy & Wolf (2005) argue that this is the *only* candidate violating MPARSE which has this property of satisfying all other constraints. Other candidates will by necessity always have some segment in the output — this is more marked than having nothing at all — or otherwise contain an empty string – which will cause a faithfulness violations. All candidates violating MPARSE are thus harmonically bounded by the one form with an empty output. This is why violating MPARSE will always cause the form to be unpronounced.

Here is an example from Swedish (Iverson, 1981; Rice, 2005). Adjectives get a

(43) a. *en rysk* (MASC) *pojke* 'a Russian boy'
b. *et rysk-t* (NEUTER) *barn* 'a Russian child'

However, if the adjectival stem ends in /d:/, the neuter form simply becomes impossible:

(44) a. *en rädd* (MASC) *pojke* 'a scared boy'
b. **et rädd-t* (NEUTER) *barn* 'a scared child'

[6] There are a few markedness constraints which can be formalized in such a way that absence of structure could violate it; for instance if we define constraints on word minimality as a constraint saying that every output should contain at least two syllables, it would cause a problem. As far as I can see, such constraints can always be reformulated (e.g. in conditional terms: if we have a phonological word, it should contain at least two syllables).

In cases like this, we thus have a gap in the paradigm. The string-based analysis now runs as follows. We assume that the gap is due to an OCP effect on the feature coronal. Furthermore, other ('phonological') options of resolving the OCP, for instance mapping the stem /d:/ and suffix /t/ into one segment, are not available because of high-ranking faithfulness constraints such as UNIFORMITY. We then have the following tableau ('⊙' represents the null parse in the tableau):

(45)

/räd:/+/t/	OCP(cor)	UNIFORMITY	MPARSE$_{/t/}$
☞⊙			*
räd:t	*!		
rät:		*!	

The only way to solve the conflict between markedness and faithfulness, is to say nothing at all. (This implies that in many languages MPARSE will have a fairly high ranking, because otherwise there would be many gaps.)

The possibility to produce this single candidate ⊙ comes at a considerable cost if we consider computational power: there are many more candidates in the universe than even within segment-based Correspondence Theory. Consider for instance the input /ta/. As in most versions of faithfulness theory, there is in principle an infinite number of possible output strings, including {∅, t, a, ta, i, ti, pa, pi, tat, tata, ...}. But in this theory every possible output string corresponds to an infinite number of candidates. Let us take the output [ta] as an example. Since we can decompose the string ta in an infinite number of ways, we get an infinite number of output candidates:

(46)

candidate	input	output
1.	$< ta >$	$< ta >$
2.	$< ta >$	$< t, a >$
3.	$< t, a >$	$< ta >$
4.	$< ta >$	$< ta, \varnothing >$
5.	$< ta, \varnothing >$	$< ta >$
6.	$< t, a >$	$< t, a >$
7.	$< t, a >$	$< t, a, \varnothing >$
8.	$< t, a, \varnothing >$	$< t, a, \varnothing >$
9.	$< \varnothing, t, \varnothing, a, \varnothing >$	$< \varnothing, t, \varnothing, a, \varnothing >$
...	...	...

There is an infinite number of ways to decompose the input and an infinite number of ways to decompose the output, and every decomposition of the input can be combined with any decomposition of the output. But even this brings no end to our multiplications, because every input-output pair in (46)

corresponds to a large number of candidates, because of the correspondence function. Here are the candidates corresponding to number 6. in (46):

(47)

candidate	input	output	correspondence relation
6.01.	$< t, a >$	$< t, a >$	$<>$
6.02.	$< t, a >$	$< t, a >$	$<< t, t >>$
6.03.	$< t, a >$	$< t, a >$	$<< t, a >>$
6.04.	$< t, a >$	$< t, a >$	$<< a, t >>$
6.05.	$< t, a >$	$< t, a >$	$<< a, a >>$
6.06.	$< t, a >$	$< t, a >$	$<< t, t >, < a, t >>$
6.07.	$< t, a >$	$< t, a >$	$<< t, t >, < a, a >>$
6.08.	$< t, a >$	$< t, a >$	$<< t, a >, < a, t >>$
6.09.	$< t, a >$	$< t, a >$	$<< t, a >, < a, a >>$
6.10.	$< t, a >$	$< t, a >$	$<< t, t >, < t, a >>$
6.11.	$< t, a >$	$< t, a >$	$<< a, t >, < a, a >>$
6.12.	$< t, a >$	$< t, a >$	$<< t, t >, < t, a >, < a, t >>$
6.13.	$< t, a >$	$< t, a >$	$<< t, t >, < t, a >, < a, a >>$
6.14.	$< t, a >$	$< t, a >$	$<< t, t >, < a, t >, < a, a >>$
6.15.	$< t, a >$	$< t, a >$	$<< t, a >, < a, t >, < a, a >>$
6.16.	$< t, a >$	$< t, a >$	$<< t, a >, < t, t >, < a, t >, < a, a >>$

The number of correspondence functions for any given input-output decomposition is never infinite, but it can become very large. For an input and output both decomposed into two substrings, as in example (47), the number of candidates is 2^{2^2}. More in general for an input which is decomposed into n substrings and an output decomposed into m substrings, the number of possible correspondence functions is 2^{n^m}. For the decomposition 9 in (46) there are already $2^{5^5} = 33,554,432$ possible correspondence relations. (There might be ways to reduce the number of candidates to consider, of course, but these need to be worked out.)

4 Positional faithfulness

One of the most succesful extensions to faithfulness theory is so-called 'positional faithfulness': faithfulness constraints which are relative to certain phonological positions. Since these more specific constraints are freely rankable, they can force more faithfulness on those specific positions than for others. The term is coined by Beckman (1998), who also provided many examples.

The positions concerned are typically the more prominent positions in the output: the first segments of the word, the stressed vowels, the morphological roots. Positional faithfulness says that these positions in principle support more contrast than less prominent positions in the word. These

constraints thus express the intuition that prominent positions allow more complex (marked) structure than non-prominent positions. This observation is sometimes explained functionally, by reference to the fact that either it is 'more important' to hear contrasts on prominent positions, or that is 'easier' to do so.

Positional faithfulness resembles markedness, since it refers crucially to the structure (distinctions between positions) of the output. It has as an effect that some marked vowels and consonants can occur in prominent positions, but not in less prominent positions. We will see below that at least in some cases an alternative to position-specific faithfulness accounts may be found in position-specific markedness.

Even though most proposals have been made within Correspondence Theory, not many things seem to depend on that particular choice, but we will keep to its notation here.

4.1 First position faithfulness

In many languages with vowel harmony, the first syllable (the first vowel) in the word seems to be different from other positions, in that it supports more contrast. For instance, vowels of all vowel heights can occur in the first syllable of the word in Shona (a Bantu language spoken primarily in Zimbabwe, (48a)); but in non-initial syllables, mid vowels can only occur if they are preceded by other mid vowels (48b).

(48) a. *Initial vowel*

High	*ipa* 'be evil', *bvuma* 'agree'
Mid	*pera* 'end', *sona* 'sew'
Low	*shamba* 'wash'

b. *Non-initial mid vowels* only occur after initial mid vowels:
tonhor- 'be cold', *buruk-* 'dismount', *pember-* 'dance for joy', *simuk-* 'stand up' (**simek*), *charuk-* 'jump over/across' (**charok*)

The actual pattern is more complicated, as Beckman (1998) explains, but we will not go into the details here. We can now describe the facts as follows. We represent vowel height with the features [±low] and [±high] (mid vowels are represented as [-high,-low]). There is a markedness constraint against mid vowels, *MID, as well as markedness constraints against high and low vowels (*HIGH, *LOW). These constraints dominate at least one faithfulness constraint, IDENT-[high]. If *MID≫*HIGH, this means that mid vowels will turn into high vowels (we assume that IDENT-[low] is unviolated in Shona):

(49)

/charok/	*MID	*HIGH	IDENT-[high]
☞[charuk]		*	*
[charok]	*!		

In order to save the initial vowel from changing, we introduce a high-ranking faithfulness constraint on the first syllable:

(50) a. IDENTσ_1-[high]: a segment in the first syllable in the output should be identical in its specification for [high] to its correspondent in the input.

b.

/pera/	IDENTσ_1-[high]	*MID	*HIGH	IDENT-[high]
☞[pera]		*		
[pira]	*!		*	*

If a mid vowel follows another mid vowel, it can share the feature specification of the preceding mid vowel. Actually, high vowels following mid vowels will be forced to be subject to feature spreading. The two vowels together will only give one violation of *MID since the offending feature configuration is shared. Yet a form without spreading will violate the constraint *HIGH as well:

(51)

/pembir/	IDENTσ_1-[high]	*MID	*HIGH	IDENT-[high]
☞[pember]		*		*
[pembir]		*	*!	
[pimbir]	*!		*	*
[pimber]	*!		*	**

(Note that this account crucially depends on an autosegmental representation of height features, since otherwise *pember* would fatally have two violations of *MID.) This prediction conforms to the facts, since high vowels are indeed disallowed after mid vowels in Shona.

We have noted above that positional faithfulness incorporates some aspects of markedness, since it refers to the structure of the output. An alternative account, which is based on positional markedness and only general faithfulness constraints is readily available. Such an approach might be based on the idea of *positional licensing* (Zoll, 1998; Walker, 2001):

✓ LIC(F, S-Pos): Feature specification [F] is licensed by (dominated by) strong position S.

It is not hard to see that if we replace IDENTσ_1-[high] and *MID in the tableaux above by LIC(Mid, σ_1), we get the same outcome. It has been argued that this

approach is actually empirically superior to the positional faithfulness account. There is one difference in prediction: positional licensing claims that in some languages the feature specification of mid vowels from later syllables should spread or migrate towards the initial vowel, so that it can be licensed there. Positional faithfulness makes no such prediction: to the contrary, the initial position should stay immune to spreading since it is more faithful.

The predictions of positional licensing turn out to be just right for prefix height alternations in Esimbi, a Bantoid language spoken in Cameroon (Hyman, 1988; Walker, 2001). This language has an infinitive prefix /u/- underlyingly, and roots with underlyingly high, mid or low vowels. On the surface, the prefix takes up the height specification of the root vowel, which itself turns high. A low vowel stem similarly lowers the prefix vowel[7]

(52)

Root vowel	Underlying	Surface
High	*u-ri* 'eat'	[uri]
	u-zu 'kill'	[uzu]
Mid	*u-se* 'laugh'	[osi]
	u-to 'insult'	[otu]
Low	*u-rɛ* 'daub'	[ɔri]
	u-hɔ 'knead'	[ɔhu]

Clearly, this cannot be analysed by positional faithfulness, since no vowel stays faithful at all. On the other hand, we can analyse this by positional licensing: the features move to the initial position of the word, since this gives them a better opportunity of being licensed.

It should also be noted that this account, just like the positional faithfulness account of Shona, depends crucially on an autosegmental representation: the features migrate from one vowel to another, typically something for which we need autosegments. But this in turn means that the classical Correspondence Theory, involving IDENT constraints on segments, cannot handle this. As we just have seen, none of the vowels is faithful. So how can we explain that the prefix vowel gets precisely the features of the stem?

If we want to understand this behaviour, we need to assign to features a faithfulness life of their own. This means that we have to introduce MAX (and DEP) constraints which refer to features (see Ringen & Vago, 1988, for application of feature faithfulness to Hungarian vowel harmony). Within Correspondence Theory, this means that we need to assign separate indices to features, and to extend the correspondence relation also to them. As we have seen, there is no way to capture feature faithfulness within Containment Theory.

[7] Something similar happens to another high vowel suffix; there also is a low vowel suffix which has a slightly more complicated behaviour.

4.2 Head position faithfulness

Another type of 'prominent' position within the word is obviously the syllable bearing stress. This prosodic prominence often corresponds to the allowance of more marked structure. It is often the case that a language allows for more, and more marked, vowels in stressed position than in unstressed position. For instance, Russian has six different vowels /i ɪ e a o u/, but in (certain) unstressed syllables, only the peripheral vowels /i a u/ are allowed, causing alternations such as the following (Alderete, 1999a).

(53)

Nom. Sg.	stól	slóv-o
Gen.	stal-á	slóv-a
Dat.	stal-ú	slóv-u
Instr.	stal-óm	slóv-om
Loc.	stal-é	slóv-e
	'table'	'word'

We can understand this phenomenon if we assume that /o/ turns to [a] when in unstressed position. This obviously can be modelled by a positional faithfulness constraint IDENTσ'-[low] ('the value for low may not be changed in a stressed position'). If this constraint is high ranking, it will make sure that the mid vowel in *stól* can stay, while other mid vowels have to go if (general) faithfulness is sufficiently low ranking:

(54)

/stol/	IDENTσ'-[low]	*MID	Faith
☞[stól]		*	
[stál]	*!		*
/stol/+/á/			
[stolá]		*!	
☞[stalá]			*

But again a positional markedness alternative presents itself readily: if we replace IDENTσ'-[low] and *MID above by LIC(Mid, σ') ('a mid vowel should be licensed by a stressed syllable') we get again the right result.

(55)

/stol/	LIC(Mid, σ')	Faith
☞[stól]		
[stál]		*! *
/stol/+/á/		
[stolá]	*!	
☞[stalá]		*

And again, there is actually evidence that we need positional licensing independently from vowel harmony. An example of this is Ascrea Italian (Maiden, 1991; Walker, 2004), where stressed mid vowels in the stem raise to high if they are followed by a high suffix:[8]

(56)		Nonhigh post-tonic	High post-tonic
	a.	*sórda* 'deaf (f sg)'	*súrdu* 'deaf (m sg)'
	b.	*véʃte* 'this (f pl)'	*víʃti* 'this (m pl)'
	c.	*u̯édoa* 'widow (f sg)'	*u̯íduu* 'widower (m sg)'
	d.	*metésse* 'reap (1sg impf. subj.)'	*metíʃʃi* 'reap (2sg impf. subj.)'
	e.	*prefónna* 'profound (f sg)'	*prefúnnu* 'profound (m sg)'

Again, the most natural assumption is that the stressed vowel is underlyingly mid, but it turns into high in the context of a high vowel (as do intermediary vowels). The stressed vowel thus is unfaithful, but still the positional asymmetry shows up.

The argument is a little more complicated in this case, however, since there are also phenomena which are more difficult to understand as instances of positional markedness. An instance of this is the interaction between epenthesis and stress in the Mississippi Valley Siouan language Dakota (Shaw, 1976; Alderete, 1999a). Stress usually falls on the second syllable of the word in this language (57a), but epenthetic vowels form a systematic exception to this (57b):

(57) a. *čhi-kté* 'I kill you'
ma-yá-kte 'you kill me'
wičhá-ya-kte 'you kill them'

b. /ček/ → [čéka] 'stagger'
/khuš/ → [khúža] 'lazy'
/čap/ → [čápa] 'trot'

What is the source of this systematic set of exceptions? Positional faithfulness has an answer. Normally, epenthesis is prohibited by a DEP constraint; but this constraint is obviously outranked in Dakota by some other constraint (say, NOCODA) since we do find epenthesis. But now suppose that there is a positional faithfulness constraint DEP-σ' ('an segment in a stressed syllable in the output should correspond to an input segment'). If this is ranked above the constraint(s) which place stress normally on the second syllable in the word, we get the type of exceptions that we can observe here.

[8]Notice that there is an interesting twist here for markedness theory, since in this case it seem to be the high vowels that are restricted in their distribution, rather than the mid vowels, as in the previous cases.

Positional licensing does not have anything to say about this, since epenthetic segments are not different from other vowels within Correspondence Theory, hence they will have no special faithfulness requirements. A markedness account would only be possible if we could somehow distinguish epenthetic vowels from underlying vowels on the surface. Notice that this would indeed be possible and even quite plausible under Containtment ('empty vowels cannot be heads of stress feet'), but this theory does not distinguish between markedness and faithfulness in the first place.

4.3 Root position faithfulness

In the previous two sections we have looked at positions which were prominent for phonological reasons (because they were initial or because they were stressed). Another cause of segmental prominence is morphological: segments in a root can be considered more prominent than segments in an affix, and (therefore) root segments are more strongly faithful than affix segments. This idea of morphological positional faithfulness is a relatively old one within the OT literature; it can be traced back to McCarthy & Prince (1995a).

It has been observed that in many languages the sets of vowels and consonants that can occur in affixes is more restricted than what can occur in roots. For instance, pharyngeal consonants are allowed in Arabic roots, but not in Arabic affixes. We can conveniently describe this state of affairs if we suppose that there is a separate set of faithfulness constraints on roots. (We could furthermore argue either that there also is a separate set of faithfulness constraints on affixes in which case there has to be a universal ordering $\text{FAITH}_{Rt} \gg \text{FAITH}_{Af}$, or that there only is a set of general faithfulness constraints).

Root faithfulness can possibly also be used to understand certain aspects of vowel harmony. In particular, there seem to be rougly two types of vowel harmony. For the first type, morphological structure is invisible and harmony simply applies left-to-right or right-to-left within the word. For the second type, morphological structure is relevant. In such languages, harmony always apply from the inside-out: the harmonic feature spreads from the stem to the suffix, and not the other way around.

The Western Chadic language Tangale may illustrate this point Bakovic (2000, 2003). This language has [±ATR] vowel harmony. What this means, is that suffixes adapt to the root, not the other way around:

(58) a. /$\sqrt{}$tug + ɔ/ →[tugo] 'pounding'
b. /$\sqrt{}$wʊd + ɔ/ →[wʊdɔ] 'farming'
c. /$\sqrt{}$ɗob + ʊm + gʊ/ →[ɗobumgu] 'called us'
d. /$\sqrt{}$tɛŋl + ʊn + gɔ/ →[tɛŋlʊngɔ] 'misled me'

In order to explain this behaviour, we could again refer to morphological positional faithfulness. A caveat is in order here, since in vowel harmony it is not usually the root which decides, but rather the *stem*. We can see this in another language with vowel harmony, Turkish. In this language, suffix vowels adapt to stem vowels with respect to rounding and backness. Some suffixes (such as nominalising *-gen*) are disharmonic, i.e. they do not adapt themselves to the stem. Two observations are important: (i) the stems also never harmonize to these suffixes, and (ii) suffixes that follow *-gen* do not harmonize to the root, but to the suffix, i.e. to the last part of the stem. The first observation shows that there is really an asymmetry between affixes and stems ('stem control'), but the latter shows that it is the *stem* rather than the *root* that counts.

(59) a.

	nom.sg.	*gen.sg.*	*nom.pl.*	*gen.pl.*
'rope'	ip	ipin	ipler	iplerin
'girl'	kız	kızın	kızlar	kızların
'face'	yüz	yüzün	yüzler	yüzlerin
'stamp'	pul	pulun	pullar	pulların
'hand'	el̥	el̥in	el̥ler	el̥lerin
'stalk'	sap	sapın	saplar	sapların

b. i. *üç* 'three', *üç-gen-ler* 'triangles'
ii. *altı* 'six', *altı-gen-ler* 'hexagonals'
iii. *çok* 'many', *çok-gen-ler* 'polygonals'

It is not immediately obvious how we can formalize the relevant constraint: how does it see which part of the output representation in (59b) is a stem and which part is an affix? Somehow we need a way to describe the 'cyclic' nature of this phenomenon (the fact that every combination of stem plus affix). We will return to this issue in the chapters to follow.

Let us for now briefly return to the simpler case of *roots* versus affixes. This is simpler, since roots are obvious morphological categories, which are present in the underlying representation. We have to make sure, however, that Gen does not change this: if a vowel which is part of a suffix underlyingly would be permitted into part of the root on the surface, the analysis would become severely complicated. This is where another central tenet of Optimality Theory (which is not very often discussed, but which will turn out very important in chapter 8):

Definition 10 (Consistency of Exponence) *No changes in the exponence of a phonologically-specified morpheme are permitted.*

This principle says that the morphological affiliation of every phonological element stays constant. A vowel which belongs to an affix underlyingly will

belong to that affix in all surface representations (at least those in which it occurs). McCarthy & Prince (1993) note that this implies that

> epenthetic segments posited by Gen will have no morphological affiliation, even if they are bounded by morphemes or wholly contained within a morpheme.

Interestingly, this gives us a new way of accounting for the Dakota case in section 4.2. We now have a way of seeing the morphological affiliation of segments on the surface, which means we could now formulate a positional markedness constraint to describe this phenomenon after all:

☞HEADMORPH: The heads of prosodic constituents need to be morphologically affiliated.

5 Output-output correspondence

5.1 Cyclic effects as transderivational faithfulness

Until this point, we have concentrated on faithfulness between input and output representations, with a short digression to faithfulness between base and reduplicant. It has been proposed by a number of researchers (Benua, 1997; Burzio, 1994, 1998, 2003; Kager, 1999a,b; Kenstowicz, 1996), however, that faithfulness relations can also hold between individual words. One crucial reason to do this is to capture so-called cyclic effects. We have already seen an example of this above in the analysis of stem-controlled vowel harmony, since this is one of the most well-known cyclic effects.

A classical example is the difference between the English words *condensation* and *compensation*. (The relevance of the example is not uncontested, but we will use it here for illustrative purposes.) These words have virtually the same segmental makeup, but there stress pattern is different, and so is schwa reduction as a consequence of this: *condɛ̀nsátion* versus *còmpənsátion*. According to this analysis, the reason for this is that the former noun is related to the verb *condɛ́nse*, whereas the latter is related to *còmpənsáte*. These relations are reflected in the stress structure of the verbs.

The SPE account of this would run along the following lines. We first derive the stress structure of the verbs, then we attach the suffixes and — on the next cycle — we get the stress structure of the nouns.

(60)	underlying	*compensate*	*condense*	
		↓	↓	stress assignment
		còmpənsáte	*condɛ́nse*	
		↓	↓	nominalisation
		còmpənsáte+ion	*condɛ́nse+ation*	
		↓	↓	stress assignment
	surface	*còmpənsátion*	*condɛ̀nsátion*	

The working of the cycle is one of the key components of SPE phonology. It was first formulated in Chomsky *et al.* (1956) Within generative syntax (minimalism) it still survives in the form of derivational phases; it may be considered as one of Chomsky's most important contributions to our insight into linguistics. Cole (1995, p. 70) conveniently distinguishes three phenomena for which cyclicity has been invoked in the literature:

1. the failure of rule application in nonderived monomorphemic environments;
2. the application of a rule to a morphological environment which is a substring of a word;
3. rule ordering paradoxes — apparent violations of the strict linear ordering hypothesis, which requires all rules to apply in a sequence, with each rule applying only once

The third 'phenomenon' is not very interesting for analysts who do not subscribe to the stric linear ordering hypothesis; the first phenomenon will be the topic of our attention in chapter 6; here we will restrict ourselves to phenomena of the second type.

There is no obvious reason why this approach would not be feasible within Optimality Theory: cyclicity is not in any way incompatible with Optimality Theory. The reason which is usually mentioned, is that OT is essentially nonderivational, but it is not clear why this is the case: it does away with extrinsically ordered rules, but from this nothing logically follows about the rest of the organisation of the grammar. We could postulate for instance that Gen can only handle one stem plus at most one (cyclic) suffix at a time. The output of such a round could then be fed again to Gen with another suffix. We would then have two faithfulness relations: one between the underlying representation of the stems *compensate* and *condense* and their stressed forms, and one between the stem + suffix combinations and their stressed forms.

Yet such a cyclic approach to Optimality Theory has never been worked out, as far as I am aware (the only example I know is Duanmu, 1999, see below for some discussion). Effects such as this have been worked out in a slightly different way. The most worked out alternative is output-output correspondence. It is assumed that the nouns are derived from the underlying structures directly, but their surface form is also influenced by the surface forms of the corresponding verbs. This influence is formalised in terms of an 'Output-output' (O-O) Faithfulness relation, requiring the noun to be as similar to the verb as is allowed by higher-ranking constraints:

(61)

cond[é]nse	← O-O Faith →	*cond[é]nsátion*
↑		↑
I-O Faith		I-O Faith
↓		↓
condense		*condense+ation*

OO Faithfulness constraints can be formulated in Correspondence Theory as follows (Containment theory disallows them for obvious reasons):

(62) a. MAX$_{OO}$: A segment in output representation R_1 should correspond to a segment in output representation R_2.
b. IDENT-[F]$_{OO}$: If two segments S_1 and S_2 in output representations R_1 and R_2 are in correspondence, and S_1 is specified as [αF], then S_2 should be specified as [αF].
c. ...

One empirical difference between the cyclic approach illustrated above and O-O Faithfulness could be that the latter assumes that the derived form has separate access to the underlying representation as well as to the base word (there are two arrows pointing to *condensation*); cylic analyses only allow access to the base (there is only one arrow). Yet, some O-O analysts have actually denied the existence of input-output faithfulness constraints for (some) Output-Output cases.

The most important question for O-O Faithfulness is: how do we decide which words can stand in an O-O Faithfulness relation to each other. Basically three options are available:

1. Morphologically simpler words can influence morphologically more complex words.
2. Words which are morphologically related can influence each other.
3. All words can influence each other.

We will concentrate on the first and third position in sections 5.2 and 5.4 respectively. The more moderate second position will be considered in chapter 5.5.

Before we go on, it is useful to point out that both extreme positions suffer from conceptual problems. Under the first approach, it is not clear why we would impose such a restriction on the O-O faithfulness relation, which now looks suspiciously like cyclicity. In particular, the fact that morphologically more complex forms are faithful to the morphologically less complex ones cannot really be understood within O-O faithfulness. In a cyclic approach, we can relate this to the fact that the arrow of derivations point in one direction only. The third position on the other hand seems too unrestricted. Calculations become extremely complex if we have to know all the surface forms of all words in order to get the right result for one individual form. Furthermore, there is a potential problem of inifinite regress: if the structure of every lexical item influences the structure of every other lexical item, we cannot be sure that we will ever reach a stable description of a lexicon. Both problems will be discussed more in the following sections.

5.2 Cyclicity

We have seen a miniature example of cyclic behaviour in English stress. We will now look at a more complicated (and realistic) example from Palestinian Arabic (Brame, 1974; Kager, 1999b; Kiparsky, 2000). This language has a process deleting unstressed high front vowels /i/ in all syllables of the word except for the last one:

(63) a. /fihim/ 'to understand' (verb stem)
b. /fihim/+∅ → [fíhim] 'he understood'
c. /fihim/+/na/ → [fhímna] 'we understood'
d. /fihim/+/u/ → [fíhmu] 'they understood'

No consider the following form:

(64) /fihim/+∅ + /na/ → [fihímna], *[fhímna] 'he understood us'

/i/ deletion does not take place here, even though its phonological conditioning is met. Brame (1974)'s insight was that the reason for this is that structures with object clitics are built on the basis of structures which occur as independent words. He formulates the following:

Definition 11 (Natural Bracketing Hypothesis) *A substring ψ of a string ϕ is a domain of cyclic rule application in phonology only if it shows up elsewhere as an independent word sequence which enters compositionally into the determination of the meaning of ϕ.*

Since *fíhim* 'he understood' occurs independently in Palestinian Arabic (e.g. in the sentence *fíhim il-walád* 'he understood the boy'), and since it enters compositionally into the determination of [fihímna] — we have to calculate what the former means in order to understand what the latter means —, we also phonologically determine the structure of 'he understood' in order to get the structure of the whole form. On the other hand, *fíhim* 'he understood' itself derives from the verbal stem *fihim*, but this is not a separately pronounceable word, hence it cannot influence the structure of the stem in any way.

Note that the example looks very much like the English case discussed above, except that in English we were dealing with vowel reduction rather than vowel deletion. There is another difference as well: for the English case we could assume that it would be the stress which is transferred from the base to the extended form and that there would be some secondary stress on the [ɛ] in *condensation*, blocking its reduction. Yet it has been shown by Kenstowicz & Abdul-Karim (1980) that this is not true for the Palestinian dialect of Arabic. There is no trace of secondary stress in the cliticised form.

This becomes apparent in parallel forms with other vowels than /i/. These vowels are not deleted, and words like *ḍarábna* are ambiguous between the meaning 'he hit' and 'he hit us'.

The cyclic analysis can be mimicked with Output-Output Faithfulness. Kager (1999b) assumes that OO Faithfulness runs from a 'base' to a derived form. The base is defined in accordance with Brame's Natural Bracketing Hypothesis:

Definition 12 (Base) *a. The base is a free-standing output form — a* word
a. The base contains a subset of the grammatical features of the derived form.

The first part of the definition follows from the assumption that cyclicity is O-O faithfulness; the second part makes explicit the notion *base*. The form *fhímna* 'we understood' does not have a base in the relevant sense. The verbal stem *fihim* cannot function as such, since it is not a word. *fíhim* 'he understood' is a word, but its features are not a subset of those of the derived word; it contains [3Person, +Singular], not present in the input.

Kager (1999a) claims that it is an advantage of this account over a derivational approach that it does not have to be stipulated that the cyclic domains are words. This is true, to some extent. On the other hand, we have seen above (section 4.3) that in some cases we must assume that roots are more faithful than affixes. This is formally done by a different type of faithfulness constraint, viz. Faith$_{Rt}$, but this clearly describes some form of cyclicity as well, and it is not clear that it is advantageous that root and word cyclicity are achieved by different means.

Furthermore, the second part of the definition of a base is stipulatory. We do not necessarily expect OO Faithfulness to work from the inside out. If things happened to be the other way around, we might have stipulated that bases are defined by *supersets*. Yet within a derivational theory, we do not have to stipulate this. It is clear that we have to build smaller words before we can incorporate them into bigger words and not the other way around.

Kiparsky (2000) notes that Kager's definition of 'base' runs into problems for other cases of purported OO faithfulness. In Philadelphia English (Labov, 1993), /æ/ tenses to a vowel that is transcribed as /E/ in closed syllables ending in an /s/ (as well as some other consonants). Thus the vowel in [pEs] differs from that in [pæssive]. Yet in the plural form we do find an [E]: [pEsəs]. Kager (1999a) suggests, following Benua (1997), that the reason for this is OO Faithfulness. But Kiparsky correctly points out that this is incompatible with the account of Palestinian Arabic we have just seen. First or second person singular [pEs] cannot be bases for OO Faithfulness, since they have the feature [+Singular] which is not present in the plural.

"At the root of this problem is the fact", dixit Kiparsky (2000), "that parallel OT attempts to deal with the morphology/phonology interface without a

theory of morphology." The theory only recognizes unstructured sets of morphemes as inputs and words without internal structure as outputs. There is basically no place for morphological structure (or morphological derivation) within this theory. Many previous approaches to the phonology-morphology interface were based on the assumption of *bracket erasure* (Siegel, 1974, 1978; Pesetsky, 1979; Kiparsky, 1982b; Mohanan, 1986; Inkelas, 1990; Booij, 1997), which essentially claimed that later stages could not look inside the morphological structure of their constituents. At every cycle, one was only allowed to see the immediately constituing parts, but not the parts which themselves were part of these constituents.

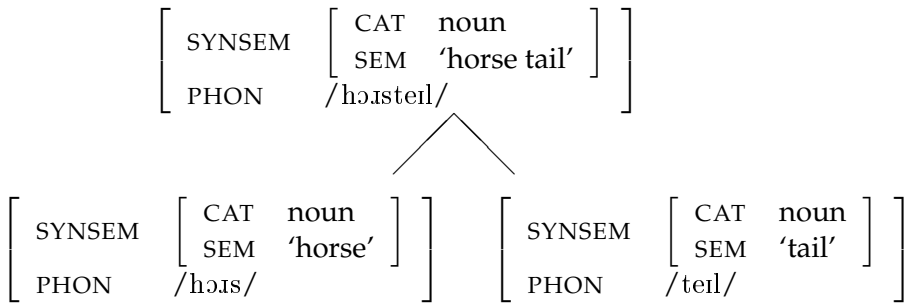
Definition 13 (Bracket Erasure) *(Pesetsky, 1979)*
Given the nested constituents
$[_n \ldots [_{n-1} \ldots]_{n-1}]_n$
the last rule of the cycle n *is: Erase brackets* $n-1$

O-O approaches using a notion of *base* as defined above, are not restricted by Bracket Erasure. The smaller constituent parts can also be independent words, in which case they will be able to influence the bigger words, but this does not happen in natural language. A well-known example is that the stress pattern of *orìginálity* may be influenced by *orígina*l, but not by the even small constituent *órigin*. It is even hard to see a way in which we could restrict the theory so that it does not see the internal structure of words. In the absence of compelling empirical evidence that we do indeed need to broaden the range of possible effects strongly, this seems a weak point of this theory (see Potts & Pullum, 2002, for a formal statement of this argument).

We may also note that OO Faithfulness approaches exclusively deal with lexical (word-level) phonology. It is hard to conceive of a parallel to it in phrase or sentence-level phonologies. We will return to Kiparsky (2000)'s own solution to these problems in section 7.

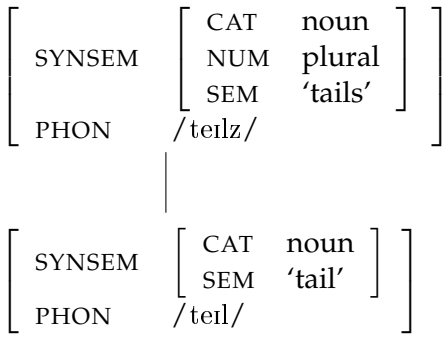
5.3 Cyclic representations

An alternative approach for describing cyclic effects within Optimality Theory can be found in the work of Inkelas (1990); Orgun (1996, 1998); Inkelas & Zoll (2005); Inkelas & Orgun (2001). This work (sometimes referred to as 'Sign-Based Morphology') assumes nodes of linguistic structure that are somewhat more complicated than what we usually find in morphology: every node contains all the information that is necessary in order to be pronounced. The structure of a compound such as *horsetail*, for instance, is roughly the following:



(65)

The assumption is that the PHON field of the top node is pronounced; it is a function of the phonologies of the two daughter nodes, which themselves may have been computed from their daughters. It is clear that Bracketing Erasure can be derived this: mother nodes only see their daughters, not the constituents which make up these daughters. The unidirectionality of cycles can also be derived: a mother node may be influenced by its daughters, but if we decide one of the daughter nodes, we will not construct the mother, so that it will not influence the independent pronunciation of the smaller structure. Natural Bracketing has also been implemented within this frameword: morphemes which are not independent words are not independent nodes in a structure. An inflected form, for instance, will be represented as follows:



(66)

Given these representations, affixes (non words) are not independent cyclic domains, hence Natural Bracketing follows. Note that this approach now involves faithfulness between all different nodes in the representation, i.e. between the values for PHON between the mother and its daughters in (65) and (66). From the point of faithfulnes theory, there thus is not much of a difference between Sign-Based theories and 'derivational' cyclic theories. Indeed, one could wonder whether more in general, these approaches are not mere notational variants with formal properties which would show up to be the same, eventually.

The problem of how to distinguish roots from stems, for instance, basically remains the same. Consider, for instance, the difference between *fhímna* 'we understood' and *fihímna* 'he understood us' in Palestinian Arabic. The

difference here would have to follow from the fact that the latter has an independently pronounceable substructure *fíhim* 'he understood', which constitutes a node of its own. Yet the former also needs to be 'faithful' to a root substructure /fihim/, but we will have to stipulate that faithfulness to this type of structure is (possibly universally) less forceful than faithfulness to independent words.

5.4 Abandoning separate inputs

A radical approach to O-O Faithfulness relations has been proposed by Burzio (1994, 1998, 2000, 2003) and a number of related works. Burzio (2000, p. 53) observes that

> reliance on OO-Correspondence by phonological analysis raises the natural question of whether morphological analysis should not just follow suit. That is, if the sound structure of *condensation* is calculated from the surface form *condense* plus *-ation*, dispensing with underlying representation (UR) altogether?

Burzio (2000)'s line of reasoning follows a number of steps. First he observes that according to Richness of the Base, the actual inputs (i.e. the lexical forms) are identical to the outputs at least in cases in which there is no alternation (cf. section 2.2). Now, if input and output are indeed identical, they form one representation, according to Burzio, and "the grammar is to be understood as a checking device (e.g. like the 'binding theory' of syntax) rather than a structure changing (or filling) one as in derivational theories" Burzio (2000, p. 55). The idea thus is that the grammar only has to interpret structures and it does not have to generate them. Interestingly, this idea is based on the reverse of what we have called Chomsky's Problem ('input-output faithfulness is never satisfied').

The next step in the argumentation is to note that we can distinguish between two aspects of the input representations. In most inputs, some specifications will be 'active' and some will be 'inactive'. 'Active' parts of the representation are needed because they force violations of faithfulness; other parts are 'inactive', those are the parts that conform to the markedness requirements in the optimal way. E.g., suppose that we have the word *tak* in a language in which *t* is the optimal consonant and *a* the optimal vowel. Then only the specifications that there is a coda consonant and that it is velar are 'active'. In derivational (underspecification) theory, it is often assumed that only the active parts of the representation are underlying, but under Richness of the Base (and Lexicon Optimisation), the only difference is that for active input IO-FAITH≫Markedness, whereas for inactive input Markedness may dominate IO-FAITH. There thus is no real reason to distinguish the two in the underlying represention. (Note that strictly speaking this means, paradoxically, that also the absence of material will be 'active' input; in the example

given above the absence of a second vowel and high ranking faithfulness will lead to the violation of the markedness constraints on word minimality).

Burzio subsequently extends this reasoning also to derived forms. Words like *electricity* have their own input, identical to the output (thus *electri/s/ity*) next to *electri/k/*). Furthermore, IO-FAITH≫OO-FAITH in these cases (i.e. of so-called Level I morphology).

Until this point, it is hard to find empirical differences between Burzio's approach and standard cyclic approaches. An important argument in favour of OO Faithfulness are so-called Multiple Correspondence effects. These are cases where a single form seems to be faithful to two other forms at the same time, there thus are two 'bases' for an output, and this obviously cannot be done in a standard cyclic way. Burzio (1998) claims that Italian provides examples of exactly this type, viz. words such as *ascens-ore* 'elevator' which are based on the participle *asces-o* 'ascended', but at the same time feature the *n* of the infinitive *ascendere* 'to ascend'. A similar line holds for *vinc-it-ore* 'winner', based on the participle *vin-t-o* 'won' and the infinitive *vinc-ere* 'to win' at the same time. The reason is, approximately, that the suffix *-óre* is always stressed in Italian — a fact which itself is due to OO Faithfulness, according to Burzio — and therefore it cannot be directly suffixed to *vint*, since this would result in stress clash. This is the reason why the alternative vowel-initial suffix *it* is chosen. Yet **vinito* would give another OO Faithfulness violation because the *n* would appear in an onset position, which it doesn't do in other parts of the paradigm. This is the reason why, instead, the alternative stem *vinc-* is chosen.

Another argument for Burzio's approach comes from paradigms such as the following:

(67)

	'go' PRES.IND.	'finish' PRES.IND.
1	vád-o	fin-ísc-o
2	vá-i	fin-ísc-1
3	vá	fin-ísc-e
4	and-iámo	fin- -iámo
5	and-áte	fin- -íte
6	ván-no	fin-ísc-ono

Again we can observe that the inflectional suffixes have the same stress in both paradigms; a result of OO Faithfulness, for Burzio. But in this case we can clearly observe that the stems also have always the same stress: *fin-* and *and-* are always unstressed, and *vá-* is always stressed. The two verbs choose different options: allomorphy for *and-/vá-*, and an optional stressed suffix *-ísc* for *fin-* (but the latter can be reduced of course to allomorphy between *fin-/finísc-* or between *-ísc/∅*).

Burzio (2003) acknowledges that there is another way of dealing with these phenomena beyond OO Faithfulness, viz. by positing disjoint inputs

for the forms in question. For instance, we could make the input representation of 'to go' something like {*and-*, *vád-*} (compare the analysis of Dyirbal on p. 22). In that case, we can give an analysis such as the following (we assume that a constraint against stress clash is inviolable):

(68)

a.{*and-*, *vád-*}+*o*	IO FAITH
ánd-o	*!
☞vád-o	
vad-ó	*!

b. {*and-*, *vád-*}+*iámo*	IO FAITH
☞and-iámo	
vád-iamo	*!
vad-iámo	*!

Burzio remarks about this: "While this solution would be adequate, it makes certain concessions to the present claims: the needed 'inputs' have all the crucial properties of the 'outputs' of the present framework: they are multiply available, and they have metrical structure, suggesting the IO-F of [(68)] is in fact just a surrogate for OO-F." But it is hard to find a criterion according to which of these analyses should be seen as a surrogate for which other. Notice that even the case of *vinc-it-ore* 'winner' could be seen as derived from a conjoined input {*vinc*, *vin* }.

We could add that there are a number of problems connected to this approach. Some of these we have already noted above: in the first place, we need a clear definition of when two forms can be supposed to be related. This becomes even more pressing since as we have seen above even suffixed like *iámo* can establish OO relations (thus, there is a relation between *andiámo* and *finisciámo*. But since there is no concept of 'suffix' in this theory, this basically means that any sequence of phonemes can establish faithfulness relations, and this is indeed the thrust of Burzio's work, but this in turn means that virtually every word is in correspondence with virtually every other word. It is not clear at all, however, what this means for the actual calculation of words. In the case of Italian verbal paradigms, for instance, we could assume a situation where all verbal stems are always stressed and all inflectional suffixes are unstressed. This would satisfy all the constraints posited by Burzio, so it is not clear why this situation does not arise.

Also, we have seen above that it can sometimes be convenient to manipulate faithfulness constraints in order to explain language variation (cf. p. 37). It happens that one word is pronounced in different ways in the same contexts even within one idiolect (see Antilla, 2002, for an overview of the literature on phonological language variation within OT). Cases like this seem to suggest that faithfulness sometimes is violated, unless we assume that for every small variation we have a separate underlying form, a highly unlikely state of affairs.

McCarthy (2003c) mentions a few other problems with approaches without underlying representations. He discusses a pattern of two alternations in

Cairene Arabic: some nouns always end in a consonant, others end in a short vowel in the end of the word and in a long vowel before a suffix.

(69) a. *abu* 'father', *abu:ja* 'my father'
kunti 'you FEM. SG. were', *ma kunti:ʃ* 'you FEM. SG. were'
b. *daras* 'he learned', *darasha* 'he learned it FEM.'

There are no other possibilities, e.g. there are no stems which uniformly end in a short vowel:

> One [problem] is the matter of inventory size: how does the grammar specify that there are two patterns and not three or four or one? [...] no satisfactory solution has yet emerged.

McCarthy (2003c) also demonstrates that there is an empirical problem with the OO analysis of Cairene Arabic. The reason for this is that there is no obvious reason why there should be long vowels before all suffixes. If we use underlying representations, we can posit that these long vowels are underlying (and shortened at the end of the word), but without underlying representations, there is no reason at all why *abu* 'father' - **abuja* 'my father', without a length alternation would not be able to occur. (We will not go into McCarthy's own IO Faithfulness analysis, since it is somewhat complicated for reasons that do not seem relevant to our present concerns.)

As a final point, we may note that OO Faithfulness does not seem to extend to phrasal phonology, e.g. to cases where one word adapts to a following word; we presumably do not want to assume that all combinations of words are stored as inputs as well, but this then means that we have cases where the inputs are not completely faithful to the output, i.e. where they are really different representations. On the other hand, Steriade (1999) discusses a case of phrasal phonology which is reminiscent of the Italian *vincitore* case discussed aboveL: French liaison. It is well known that in French there is a form of allomorphy for vowel-final masculine adjectives (among others), which take the 'feminine' form when they occur before a vowel:

(70) a. *nouvel an* 'new year' [nuvɛl ɑ̃]
(citation forms, MASC [nuvo], FEM [nuvɛl])
b. *bon endroit* 'right place' [bɔn ɑ̃dʀwɑ]
(citation forms, MASC [bɔ̃], FEM [bɔn])

Facts like this are problematic for every strict level-based approach (chapter 7) in which the output of the lexicon is determined before and forms the input of the output of the post-lexical phonology. But Steriade (1999) argues that, on top of this, the output in liaison contexts is sometimes in multiple cor-

respondence with both the masculine and the feminine citation forms. This concerns cases like the following:[9]

(71)

MASC *Liaison*	MASC *Citation*	FEM *Citation*
[pʀɛmjeʀ]˜[pʀɛmjɛʀ] *ami*	[pʀɛmje]	[pʀɛmjɛʀ]
[pʀɔʃɛ̃n]˜[pʀɔʃɛn] *arrêt*	[pʀɔʃɛ̃]	[pʀɔʃɛn]
[divɛ̃n]˜[divin] *archer*	[divɛ̃]	[divin]

The first liaison variant is the important one: it combines the vowel quality of the masculine form with the consonant of the 'feminine'. According to Steriade (1999), the reason for this is a constraint which demands the stressed vowel in a [+Masculine] output form to be identical to the stressed vowel in a [-Masculine] output form. In a cyclic approach, it is hard to see how both 'base forms' could be relevant at the same time. (Yet notice that in an approach accepting OO Faithfulness, we still need to explain why the masculine and the feminine 'citation forms' are 'bases' for the masculine liaison form, and not for the feminine; or why the masc. liaison form is not the base for the masc. citation form; etc.) Another problem we have to note here that radical OO Faithfulness approaches such as the one needed for this account seem very hard to formalize.

5.5 Optimal Paradigms

We have seen above that OO Faithfulness approaches face several problems. Most importantly, it is not clear which forms should be related to which other forms. Many researchers have restricted themselves to forms which are parts of the same paradigm. This restriction has been made explicit in McCarthy (2003b), presenting a theory of OO faithfulness called *Optimal Paradigms* (OP), which has the following basic principles:

1. Candidates consist of entire inflectional paradigms, where an inflectional paradigm contain all and only the words based on a single lexeme.
2. Markedness and input-output faithfulness constraints evaluate all members of a candidate paradigm. The violation marks incurred by each paradigm member are added to those incurred by all the others.
3. The stem (output form of the shared lexeme) in each paradigm member is in a correspondence relation $\mathscr{R}_{OP}$[10] with the stem in every other paradigm member. [...] There is no distinctive base — rather, every member of a paradigm is a base of sorts with respect to every other member.

[9] These facts are not uncontroversial, but we assume that they hold for at least some varieties of French.

[10] For the sake of uniformity, we will keep to the symbol $\mathscr{C}$ rather than $\mathscr{R}_{OP}$ below.

4. There is a set of output-output faithfulness constraints on the $\mathscr{R}_{OP}$ correspondence relation

Rather than one word, the Generator function thus generates a whole paradigm. The structure which are up to evaluation (for the English word *dog*, under the assumption that the plural is the only other form in the paradigm, and leaving out syllable structure, etc.) thus look like (72) rather than like (40):

(72)

Input	*Output*	*Correspondence*		
$\mathrm{d}_\alpha\mathrm{o}_\beta\mathrm{g}_\gamma$	$\mathrm{d}_a\mathrm{o}_b\mathrm{g}_c$ $\mathrm{d}_1\mathrm{o}_2\mathrm{g}_3\mathrm{z}_4$	$\mathscr{C}(d_\alpha, d_a)$ $\mathscr{C}(o_\beta, o_b)$ $\mathscr{C}(g_\gamma, g_c)$	$\mathscr{C}(d_\alpha, d_1)$ $\mathscr{C}(o_\beta, o_2)$ $\mathscr{C}(g_\gamma, g_3)$	$\mathscr{C}(d_a, d_1)$ $\mathscr{C}(o_b, o_2)$ $\mathscr{C}(g_c, g_3)$

An advantage of OP clearly is that we can formalize it within standard OT, without a lot of extra additions (it is not easy to draw the forms which have to be evaluated in such a simple way as (72) for more radical OO Faithfulness approaches). Another advantage is that it allows to straightforwardly formulate faithfulness relations in cases in which there is no obvious independently occurring base. E.g. which form should be assigned this role in the Latin verbal paradigm *amo, amas, amat*, etc? In OP, all forms function as 'base' for all other forms.

McCarthy (2003b) uses OP to explain a hitherto unexplained fact about Classical Arabic. In this language, all verbs fit within one of a number of different templates. All of those templates in turn have a lot of properties in common, allowing us to define a *template of templates* for Classical Arabic verbs:

(73) Template of templates for Classical Arabic verbs

$$(\mathrm{C})\left\{\begin{array}{l}\mathrm{CV}\\ \mathrm{CVC}\\ \mathrm{CV\text{ː}}\end{array}\right\}\mathrm{CVC}$$

The verb thus typically has two syllables, of which the first can be almost arbitrarily complex: it can have a complex onset and/or a coda or a long vowel. The second syllable is much more restricted however. This becomes even more apparent if we compare the verb to the Classical Arabic noun, which can have a stem ending in CVC, CVːC or CVCC (e.g. [faʕal, faʕaːl, faʕl] are all well-formed nouns, but the latter two would not be well-formed verbs). Inversely, nouns can *begin* with at most one consonant, but this restriction does not hold for verbs: [ftaʕal, staffal] are well-formed as verbs, but not as nouns. (We will not go into the restriction on nouns; it is discussed in McCarthy (2003b), where it gets essentially the same explanation as the one given here for verbs.)

We could of course postulate that this happens to be a difference between nouns and verbs, and invoke separate noun and verb grammars. Yet Mc-

Carthy (2003b) correctly points out that such a separation would be arbitrary, and furthermore we would still need to explain *why* nouns have these curious restrictions at the beginning and verbs at the end of the template. Instead of this, McCarthy (2003b) proposes to derive the differences between nouns and verbs from another, independent difference: nouns and verbs have to live in different inflectional paradigms. Nominal inflection is formed exclusively by vowel-initial suffixes (74a), but verbal inflection is much more varied and includes both vowel and consonant-initial suffixes as well as a variety of (CV shaped) prefixes (74b).

(74) a. *Nominal suffixes* (sample): *-u* NOM. SG., *-a -u* ACC. SG., *-a*: NOM. DUAL., *-u*: NOM. MASC. PL.

b. *Verbal suffixes* (sample): *-tu* 1 SG. COMM., *-a* 3 SG. MASC., *-ta* 2 SG. MASC, *-at* 3 SG. FEM., *ʔa-* NOM. SG., *na-* 3 PL. COMM.

It is clear that we can set up an OT analysis in such a way that a CVCC or CV:C stem cannot survive the confrontation with a -CV suffix: a constraint against word-internal superheavy syllables would block them. Yet before a vowel-initial suffix the last consonant of the stem could be syllabified into the onset of a syllable which would be headed by the suffix vowel. This explains then, why 'long' stems are allowed in nouns, since these are never confronted with a marked situation.

However for verbs we would expect alternations, given Richness of the Base and a standard conception of faithfulness. Consider the fate of the hypothetical input /faʕaːl/:

(75) a.

/faʕaːl/+/a/	SUPERHEAVY	FAITH-LENGTH
☞[fa.ʕaː.la]		
[fa.ʕa.la]		*!

b.

/faʕaːl/+/ta/	SUPERHEAVY	FAITH-LENGTH
[fa.ʕaːl.ta]	*!	
☞[fa.ʕal.ta]		*

We thus expect forms which have a long vowel in some contexts and short vowels in others. But this is not what we find: final vowels in verbs are always short, regardless of context. McCarthy (2003b) proposes that the reason for this is that all vowels in the paradigm stay faithful to the one which is most unmarked, i.e. in this case the one in the form with a consonant-initial suffix. In noun stems, this type of faithfulness has no work to do, since *all* suffixes are vowel-initial. This is why nominal stems are subject to a smaller number of restrictions than verbal stems.

McCarthy (2003b) points out that OP predicts that we only have 'overapplication' of phonological processes as a result of paradigm uniformity. The Classical Arabic case is an example of this: vowel shortening 'overapplies' to forms which do not satisfy its context. The reason why we can only have overapplication is that OP Faithfulness has to dominate IO Faithfulness in order to be effective. In our example:

(76)

/faʕaːl/	SUPERHEAVY	OO FAITH	IO FAITH
{ [fa.ʕaː.la], [fa.ʕaːl.ta], ... }	*!		
☞{ [fa.ʕa.la], [fa.ʕal.ta], ... }			**
{ [fa.ʕaː.la], [fa.ʕal.ta], ... }		*!	

It is easy to see that the alternating pattern would be the winner if IO FAITH≫OO FAITH. But if OO FAITH wins (so if we have paradigm effects), it will always be more advantageous to go with the paradigm in which every form goes with the unmarked shape. This is an interesting empirical prediction which at the moment still needs to be tested.

Another prediction is called *majority-rules* by McCarthy (2003b) in which the pattern that is most common in a paradigm acts as an attractor to other forms. He gives the distribution of schwa in the Moroccan Arabic verb as an example. Schwa behaves as an epenthetic vowel in this language: its distribution is predictable. The third person singular (masculine) preterite of verbs does not bear inflection; in triconsonantal stems, a schwa shows up. It does so always between the second and the third consonant (77a). Verbal stems differ in this respect from nominal stems in which the schwa also sometimes appears between the first and the second consonant, if this is what sonority requires (77b):[11]

(77) a. *Schwa epenthesis in verbal stems*: *ktəb* 'he wrote', *kbər* 'he grew', *lʕəb* 'he played'

b. *Schwa epenthesis in nominal stems*: *kəlb* 'dog', *bərd* 'wind', *ktəf* 'shoulder', *wtəd* 'peg'

As in Classical Arabic, the nominal paradigm is not very complex in Moroccan and therefore OP does not exert its influence. Yet in verbs, we again have both consonant-initial and vowel-initial suffixes. The former show up with a CCəC shape of the stem (*ʃrəbna* 'we drank', *ʃrəbti* 'you drank'), presumably because **ʃərbna* would involve a cluster of three-consonants which is too long (according to a constraint *CCC; this is the reason for epenthesis in the first place). Vowel-initial suffixes, on the other hand, prefer a CəCC base (*ʃərbu*

[11] We present the facts here as if the roots are triliterals and the schwa is the result of 'epenthesis', but McCarthy (2003b) shows that the analysis also works for inputs CəCC, CCəC and CəCəC.

'they drank', *ʃərbət* 'she drank'), because schwa does not occur in open syllables in Moroccan Arabic, excluding *ʃrə.bu*, according to a constraint *ə]$_\sigma$.

The question is: why does the 'bare' third person masculine go with the consonant-initial suffixes rather than with the vowel-initial ones? Neither *CCC nor *ə]$_\sigma$ is an issue, since both would be satisfied both by *ʃrəb* and by *ʃərb*. But there are four consonant-initial suffixes in the Moroccan Arabic verbal paradigm, and only two vowel-initial suffixes. The paradigm is more uniform if the bare form goes with the majority, because in this way there will be fewer violations of OP Faithfulness (to be precise, ((4-2)x2)=4 fewer violatons). Notice that otherwise OP Faithfulness has to dominated in Moroccan Arabic, since the paradigm is not uniform (both epenthesis sites are used).

The theory of McCarthy (2003b) is relatively simple, given Correspondence Theory, and it makes a few strong empirical predictions. Yet we also have to mention one issue which seems hard to resolve: it is absolutely essential for this theory to work that inflectional *affixes* are not subject to Richness of the Base. If we were allowed to freely postulate inflectional suffixes for both nouns and suffixes in every paradigm, we would not get the required results: nominal stems in Classical Arabic would now 'know' that they never have to deal with consonant-initial suffixes and that they therefore are free to end in consonant-clusters. Similarly, verbal stems in Moroccan Arabic would not 'know' that most of their suffixes are consonant-initial and therefore a schwa-form is preferable.

This assumption in itself is not uncommon. It may be related to the so-called 'item-and-process' view of morphology, according to which affixes do not have an underlying representation at all, but are merely introduced by rules (see Anderson, 1992, for a fairly recent formulation of this position). Yet it is not at all clear how this relates to many other proposals within OT that seem to be based on the assumption that suffixes have there own underlying representation. For instance, IO Faithfulness on affixes needs to be guaranteed in some way, in order to make sure that suffixes do not get a completely different representation from what is introduced by the morphology. On the other hand, suffixes do sometimes adapt themselves to the phonological environment (e.g. they are typically subject to vowel harmony) so that this faithfulness has to be violable. All of this seems hard to reconcile with an OP approach.

There is an empirical issue here as well. It seems to be the case in quite a number of languages of the world that stems are typically consonant-final and suffixes are typically vowel-initial. In an OP approach, we can formulate only half of this generalisation: if suffixes are vowel-initial, it is profitable for stems to be consonant-final. But we do not have any hope of ever understanding why affixes would be vowel-initial in the first place, within the OP framework. But to be fair, in most other approaches to the phonology-morphology interface the above tendency (if correct) cannot be formulated

at all.

Another issue is that OP seems to presuppose a multiple level model of phonology, or at least a distinction between lexical phonology and postlexical phonology (just like in the model of Burzio discussed above). The reason is that we have to generate paradigms before entering the postlexical phonology: in the context of a sentence, we cannot just generate a whole paradigm but we have to pick an individual form (the one that shows agreement with the other words in the sentence).

5.6 The first person singular: Insular Catalan vs. Dutch

Lloret (2004) applies the OP framework to certain facts of the Catalan verb. Her point of departure is a comparison between Alguerese (A) and Balearic (B) on the one hand, and Central (C) Catalan on the other. All three dialects have vowel epenthesis in certain illicit clusters in the noun (78a); but the dialects A and B do not have the same restictions in the first person singular form of verbs (which is without an ending), whereas the C dialect does (78b).

(78) a.

A	*B*	*C*	
sófra	sófrə	sófrə	'sulphur MASC'
séntra	séntrə	séntrə	'center MASC'
ra.táw.la	rə.táw.lə	rə.táw.lə	'altarpiece MASC'

b.

A	*B*	*C*	
éntr	ə́ntɾ	éntɾu	'I enter'
úmpr	úmpl	ómplu	'I fill'
res.táwr	rəs.táwɾ	rəs.táwɾu	'I restore'

We thus see a difference here between the nominal and the verbal paradigm which is reminiscent of what we have seen in Classical Arabic, and Lloret (2004) proposes that it can be solved in a similar vein. She assumes that the three dialects have the following verbal conjugations (for the so-called Conjugation I verbs — the other two classes we will disregard here):

(79)

	A	*B*	*C*
1SG	∅	∅	u
2SG	as	əs	əs
3SG	a	ə	ə
1PL	ém	ám	ɛ́m
2PL	áw	áw	ɛ́w
3PL	an	ən	ən

All suffixes except for the 1SG in A and B Catalan are vowel-initial in this table. Because of OP, 1SG then will also behave as if it is followed by a

vowel as well, and specifically, it will not allow vowel epenthesis.[12] The stem of Balearic 1SG séntrə+∅ would be to different from 2SG séntr+əs or 1PL sentr+ám, which do not have a vowel in the stem (and 2SG séntrə+əs is excluded because of a constraint against two unmarked vowels in a row).

It is not true that the stem of the 1SG verb is exactly identical to stems in other parts of the paradigm; Lloret (2004) lists several segmental process which distinguish it in different dialects. One of them is final devoicing, which makes this position perfectly comparable to other final positions, but different from other forms in the paradigm:

(80) a. 1SG: *aca[*p*]* 'I finish' (cf. *aca[*b*]e* 'he finishes')
b. *Other final positions*: *tu[*p*]* 'tube' (cf. *tu[*b*]et* 'tube DIM')

Obviously, this fact does not necessarily constitute a problem: the OP Faithfulness constraints against vowel insertion may be high ranked even though the OP Faithfulness constraints on consonant identity are low ranked. We might even expect this kind of phenomenon to happen if we assume that there are many OP Faithfulness constraints, and they are ranked independently.

On the other hand, Lloret (2004)'s analysis makes apparent some of the more problematic aspects of the OP paradigm. We already noted in connection to McCarthy (2003b)'s analysis that it needs to assume that affixes are given, and cannot be changed. This is crucial for Lloret (2004) as well: the analysis breaks down as soon as we postulate that the first person singular could be séntr+ə rather than séntrə+∅, i.e. that the epenthetic vowel could be part of the suffix rather than of the stem. Nothing would block the former structure within the OP paradigm.

The same problem actually holds for McCarthy (2003b)'s proposal, even though it is harder to notice it there: the dissimilarity of the stems of **ʃərb* and *ʃrəbna* only is clear if we can be absolutely sure that the vowels are parts of the 'stem', not of some infix, or something similar. We thus have to abandon the principle *Consistency of exponence* (definition 10 on page 47), and it has to be replaced by a principle stating approximately that everything which is not an affix is part of the stem. This makes it necessary to somehow see that something is an affix, but this cannot be the normal faithfulness relations, because we have just established that affixes are not sensitive to them.

Notice in this connection that the vowel in the unstressed suffixes is exactly the same as the epenthetic vowel ([a] in Alguerese and [ə] in Balearic and Central Catalan) in (79). This seems an unlikely state of affairs, and it is not a priori clear why we would not postulate that the consonants on their

[12] With Lloret (2004), we will assume that the vowel is the result of epenthesis. With some complications, the analysis would actually also work if we assume that the schwa can also be underlying, as we are forced to do, given Richness of the Base.

own are the suffixes, and the vowels are indeed epenthetic. Yet, we cannot say this within this theory, since this would force OP to be violated, and since the majority of suffixes would now actually be consonant-initial (the exceptions would still be the stressed suffixes, which have a vowel of unpredictable quality), the stem might be attracted to go with the majority, i.e. to force epenthesis rather than to block it.

In brief, the problem of an OP approach is that we have to abandon Richness of the Base. Lloret (2004) briefly discusses an alternative option, which she attributes to Mascaró (1983); Dols (2000), among others. In this view, the 1SG is not absent, but it is an empty vowel, licensing the preceding complex onset. Therefore, vowel epenthesis is not necessary in this case. Lloret (2004) points out that there is a problem with this approach: final devoicing (and other segmental phenomena) seem to clearly show that the last segment in a word belongs to a coda, not to an onset. Notice, however, that this argument only holds if we assume that the devoicing in question is *syllable final devoicing* only. Now the evidence shows that the syllable is indeed the domain of devoicing normally. However, constraints on word final devoicing presumably should also exist, as we know from the study of other languages (Steriade, 2001). Its effects may not be particularly visible in other circumstances, where its effects could always be due to other factors, but that does not mean that it could not show up here.

Interestingly, there is some evidence from Dutch dialects which seem to point exactly in the direction of this representational approach rather than paradigm uniformity. Coincidentally it also involves the first person singular *and* final devoicing. All dialects of Dutch have final devoicing just like Catalan. However, in some dialects, the 1SG form of verbs are exceptions to this. This gives us again a difference between verbs and nouns:

(81) a. *Verb*: *ik geleuv* 'I believe' [ɪkxəløv]
b. *Noun*: *geloof* 'belief' [xəløf] (cf. *geloven* 'beliefs PLUR.' [ɣəlovən])

As in the Catalan case, there are two ways of describing the difference between the verb and the noun. A *structural* analysis, on the one hand, assumes that the first person singular has some property which blocks final devoicing, e.g. an phonetically empty suffix vowel. A *paradigmatic* analysis has it that the first person singular should resemble 'related' forms as much as possible; apllication of final devoicing would increase the differences between forms in the paradigm to an unacceptable level. van Oostendorp (in press) claims that there are several problems connected to the paradigmatic (OP) analysis in this case.

i. The *dialect geography* seems to point in a completely different direction. Whereas in most Dutch dialects, the 1SG is not pronounced, in three independent areas it *is*. And the phenomenon shown in (81) is something we find *on the border* of these three areas.

It is reasonable to assume that the dialectgeography mirrors language change in these cases. But within a paradigmatic account, there is no particular reason why this geographical patterning should happen: paradigm effects could show up anywhere.

ii. The structure of the paradigm: in at least some of the Dutch cases, it is not clear at all what the voiced segments are faithful to. In some of these dialects *none* of the other endings in the present tense paradigm have a vowel (they are -/st/ and -/t/ respectively). The infinitive does have a vowel, but this raises the question which other forms exactly should be included in the paradigm. Further, even if we would include the infinitive, it is not clear why the other forms in the paradigm would not be attracted to it: if 1SG is pronounced with a [v] because the infinitive is [ɣələøvən], why is the 1PL pronounced as [ɣələøft] and not as [ɣələøvd]?

Notice that the structural approach suffers from neither of these problems. It needs to assume that the 1SG is an 'empty' vowel of some sort. Loss of inflectional schwa (reduction) may then be assumed to go through a stage where the vowel is completely empty: this explains the geographical distribution. Furthermore, the fact that other forms in the paradigm are not affected follows from the fact that these other forms do not have a 1SG ending.

We would have to assume that a relevant difference between Catalan and Dutch dialects is that the former show effects of word-final as well as syllable-final devoicing, but otherwise both systems seem to be adaptable to a structural analysis. There is a trade-off, however: we have to accept an analysis which is to some extent abstract: it postulates phonological categories which are not directly visible in the phonetics, i.e. a requires a view of phonology where the output is not directly the same as the phonetic form. The representations in OP (and other OO Faithfulness accounts) can be and should be more concrete. This does not necessarily mean that the latter are theoretically more parsimonious, however, or even less 'abstract', since they have to postulate many (invisible) correspondence relations between individual segments in all representations, and they have to assume that all these representations are available in the production of one form, even when they are not pronounced. In terms of computational extras, it might well be the 'concrete' approaches which face the most serious problems.

6 Further extensions of faithfulness theory

6.1 Sympathy Theory

When asked what is the most serious problem for Optimality Theory, most scholars would mention the issue of rule opacity: some process has applied, even though its contextual requirements have not been met on the surface; or it has not applied, even though its context was present. Such processes

(known as counterfeeding and counterbleeding, respectively) can be routinely described in an ordered-rule theory such as the one of Chomsky & Halle (1968). There rules could be said to look at representations which were different from either input or output and at which the extra representations were (or were not) present.

Some cases of apparent opacity disappear in a Containment analysis of faithfulness. An example from Sea Dayak (Kenstowicz & Kisseberth, 1979; McCarthy, 1999) illustrates this point. This language has a process of(rightward) nasal harmony, spreading nasality from a consonant to all following vowels (82a); spreading is blocked by oral consonants (82b). The language also has an optional process of consonant deletion. This makes the spreadin opaque, since deleted oral consonants still block spreading (82c):

(82) a. /naŋa/ → [nãŋãʔ] 'straighten'
b. /naŋga/ → [nãŋgaʔ], *[nãŋgãʔ] 'set up a ladder'
c. /naŋga/ → [nãŋaʔ], *[nãŋãʔ] 'id.'

For a Containment analysis, this process is not opaque at all, since there is no literal deletion in the phonology. The underlying stop (82c) may therefore stay unpronounced, but it is not absent. It could therefore still block the spreading of the feature [nasal].Yet McCarthy (1999) suggests that many cases cannot be reanalysed in this way. Yet McCarthy (1999) claims that this cannot always be the case: there are instances where we need to refer to properties which are present neither in the input nor in the output.

A well-known example comes from Tiberian Hebrew (Malone, 1993; McCarthy, 1999). This language has a process of vowel epenthesis into clusters (83a), as well as a process deleting /ʔ/ (83b). The latter process makes the former opaque: in (83c) there are examples of epenthesis which are not explicable on the basis of the phonetic surface structure alone, since the glottal stop has disappeared:

(83) a. /melk/ → [melex] 'king'
b. /qaraʔ/ → [qārā] 'he called'
c. /deʃʔ/ (→ [deʃeʔ]) → [deʃe] 'tender grass'

We need to refer here to syllable structure in order to explain the epenthesis. But this syllable structure cannot be present in the input[13] and the structure is already different in the output, since the glottal stop has gone.

[13]To be more precise, we may assume underlying syllable structure, of course, but then we need to assume as well, given Richness of the Base, that every logically possible syllabification can be present underlyingly. We need to refer, however, to a level of structure where the /ʃʔ/ form a complex coda; so the underlying representations would already have to be changed in the same direction.

Various proposals have been made to solve this problem within OT, but none of them seem to have met with general acceptance (yet). The most succesful accounts manage to introduce extra representations beyond (lexical) input and (phonetic) output. One obvious way of doing this, is by introducing derivational levels (e.g. a lexical and a postlexical level), as will be discussed in chapter 7. Here we will concentrate on another proposal, made by McCarthy (1999). In this proposal, candidate output forms can be faithful not just to the phonological input, or to other outputs, but also to designated other candidate output forms, i.e. to phonological representations which themselves never surface.

Potentially, this could render the computational problems of defining the correspondence function all but intractable since Gen produces an infinite number of candidates: we thus have $\infty \times \infty$ many pairs of candidates, and the correspondence function has to be defined on them (this is still countable infinite, but it certainly is infinite). Yet there is a straightforward way of restricting the set of relevant candidate outputs:

Definition 14 (Relevant candidate outputs) *Those outputs that would win under some constraint ranking we will call relevant candidate outputs.*

The set of relevant candidate outputs for any given input is finite (albeit potentially very large), at least if we assume that the set of constraints if finite (for any individual grammar), and that every constraint ranking will lead to a finite number of candidates. This brings the calculation of correspondence relations already within manageable boundaries, but McCarthy (1999) restricts the number of candidates to be considered even further "to the most harmonic member of the set of candidates that obey a designated input-output (IO) faithfulness constraint, called the *selector*. The form deʃeʔ [in (83c)] is the most harmonic member of the set of candidates that obey the IO faithfulness constraint MAX-C, which prohibits consonant deletion in the input output mapping." This form deʃeʔ is called the *sympathetic candidate*. It is chosen among all the candidates that maximally satisfy MAX-C (such as dʃʔ, edeʃeʔe, deʃeʔedege and infinitely many others) as the one that is 'most harmonic' according to the constraint ranking of the language. This is the general definition of the sympathetic candidate:

Definition 15 (Sympathetic candidate) *The most harmonic candidate which satisfies the selector faithfulness constraint.*

Clearly, the sympathetic candidate is among the relevant candidate outputs: it can be generated by a constraint ranking, viz. the constraint ranking of the language concerned, but with the selector constraint on top of the hierarchy. The stipulation that the selector constraint (marked by a ✯ in tableaux) is a

faithfulness constraint, mimicks the fact that in a rule-based analysis an intermediary representation (one which is closer to the input than the actual output) is relevant. Another faithfulness constraint is involved in sympathy analyses as well, viz. one which says that the actual output should resemble the sympathetic candidate in some relevant dimension of the phonology. This constraint is called the *sympathy constraint* and marked by a ❁ in the tableaux. The analysis of the Tiberian Hebrew case could now run as follows:

(84)

	/deʃʔ/	CODA-COND	*COMPLEX	❁MAX-V	★MAX-C	DEP-V
opaque	☞[deʃe]				*	*
transparent	[deʃ]			*!	*	
sympathetic	❁[deʃeʔ]	*!			✓	*
faithful	[deʃʔ]	*!	*!	*!	✓	

CODA-COND and *COMPLEX are markedness constraints; the former militates against glottal stops in codas, the latter against complex codas. The other constraints are faithfulness constraints, formulated here in terms of correspondence. The sympathetic candidate is chosen from those which satisfy MAX-C; notice that the actual winner is not even in this set (it violates that constraint). The fully faithful candidate [deʃ ʔ] is in the set, but it is not as 'harmonic' as [deʃeʔ], because it violates a high ranking constraint against coda clusters.

The sympathetic candidate looses in the 'real' constraint ranking since it has a glottal stop in a coda position, offending CODA-COND. But it can influence the choice between the 'opaque' and the 'transparent' candidate. Since the former is more faithful to the sympathetic candidate as far as vowels are concerned — this is required by ❁MAX-V — this is the one which actually wins, in spite of the fact that it has an 'unnecessary' epenthetic vowel.

The Hebrew case presents an example of *overapplication*: epenthesis applies even though its condition is not met in the winning candidate. McCarthy (1999) also mentions cases of *underapplication*, where a rule does not seem to apply, even though its condition is met. He cites the following example, from Bedouin Arabic (Al-Mozainy, 1981). In this language, low vowels raise to high vowels in open syllables (85a), and glides vocalize when they are not adjacent to a vowel (85b). The latter process makes the former opaque: if a low vowel ends up in an open syllable as a result of glide formation, it does not raise (85c):

(85) a. /katab/ → [ki.tab] 'he wrote'
b. /badw/ → [badu] 'Bedouin'
c. *[bi.du] 'Bedouin'

A sympathy analysis of this would require a constraint against [a] in open syllables next to the constraints we have already seen:

(86)

	/badw/	*COMPLEX	☹IDENT(hi)	*A]$_\sigma$	IDENT(hi)	✶DEP-μ
opaque	☞[badu]			*		*
transparent	[bidu]		*!		*	*
sympathetic & faithful	☹[badw]	*!				

Like the Tiberian Hebrew example, Bedouin Arabic cannot be explained by Containment Theory, according to McCarthy (1999). The reason is that we have to refer to a level where the /a/ is in a closed syllable (or where it is not in an open syllable). This cannot be the input, since we cannot assume that inputs are uniformly (or correctly) syllabified, given Richness of the Base; but it also is not the output, where the [a] is in an open syllable.

In both cases, the relevant property of the 'intermediate' (sympathetic) structure is syllabification. This is probably no coincidence, as we will see below, in section 6.3. It should also be assumed that we know what the syllabification *is*, for instance that the syllabification of *kitab* is exactly the same as that of *badu*. Actually, there is an interesting twist to the Bedouin case: we need to assume that /w/ is underlyingly a glide, and not the vowel /u/. It is usually assumed that the difference between these two segments is one of syllabification only; in other words, we need to assume that there is some underlying syllabification in this case.

The Tiberian case similarly could certainly be analysed in a different way. Notice that the closest competitor for the winner deʃe is 'transparent' deʃ. However, the latter form is only more 'transparent' if we assume that the final e is indeed the result of epenthesis. Yet there is another way to get from /deʃʔ/ to [deʃ]: we could also turn /ʔ/ into [e]. In this way, deʃe would simply be more faithful to the underlying representation than deʃ, without having the problem of a coda glottal stop. ('Real' cases of glottal stop deletion all involve the position next to a vowel; we could argue that in these cases, the option of turning ʔ into a vowel is not available because of a constraint against hiatus.)

6.2 Sympathy Theory and allophony

As we noted at the beginning of this chapter, Sympathy Theory is not generally accepted by phonologists in the same way that OT is. A well-known empirical problem is how that it does not have a proper way of dealing with certain opaque phenomena which involve allophony. The distinction between [g] and [ŋ] in Tokyo Japanese is a case in point (Itô & Mester (2002, 2003); see also section 3.3). Remember that the former occurs at the beginning of words, the latter at the end of words. In terms of faithfulness theory, allophones are variants of a sound which are determined solely by markedness, and for which faithfulness does not play a role. In this case, we could postulate a constraint against word-initial [ŋ], as well as a more general constraint against [g]. Ranking those two constraints above a faithfulness constraint on

nasality gives us the facts of Tokyo Japanese.[14] It does not matter what the input is:

(87) a. *Facts*:
  i. *[g] at the beginning of words*: *geta* 'clogs', *gai+ʔiN* 'foreigner'
  ii. *[ŋ] elsewhere*: *kaŋi* 'key', *koku+ŋai* 'abroad'

b. *Constraints*:
  i. *$[_{PWd}$ŋ: 'ŋ may not occur at the beginning of a word'
  ii. *g: 'g is dispreferred'
  iii. *$[_{PWd}$ŋ≫*g≫IO IDENT-[nasal]

c. *Tableaux*:

i.

/geta/	*$[_{PWd}$ŋ	*g	IO IDENT-[nasal]
☞[geta]		*	
[ŋeta]	*!		*

ii.

/ŋeta/	*$[_{PWd}$ŋ	*g	IO IDENT-[nasal]
☞[geta]		*	*
[ŋeta]	*!		

iii.

/kagi/	*$[_{PWd}$ŋ	*g	IO IDENT-[nasal]
☞[kaŋi]			*
[kagi]		*!	

iv.

/kaŋi/	*$[_{PWd}$ŋ	*g	IO IDENT-[nasal]
☞[kaŋi]			
[kagi]		*!	*

This alternation interacts with another process of Japanese phonology in an opaque way. This is *Rendaku*, turning the second element of a compound into a voiced segment under the condition that there is no other voiced segment elsewhere in the word (88a) (we have discussed a different kind of compounding, called 'mimetic', to which Rendaku does not apply in section 3.3). Itô & Mester (2002) view this as the result of the interaction of an OCP constraint on voicing; a special faithfulness constraint on morphemes, REALIZE-MORPHEME, to which we will return in sections 6.4 and 9.2, but which here has the effect that some 'linking morpheme', consisting of the feature [voice] only and linking the parts of a compound, shows up; and faithfulness on voicing (88b), in interaction (88c).

[14](87) serves to illustrate also another point about OT – we can turn every declarative statement into a constraint. This is bad theoretical practice, but sometimes we may turn to it in order to illustrate a point.

(88) a.

tama	'ball'	*teppoo*+d*ama*	'bullet'
sono	'garden'	*hara*+z*ono*	'flower garden'
taba	'bundle'	*satsu*+t*aba*, **satsu*-d*aba*	'wad of bills'
sode	'sleeves'	*furi*+s*ode*, **furi*-z*ode*	'long-sleeved kimono'

b. i. OCP(voice): 'Do not allow two segments in a word, both specified for voice'

ii. REALIZE-MORPHEME (RM): 'Every morpheme in the input should have some visible effect on the output'

c. i.

/teppoo+tama/	OCP(voice)	RM	IO IDENT(voice)
☞teppoo+dama			*
teppoo+tama		*!	

ii.

/furi+sode/	OCP(voice)	RM	IO IDENT(voice)
☞furi+sode		*	
furi+zode	*!		*

As we can observe from the first two examples, sonorants though not count as voiced in the calculation of Rendaku, even they obviously *are* voiced on the phonetic surface.

The problem is that ŋ is a sonorant, but it does behave as if it is voiced:

(89) *saka*+*toge* → *saka*+*toŋe* 'reverse thorn'

Rendaku is thus made opaque: it is blocked, even though the blocking environment is not present on the surface. Clearly, we can give a Sympathy analysis of this if we assume that the underlying form of the second part of the compound is *toge*. The sympathetic candidate would be selected by IDENT-[nasal]: [sakatoge]. The sympathy constraint would then require the winner to be identical to the sympathetic candidate in the specification for [voice]. This would then be [saka+toŋe] rather than [saka+doŋe].

The problem is that according to Richness of the Base, we should also be allowed to postulate an input /toŋe/ for the second part of the compound. As a matter of fact, this second part might be preferred by Lexicon Optimisation, since this is how the form shows up in isolation.[15] But Sympathy in this case is not going to help us: since it requires a sympathetic candidate to be faithful to the input, and the output to be faithful to the sympathetic candidate, there is no way in which the pronunciation [g] will be able to influence the voicing behaviour of the output. We thus seem to have found an instance of opacity which is not amenable to a Sympathy analysis (we will return to this case in chapter 7, in order to see how the problem is solved by Itô & Mester (2002, 2003)).

[15] Some caution is necessary here, since Itô & Mester (2002) note that the variation between [g] and [ŋ] is subject to sociolinguistic factors.

6.3 Serialism and Cumulativity

After the first version of McCarthy (1999) appeared, several scholars remarked that Sympathy Theory seems to have a covert form of serialism (derivationalism, as opposed to parallelism) in it: if we study the way in which the output is derived, it seems as if we first have to determine the sympathetic candidate by one ranking (which shifts the selector constraint upwards) and then take go through the procedure again to determine the actual winner on the basis of this. This is not necessarily true, but the analysis of correspondence relations is very complicated, as we pointed out above.

The problem was addressed by Jun (1999) and Bye (2002) in similar ways. Both proposed that Gen does not produce *one* phonological representation as its output, but *two*.[16] This actually makes it also easier to picture how the evaluation of a single candidate works. A full candidate now looks as follows:

(90)

Input	*Output*	*Correspondence*		
		$\mathscr{C}(d_\alpha, d_a)$	$\mathscr{C}(d_\alpha, d_1)$	$\mathscr{C}(d_a, d_1)$
$\mathrm{d}_\alpha\mathrm{e}_\beta\int_\gamma$	☞$\mathrm{d}_a\mathrm{e}_b\int_c\mathrm{e}_d$	$\mathscr{C}(e_\beta, e_b)$	$\mathscr{C}(e_\beta, e_2)$	$\mathscr{C}(e_b, e_2)$
	❁$\mathrm{d}_1\mathrm{e}_2\int_3\mathrm{e}_4?_5$	$\mathscr{C}(S_\gamma, S_c)$	$\mathscr{C}(S_\gamma, S_3)$	$\mathscr{C}(S_c, S_3)$
				$\mathscr{C}(e_d, e_4)$

This is exactly identical to what we have seen in the evaluation of reduplicated forms above. In that sense, then, sympathy theory, does not require anything beyond ordinary Correspondence theory. The phonetic component has to be instructed to pronounce only the ❁-candidate, but nothing else.

Yet in a later paper, McCarthy (2003d) proposes a revision to his theory, called *Cumulativity*. The key observation is based on Pullum (1976), who observed that so-called 'Duke-of-York' (DY) derivations do not exist. These are derivations of the form A→B→A: some A first changes into B, to surface as A. Input and output are thus completely faithful, but there is an intermediate stage which is different. McCarthy (2003d) notes that

> For example, some analyses of *r*-dropping and intrusion in English dialects work this way, first deleting final *r* and then reinserting it before a vowel: *Homer is* → *Hom[ə] is* → *Homer is*. Pullum addresses this case and others like it, asking whether DY derivations are required by the facts and how they might be ruled out generally. He concludes that linguistic theory does need to provide DY power.

[16] McCarthy (1999) also mentions a few differences between his own approach, and the one defended by Jun (1999) (and Bye (2002)). The most important problem he notes for the latter approach is for cases of 'multiple opacity', which would involve a larger number of ❁-candidates.

McCarthy (2003d) then shows that Sympathy Theory does have the power to describe DY derivations, in particular of the following, presumably non-existing, type (called 'quasi-Yokuts' since it vaguely resemble a pattern from Yokuts):

(91)	Underlying	/maat/	
	⇒Epenthesis	maati	To repair trimoraic syllables
	Palatalisation	maači	ti→či generally
	⇐Apocope	maač	Final vowels delete
	Shortening	mač	To repair trimoraic syllables

The DY effect is that an epenthetic vowel appears, acts (by palatalising the preceding consonant) and then disappears on the surface again. Cases like this would provide the most solid evidence for intermediate representations, but apparently, they do not exist. Sympathy Theory could deal with them in the following way: the fact that we do everything to avoid trimoraic syllables, shows that a constraint against them (*$\mu\mu\mu$) is inviolable in the language. The sympathetic candidate must be [maači], showing that the selector must be a faithfulness constraint banning deletion of underlying mora's (✭MAX-μ, so that [mač] is not sympathetic). The sympathy constraint then states that the actual output must be identical to the sympathetic candidate in terms of palatalisation (❁IDENT-[high]). We now know to things about the actual winner: it should not have a trimoraic syllable and it should have palatalisation. If we now further posit that shortening is preferred over shortening, the winner is [mač]. We thus have a way of mimicking a DY derivation.

Assuming that such derivations do not exist, we must now conclude that Sympathy Theory is to powerful. McCarthy (2003d) points out that the source of the unwanted power is that we can transmit *any* feature from the sympathetic candidate to the actual winner. In this case we transmit the palatalisation; this "is a mere side effect of a spurious epenthesis process, yet sympathetic faithfulness constraints have no difficulty in transmitting the result of palatalization from the sympathetic candidate to the actual output form. I therefore reject the whole notion of inter-candidate faithfulness constraints and here propose a more restrictive alternative."

This alternative then involves the notion of cumulativity. Rather than having a whole range of ❁-O Correspondence constraints, we now have one 'cumulative' constraint which states that the unfaithfulness of the output candidate *vis à vis* the input should be the same as or bigger than the unfaithfulness of the sympathy candidate: if the latter is unfaithful in some respect, than the output should be similarly unfaithful in the same respect. The faithfulness mappings of [mač] are not cumulative with respect to those of ❁[maači]: the latter has a locus of unfaithfulness (the epenthetic vowel) which is not present in the former:

(92)

	1	*2*	*3*	*4*	*5*
☞	m	a		č	
UR	m	a	a	t	
❁	m	a	a	č	i

The candidate winner ☞ is unfaithful in the positions 3 (something is missing) and 4 (something has changed). The sympathy candidate ❁ on the other hand is unfaithful in the positions 4 (something has changed) and 5 (something is added). The sympathy constraint ❁SYM rules this out, since {3, 4} $\not\subseteq$ { 4, 5}. Forms such as [mači] (violations in positions 3,4 and 5) would do much better on accounts of ❁SYM.

This new definition of sympathy thus ensures that the actual winner should be *at least as unfaithful* to the UR as the sympathetic candidate. It thus resembles even more the idea of an idealized serial derivation: the distance between UR and ☞ has to be bigger than that between UR and ❁. The latter of 'halfway' between input and output in some sense which is not very difficult to formalise (the $\subseteq$ operator above). (But it has to be kept in mind that it is not clear how we could sensibly restrict rule theory in order to rule out DY effects.)

It also means bidding a farewell to Correspondence Theory. We have seen above that the picture of a Sympathy Theory candidate output (90) looks very similar to a representation of an output candidate in Correspondence Theory. But now the correspondence relations between the output candidate and sympathy candidate have disappeared.

To close of this discussion of Sympathy Theory, here is a note on syllabification. McCarthy (2003d) observes that syllabification per se does not seem to ever be used contrastively in human language (in itself this is a very interesting generalisation). No language seems to ever contrast *a.ta* from *at.a*, assuming both are monomorphemes. (There can be contrasts in moraicity and stress.) If we assume Richness of the Base, this finding implies the follogwin generalisation:

Definition 16 (Faithfulness-Free Syllabification – FFS) *No constraints of UG demand faithfulness to syllables* per se.

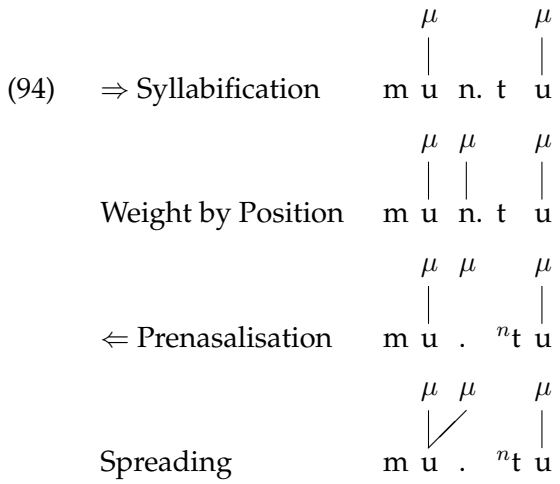
FFS has as a consequence for the theory of cumulativity that DY effects regarding syllabification should be possible. Since faithfulness does not refer to syllabification, we can be cumulative even if we change the syllable structure, in some way and then change it back again. McCarthy (2003d) discusses one example which does indeed seem to show this effect, viz. syllabification in Luganda (Bantu). In this language we find long vowels before prenasalised consonants:

(93) /ku+linda/ $\rightarrow$ [kuli:^{n}da] 'to wait'

/mu+ntu/ → [mu:^{n}tu] 'person'
/ba+ntu/ → [ba:^{n}tu] 'people'

The standard analysis of this is that the nasals first are in coda's, and the vowel length is the result of compensatory lengthening.

(94)



Syllabification and prenasalisation are in a DY relation: the former puts the nasal in a coda position, from which it is released by the latter. It is crucial that the nasal is in this coda position, even though it is not (necessarily) there in either the input or the output.

In a sympathy analysis, the sympathetic candidate would be ❁$mu_{\mu}n_{\mu}.tu_{\mu}$. The actual winner ☞$mu_{\mu\mu}.tu_{\mu}$ would differ from this only in the attachment of mora's, but neither of these count as faithfulness violations according to FFS, so the candidate counts as faithful to the sympathetic candidate – more so than its competitor *$mu_{\mu}.tu_{\mu}$, which would violate a faithfulness constraint on mora's. It does not become clear from the article what rules out *$mu_{\mu}.tu_{\mu\mu}$, i.e. why the mora stays in the same syllable; this might be a potential problem

6.4 Comparative Markedness

Another approach to opacity — as well as several other phenomena — is presented in McCarthy (2003a). Strictly speaking, this is a theory about markedness constraints, rather than about faithfulness constraints; but since faithfulness relations are in some sense built into the markedness relations. The basic proposal is that there are two versions of every markedness constraint:

1. One version counts 'old' violations, i.e. those violations in a given candidate that were also already present in the Input
2. One version counts 'new' violations, i.e. those violations that were not yet present in the Input.

The 'Input' can be seen for most practical purposes as the 'input' in the traditional sense; technically, McCarthy uses an actual output candidate (the 'Fully Faithful Candidate' or FFC), which is, roughly, the input, plus the most plausible syllabification assigned to the input. This is of no concern to us here, hence we will stick to the term 'Input' for convenience.

Formally, the paper can furthermore be seen as an extension of (McCarthy, 2003d, to appear), in the sense that every constraint looks at the precise *loci* in which it is violated (and nothing else). We define a *Locus Function*:

Definition 17 (Locus Function) *A* Locus Function *for a constraint C is a function which takes as its input a candidate and as its output the number of segments which violate that particular constraint.*

Here are a few Locus Functions for well-known markedness constraints:

- $\text{Loc}_{NoVcdObs} \equiv$ Return every C, where C is [-sonorant, +voice].
- $\text{Loc}_{NoCoda} \equiv$ Return every C, where C is final in some syllable.
- $\text{Loc}_{Parse-\sigma} \equiv$ Return every V, where V is the head of an unfooted syllable.

Combining these two insights we then get Comparative Markedness:

Definition 18 (Comparative Markedness constraints) *Divide all markedness constraints* M_i *into two separate constraints:*

- ${}_N\text{M}_i$*(cand, Input)* $\equiv$ *Let* Loc_i*(cand) =* $\{c_1, c_2, c_3, \dots\}$ *and let* Loc_i *(Input) =* $\{i_1, i_2, i_3, \dots\}$*. For each* c_n *that lacks a correspondent among* i_m*, assign one violation mark.*
- ${}_N\text{M}_i$*(cand, Input)* $\equiv$ *Let* Loc_i*(cand) =* $\{c_1, c_2, c_3, \dots\}$ *and let* Loc_i *(Input) =* $\{i_1, i_2, i_3, \dots\}$*. For each* c_n *that has a correspondent among* i_m*, assign one violation mark.*

Since every c_n either has or does not have a correspondent among i_m, ${}_N\text{M}_i \cup {}_O\text{M}_i$ = Mi, the classical markedness constraint.

It is possible in principle to formulate faithfulness constraints against insertion as CM constraints. Take DEP, the constraint against insertion of segments. First formulate the following special locus function:

- $\text{Loc}_{*Struc} \equiv$ Return every segment.

DEP can now be formulated as ${}_N\text{M}_{Struc}$:

- ${}_N\text{M}_{Struc}$(cand, Input) $\equiv$ For each segment in the candidate that lacks a correspondent among the segments in the Input, assign one violation mark.

Other constraints against insertion could be similarly reformulated; interestingly, it is not possible to formulate constraints against deletion in a similar way: this is the irreducible 'core' of faithfulness under this approach.

McCarthy (2003a) analyses a wide range of phenomena using this mechanism, including a class of cases of opacity. Here we will concentrate briefly on the phenomenon of *derived environment effects*: phonological process which apply only in environments which are derived, but not in environments which are present already underlyingly. For instance, epenthetic vowels, but not underlying vowels in Makassarese have to be followed by an epenthetic glottal stop:

(95) a. /rantas/ [rántasaʔ] 'dirty'
/jamal/ [jámalaʔ] 'naughty'
b. /lompo/ [lómpo] 'big'

McCarthy deals with this by splitting FINAL-C ('words should end in a consonant') into an 'old' and a 'new' version:

(96) a.

/rantas/	$_N$FINAL-C	CODACOND	DEP-V	DEP-C	$_O$FINAL-C
☞[rantasaʔ]			*	*	
[rantasa]	*!		*		
[rantas]		*!			

b.

/lompo/	$_N$FINAL-C	CODACOND	DEP-V	DEP-C	$_O$FINAL-C
☞[lompo]					*
[lompoʔ]				*!	

McCarthy (2003a) presents Comparative Markedness in terms of Correspondence Theory. Although this may be a natural choice from the point of view of present-day theorising, it is not the only possible option. CM could also have been presented within Containment Theory. As a matter of fact, McCarthy notes that the analysis of Lardil in Prince and Smolensky is a way of dealing with this facts which just happens to be no longer available under Correspondence Theory.

A containment model is purely monostratal: all constraints only look at one representation, and there is thus no qualitative distinction between input and output. What we need for CM to be implemented, is a way to distinguish beteen 'new' and 'old' structure. Remember that in Prince & Smolensky (1993) this is accomplished partly by leaving unparsed 'old' structure floating (it is safe to assume that floating material will never be old) and partly by giving epenthetic segments a special structure (they are left empty of feature content). This is not sufficient for the purposes of CM, however, because many new and old elements will simply be integrated in the structure and it will be no longer clear whether that structure is old or new. We would need a containment model in which every element has its status as

'old'/'new' on its sleeves: old material has a different colour from new material. Technically, we could give every element in the phonological representation a subscript 'o' or 'n' denoting its status. Constraints which can 'see' the morphological affiliation of every segment have actually been proposed in the literature. One example is a constraint we have already seen above: REALIZE-MORPHEME, which says that every morpheme should be 'visible' in the output.

In that case we could reformulate 'new' comparative markedness constraints as markedness violations which involve new material (new segments or segments dominating new features) and 'old' comparative markedness as violations in wich no new material is involved. As in the case of correspondence-based CM, these two types of constraint would divide between them all the violations of 'traditional' markedness constraint. This move would have to confront several technical problems, because it would not be as deeply embedded within the vast literature on correspondence effects we have, but the point is that such a move would indeed be possible: CM is thus to a large extent independent of Correspondence Theory.

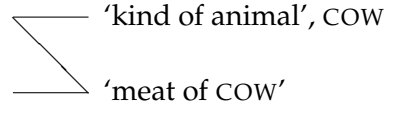
6.5 Bidirectional Evaluation

Outside phonology, Optimality Theory enjoys some popularity in syntax, and even more so in semantics/pragmatics. Within the latter field, it has become a popular assumption to not treat the Gen/Eval-pair as monodirectional — going from 'underlying form' to 'output', from meaning to form — put as 'bidirectional' — leading also from form to interpretation (Blutner, 1999, and references cited there). Thus in semantics we do not just try to find the form which expresses the inteded meaning in the optimal way, but given any form we also try to find the 'optimal' interpretation. A form-meaning pair $< \phi, \mu >$ is optimal, if there is no alternative pair $< \phi', \mu >$ where ϕ is a better expression of μ, or $< \phi, \mu' >$, where μ' is a more optimal interpretation to be assigned to ϕ.

We could say that 'classical' OT takes the point of view of the speaker; bidirectional OT also incorporates the point of view of the listener. This theory is of interest to us because similar ideas have been expressed and applied in morphology and phonology (e.g. Boersma, 1998, 1999; Wunderlich, 2001).

(Blutner, 1999) explains the bidirectional approach in terms of (97):

(97)



(98) a. A cow/*beef ran on the street.

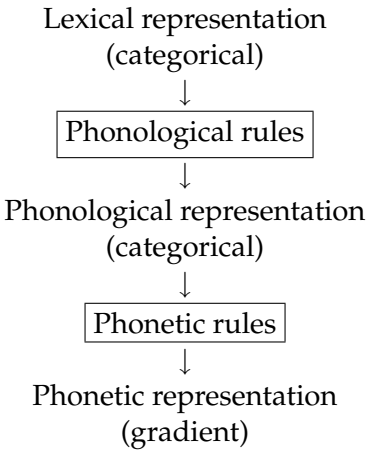
b. I do not eat $^{??}$cow/beef.

The word 'cow' is ambiguous, since it can refer both to the animal and (in certain circumstances) to the meat of the animal. On the other hand, the concept 'meat of a cow' can be expressed by two words: *cow* and *beef*. If we want to evaluate the choice between these two, we need a principle which makes us choose *meat* in the normal case. The gist of this principle will be that in the case of a choice of input, we choose the most specific form (this is known as Blocking). This means that we have to be able to choose an input; but given an input we also have to choose an output: in the absence of a relevant context, *cow* will refer to the animal, not to the meat. (A relevant context might be 'Hindu's are forbidden to eat cow/?beef', where the status of the animal as a whole is important.)

We will not go into the precise details of the implementation of this idea in semantics and pragmatics here. A very similar idea has been developed independently for phonology by Boersma (see for instance Boersma, 1998, 1999, 2005).

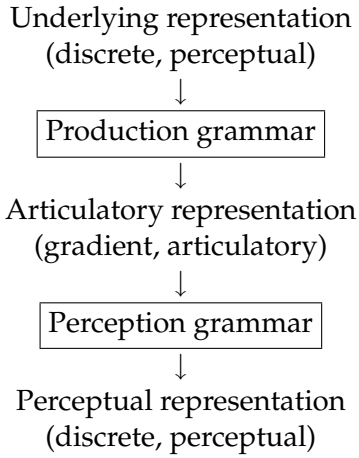
The traditional view of the phonological derivation can be seen as an abstraction of the *production* of human speech for at least two reasons. First, the arrows in the derivation usually point from underlying (lexical) forms to the surface; this is roughly how production would work.

(99)



Secondly, (most of) the phonological features are (usually) defined or definable in articulatory terms rather than articulatorily ([coronal], [spread glottis]). In Boersma (1999)'s proposal, there is a grammar for the 'speaker' (or 'production') and also one for the 'listener' (or 'perception'). Still, for most practical purposes we can concentrate on the speaker. The reason for this is that it is assumed that the speaker pays attention to the listener as well: when she has reached an acoustic output for her underlying form, she tries to establish whether the underlying representation will still be reconstructible from this by the listener. All in all we have the following in the speaker's production (simplifying certain matters somewhat):

(100)



The model thus involves different representations of different kinds, and faitfulness relations of some sort could hold between all of them, but the *real* faithfulness is between the underlying representation and the output, because these are of the same nature (they are both discrete and also both perceptual). Boersma (1999, p. 10) notes that it is a problem of standard generative grammar (and standard monostratal OT in particular, we may add) that it assumes that the grammar consists of only a (lexical, discrete) input and a (phonetic, gradient) output. But it is not clear how we could establish realistic 'faithfulness' relations (requiring them to be basically the same) between these two levels, if they are so dissimilar to begin with.

Apart from several metatheoretical arguments, Boersma (1999) also adduces a few empirical points. For instance, he notes (p. 6) that Dutch /r/ can be pronounced in various ways (including [r] and [ɾ]), but this does not seem to affect its phonology. His claim is that these various realisations do not have anything in common from an articulatory point of view, but they are similar from the point of view of perception (they are all trills).

Note that this argument may be in need of refinement, since Dutch /r/'s can be realized in many more ways, and not all of them are obvious trills. But in actual fact, at least one of these realisations shows an additional property of this framework which Boersma (1999) does not discuss in this paper (although he has mentioned it in other work). We mean the 'zero' realisation, where the /r/ is not pronounced at all. This is of course problematic for the specific claim made on page 6 (there is no trill present at all in this realisation), but not necessarily for the framework as a whole. Note that in many cases, there is at least still some trace of the 'underlying' /r/:

(101)

	'underlying form'	surface form
after long vowels	*beer* 'bear' [beːr]	[bɪː]
after short vowels	*kers* 'cherry' [kɛrs]	[kɛːs]

The long vowels turn from tense to lax before /r/, a well-known but little-

understood process which is usually called *colouring*; furthermore long lax vowels only occur in this position in Dutch. Underlyingly short (lax) vowels may lengthen in this position. Both the colouring and the lengthening are preserved even if the realisation of /r/ is zero.

We will now concentrate on colouring, but a similar reasoning will hold for lengthening. Notice that in traditional terms the colouring is 'opaque': there is no surface reason why it would have to take place. Colouring is a process which thus should have affected the form at a different level. This is actually very complicated in traditional terms, because this would mean either (i) that r-drop is phonetic and colouring is phonological (a very undesirable assumption, because colouring is completely allophonic and phonetic and has all other kinds of properties of phonetic processes) or (ii) we have to introduce some complicated mechanisms into our theory which can take care of this opacity.

In Boersma (1999)'s model, the problem is easier to solve, if we assume that colouring means the transferral of some perceptual property of /r/ onto the vowel — which is presumably what we will want to say in any case. This means then that an output [bɪː] is in some straightforward sense more faithful to the input than an alternative output *[beː], while at the same time satisfying some markedness constraint on the articulation of r's at the ends of syllables.

Boersma (2005) concerns the properties of so-called '*h* aspiré' in French. In this language, certain words start with a vowel, but they behave in some respects as if they start with a consonant. For instance, French has a process of vowel elision affecting the vowel of the definite article *le/la* (*le* is masculine, *la* is feminine) if the following word starts with a vowel, but not if the following word starts with a consonant:

(102) a. *le camerade* 'the friend', *la rue* 'the street'
b. *l'attentat* 'the attack', *l'amie* 'the friend'

However, elision also does not apply to *h aspiré* words:

(103) *le hasard* 'the coincidence' [ləazaɾ], *la hausse* 'the rise'la?os

These words thus seem to have a consonant preventing vowel deletion. Historically, this consonant has been a [h] sound, which is no longer permitted in French, and many synchronic analyses assume that this sound (or [ʔ]) is also present at some level of representation (Boersma, 2005, gives an overview).

Next to elision, there are three other processes setting *h aspiré* words apart from other vowel-initial words. In the first place, there is the process of *enchaînement*: if a word starts with a vowel and the preceding word starts with a consonant, this consonant is resyllabified into the onset of the vowel (assuming certain syntactic conditions are met), as can be observed in exam-

ple (104a). This (obviously) does not happen with consonant-initial words (104b), but it also does not happen to *h aspiré* words (104c).

(104) a. *quel homme* 'which man' [kɛ.lɔm]
b. *quel garçon* 'which boy' [kɛl.gar.sɔ̃]
c. *quel hasard* 'which coincidence' [kɛl.a.zaɾ / kɛl.ʔa.zaɾ]

Notice that, again, assuming that there is a consonant present in *h aspiré* words can do the trick here too. That is also true for the third phenomenon: *liaison*. In this case a consonant shows up before a vowel-initial word which does not surface before a consonant-initial word (perhaps because it is deleted). Again, *h aspiré* behave as if they are consonant-initial. [z] is the liaison consonant in the following examples:

(105) a. *les hommes* 'the men' [lɛ.zɔm]
b. *les garçons* 'the boys' [lɛ.gaʁ.sɔ̃]
c. *les hasards* 'the coincidences' [lɛ.a.zaʁ]

Boersma (2005) calls the last property of *h aspiré* (schwa drop) the 'most intriguing', because it sets these words apart both from vowel-initial and from consonant-intial words. The latter two classes both trigger a process of schwa deletion on indefinite determiners and adjectives agreeing with feminine gender, which is obligatory in the former case (106a), but prohibited in the latter (106b):

(106) a. *une amie* 'a friend' [yn.a.mi]
b. *une femme* 'a woman' [yn.fam] (/y.nə.fam/)
c. *une hausse* 'a rise' [y.nə.os] (*/yn.os/)

It is hard (and probably impossible) to capture this fact from the representation of *h aspiré* words being consonant-initial only. We have to answer the question why this underlying consonant triggers a different behaviour than other consonants. According to Boersma (2005), this has to be solved using the idea of a perception grammar.[17] The idea is that the hiatus created in [ynəos] is a perfect cue for the hearer to make the underlying glottal stop — because that is what is assumed to be the underlying representation of *h aspiré* — recoverable.

We thus have faithfulness constraints such as the following:

[17] The article actually discusses a number of possibilities, including the one presented above and ends in a small preference for a formalisation of the perception grammar which is slightly different from the one presented above, viz. one in which all phonological and phonetic representations are built in parallel rather than sequentially. We will not go into these details here.

(107) a. MAX(ʔ) (speaker-based): "pronounce an underlying |ʔ|as /ʔ/ (or [ʔ̰])
b. MAX(ʔ) (listener-oriented): "pronounce an underlying |ʔ|as a phonetic form that the listener will perceive as /ʔ/

In these definitions |A |denotes the 'underlying' (lexical) form A; [A] is an articulatory representation, a set of instructions to the articulatory organs, and /A/ the form which would be perceived by the listener.

Interaction of the listener oriented version with a markedness constraint against glottal stops *[ʔ̰] gives the required result (assuming that hiatus indeed gives a reasonable chance of being perceived as a glottal stop):

(108)

|ynəˀos |	MAX(ʔ)	*[ʔ̰]	*[ə]
[ynəʔ̰os]→/ynəʔos/		*!	
[ynʔ̰os]→/ynʔos/		*!	
☞[ynəos]→/ynəʔos/			*
[ynos]→/ynos/	*!		

Hiatus thus is the best way to give the effect of a glottal stop without actually having to pronounce it. Although this idea is clear enough, the framework used for it is extremely powerful. It involves many different representations, and many different constraints. Furthermore, these constraints may originate both in the perception and in the articulation. We have an 'explanation' of some phenomenon (α>β) as soon as we can show that α is 'better' than β in some phonetic dimension. But there is a problem here: phonetics is not very restrictive. There is no real phonetic theory which disallows certain states of affairs, and it is actually hard to find non-trivial phenomena which would be completely excluded by phonetics.

Further, although it is true that most representational theories, assuming that cannot deal with the phenomenon of schwa drop right away, there are certainly patches available, e.g. assuming that for some reason we cannot have two silenced segments (an underlying schwa and an underlying glottal stop, both of them unpronounced) in a row.

A more radical solution also presents itself, if we take Boersma (2005)'s analysis and give it a twist in a representational direction: if it is true that hiatus is the cue for *h aspiré* words, we can also assume that these words are prefixed not with an empty consonant – [h] or [ʔ] — but rather by an empty vowel — a schwa. The representation of *hasard* would thus be: /ʔəazar/.

7 Derivational Levels

7.1 Lexical Phonology

There was some derivational residue already in one of the first manuscripts on OT, McCarthy & Prince (1993): the use of different phonological levels, as they were introduced in the framework of Lexical Phonology (LP Kiparsky, 1982b, 1983, 1985, 2000, to appear; Mohanan, 1986; Hargus & Kaisse, 1993; Booij, 1997). Within this theory, the phonological component is divided into at least two subcomponents: lexical and postlexical phonology. These are seen as independent phonological systems, one functioning on words, and the other on linguistic expressions which are bigger than words. Within OT, each of the components consists of a Generator and an Evaluator function, built on a separate constraint ranking. They are ordered with respect to one another: the output of the lexical phonology functions as the input to the postlexical phonology. In this sense, the theory is derivational.

It is very common to also distinguish between different levels *within* the lexical phonology. In their analysis of Axininca Campa, McCarthy & Prince (1993) distinguish between three different levels:

⇒ Prefix Level ⇒ Suffix Level ⇒ Word Level

A more common distinction is the following:

⇒ Stem Level ⇒ Word Level ⇒ Post-Lexical Level

It is one of the questions of LP whether all languages have the same level structure. Another question is whether a language would allow random rerankings of constraints between different phonological levels. Both questions as yet await a definitive answer. But a more pressing question is whether we need the apparatus of Lexical Phonology, given the richness of the theory of faithfulness already provided by Correspondence Theory.

This question is in the first place an empirical one. A strong argument in favour of LP is that in many languages we find a much more restricted syllable structure at the lexical level than at the phonetic level. For instance, it makes sense to say that French onsets are maximally bipositional and satisfy the usual sonority requirements. Yet on the surface, we find many structures such as the following:

(109) *Henri devrait partir* 'H. would have to leave' [ãridvrɛpartir]

It makes sense to say that the cluster [dvr] corresponds to two onsets at some level of the phonology. We could say that this is a matter of OO Correspondence (to the isolation form [dəvrɛ]), but this begs the question why isolation forms are always more restricted than forms which do not occur in isolation. Booij (1997) points out that

> "what the derivational metaphor of evaluation in two steps expresses is that the postlexical phonology may make the effects of the lexical phonology opaque, whereas the inverse, lexical phonology making the postlexical phonology opaque, does not occur."

He provides an example of this type of opacity from Dutch. As we have already seen above, this language has syllable-final devoicing. This property becomes opaque however in encliticized structures:

(110)	*(ik) heb het*	'I have it'	/hɛb ət/	[hɛ.pət]
	(hij) had het	'he had it'	/hɑd ət/	[hɑ.tət]
	(ik) heb 'r	'I have her'	/hɛb ər/	[hɛ.pər]

This is an instance of opacity because the context for syllable-final devoicing is absent (the obstruents are in an onset), but the process still applies. Of course, a Sympathy or OO analysis might be feasible, but they would not explain why it is that small domains influence big domains rather than the other way around. The relation is not symmetric: it could be symbolized by an arrow. But arrows are what the derivational 'metaphor' is all about: as soon as we have an arrow in a relation between representations, we could see the relation as derivation; other interpretations might be possible as well, but it then is the question whether those other interpretations have different empirical ramifications, i.e. whether such a revised OO Faithfulness account would not be a notational variant of Lexical Phonology.

Furthermore, Booij (1997) points out that an OO-approach would need different faithfulness constraint rankings for cliticised forms and for suffixes. The latter do not show the effects of final devoicing (e.g. *hebben* 'to have' [hɛ.bən]). In a two-level approach, we can do with one grammar which is applied twice, and in which the coda devoicing constraint outranks faithfulness, as you can check for yourself. Still, certain changes will need to be made from one structure to another; interestingly, Booij (1997) tries to restrict these changes to resyllabification, in accordance with (but independent from) Faithfulness-Free Syllabification (def. 16 on p. 76).

We can therefore reverse the question we put at the beginning. Given the fact that Sympathy Theory and OO Faithfulness seem to explain the same facts as Lexical Phonology, we could wonder whether the former should not be done away with. This in turn would imply a severe blow for Correspondence Theory, which seems to imply these notions; it would be an argument in favour of a more restricted version of faithfulness theory, e.g. Containment. In the next section, we will see how proponents of the combination of LP and OT have solved some of the puzzles we have seen above, as well as a case which has been put forward as an argument in favour of OO Faithfulness rather than LP.

7.2 Arguments for and against Lexical Phonology

We return first to the facts of Tokyo Japanese discussed in section 6.2. We have seen there that the opaque behaviour of nasalisation in Rendaku is hard to describe, given the fact that it involves allophonic variation, and this cannot be captured with faithfulness, since we have to assume that the underlying representation is underdetermined. We have also seen that the issue would not be problematic anymore if we could assume (as classical accounts do) that the input is in fact always /ɡ/, never /ŋ/. The way this can be accomplished in Lexical Phonology is as follows: we could first make sure that the lexical component turns every ŋ into ɡ; and then the postlexical component could change intervocalic initial ɡ into ŋ again. (Or alternatively, we could turn every voiced velar into ŋ lexically, and then turn initial ŋ into ɡ in the postlexical component.)

We can see immediately that this makes the theory somewhat less restrictive than Cumulativity, since it allows the DY effect ŋ→ɡ→ŋ. But it seems that we have no other choice for cases such as these, where we have to fix an input for some form of allophonic variation. It might be, then, that in exactly in cases like this we do not some limited form of DY power. If we want to keep to Richness of the Base, on the one hand, and assume that certain forms on allophonic variation are introduced 'later' than other decisions (regardless of whether we do this with sympathy, OO Faithfulness or lexical phonology), this is the conclusion we should draw.

The intuition behind this is clear. In some sense, allophonic variation does not introduce a faithfulness violation. Remember that McCarthy (2003d) tried to establish the same point for syllabification: this is never distinctive, therefore Cumulativity does not depend on it. In the case of allophonic variation, the variation is not distinctive either. But since 'distinctivity' in itself is not a primitive notion in OT (it is derivative of the fact that all relevant markedness constraints dominate all relevant faithfulness constraints), it is not easy to see how we could establish this restriction within Sympathy Theory – although obviously the fact that I do not see how it can be done does not mean that it is impossible to do it. Within LP phonology, we could try to restrict the relation between the constraint rankings of the lexical and the postlexical phonology; Itô & Mester (2002) suggest that one restriction might be that if a contextfree markedness constraint is below faithfulness in the postlexicon (i.e. some segment type is ruled out phonetically), it will not be ranked higher in the postlexicon (i.e. the postlexicon will not disallow segment types that are allowed lexically). Notice that such an assumption would

We now return to the Japanese case. Itô & Mester (2002) argue that the constraint set in (87b) is mistaken (cf. footnote 14), for instance since it has to presuppose that in the world of context-free markedness, we find *ɡ≫*ŋ, while in the world of context-sensitive markedness we find *[$_{Pw}$ɡ≫*[$_{Pw}$ŋ. They also argue that the ranking *ŋ≫*ɡ is more plausible from a universal-

ist perspective. For this reason they assume a slightly different constraint ranking to understand the basic alternation, involving a different context-sensitive constraint:

(111) a. *VgV: No intervocalic g
b. *Post-lexical ranking:*
*VgV≫*ŋ≫*g≫IDENT-[nasal]

This again gives us allophony, since the relevant markedness constraints outrank faithfulness. Itô & Mester (2002) assume that this is the ranking for the postlexical component. You can check for yourself that it gives the right results in the morphologically simplex cases (*geta*, *kaŋi*). In order to explain the opaque behaviour in Rendaku, Itô & Mester (2002) assume that the ranking in the lexicon is as in (112a) (the reranking conforms the restriction we imposed above). We then get a tableau for the Lexical component as in (112b) and (112c):

(112) a. *Lexical ranking:*
*ŋ≫*VgV≫*g≫IDENT-[nasal]
OCP≫RM≫IDENT-[voice]

b.

/saka-toge/	*ŋ	OCP	RM	*VgV	*g	IDENT-[nas]	IDENT-[vc]
☞[saka-toge]			*	*	*		
[saka-doge]		*!		*	*		*
[saka-toŋe]	*!		*			*	
[saka-doŋe]	*!					*	*

c.

/saka-toŋe/	*ŋ	OCP	RM	*VgV	*g	IDENT-[nas]	IDENT-[vc]
☞[saka-toge]			*	*	*	*	
[saka-doge]		*!		*	*	*	*
[saka-toŋe]	*!		*				
[saka-doŋe]	*!						*

The output of the lexical component thus is saka-toge regardless of the input specification. If we input this to the postlexical grammar (which thus is not subject to Richness of the Base), we get the following:

(113)

/saka-toge/	*VgV	*ŋ	*g	IDENT-[nas]
☞[saka-toŋe]		*		*
[saka-toge]	*!		*	

What about the candidate *[saka-doŋe]? Itô & Mester (2002) claim that the fact that it does not occur, shows that we need a further reranking: REALIZE-MORPHEME now should be ranked *below* IDENT-[voice], expressing the intuition that Rendaku is no longer operative (since Rendaku is a morpheme, and its realisation is no longer required).

There is also an alternative, which Itô & Mester (2002) do not discuss but which does not seem to be implausible from the point of view of Lexical Phonology: we could assume that the Rendaku morpheme disappears altogether. It may have been the input (and output) of the lexical component, but that does not mean it is still in the input of the postlexical component. In the first place, it is an established result that postlexical processes are insensitive to morphological structure. One way of establishing this is by assuming this structure is no longer visible to it, e.g. because it has been erased from the input. Secondly, if the Rendaku morpheme indeed consists of a feature [+voice], as Itô & Mester (2002) suggest, this feature is floating in the output representation of the lexicon; it is possible that Stray Erasure applies between the lexicon and the postlexicon. In other words, we do not have to assume that the output of the lexicon and the input of the postlexicon are identical, just as we do not have to assume that the phonetic representation is exactly identical to the output of the (postlexical) phonology. Various automatic cleanup rules could have applied.

Actually, both within Correspondence Theory and within Containment Theory, we need to assume that there is some cleaning up between the two components. There is no reason, for instance, why the whole original input of the lexical component should be available to the postlexicon, even though both theories assume in one way or another that this input is still available in the phonological output. It could be then, that the the transfer of lexicon to postlexicon has further properties, such as deleting all the morphological structure. The postlexicon then becomes closer to the phonetic structure, which is a good thing. Obviously, any property of this transfer must be automatic and not language-specific, because we do not want to keep to the principle of OT that all the explanation of differences between languages should come from differences in constraint ranking.

Itô & Mester (2002) also briefly discuss the 'mimetic' reduplication in Japanese (cf. (32)), where we do not have Rendaku. Another property of this was also that the initial g in e.g. *garu-garu* does not turn into ŋ. On p. 31, we have seen how this can be analysed as an instance of 'underapplication' of the process turning g to ŋ intervocalically. The analysis there crucially relied on the fact that we have a constraint against word-initial ŋ, however; a constraint which we have just abandoned. Yet Itô & Mester (2002) point out that a different analysis is also available, viz. one in which the two parts of the mimetic compound form an independent phonological word, and the constraint *VgV only applies within the domain of such a word. The constraint then is inapplicable to either part of the compound, so that [garu-garu] is optimal, which is the required result. (In non-mimetic compounding, there is evidence that the two parts of the compound are not independent words, and here we do find normal application: *kuni-Nuni* 'various countries'.

We now turn to another language, we have discussed above, Palestinian Arabic (section 5.2). As we have seen above, Kiparsky (2000) has pointed out

a number of problems regarding such an analysis in terms of OO Faithfulness. The most important problem is that it is hard, if not impossible to give a satisfactory definition of the notion 'base' within such a theory, because it does not provide us with a good view of the interaction between phonology and morphology. In contrast, LP is build to give such a view, so we might expect it to fare better with respect to these facts.

Kiparsky (2000) notes, for instance, that an OO Faithfulness account

> does not relate the opacity of stress to anything else. In particular, it misses the generalization that all processes of word phonology ignore epenthetic vowels. For example, closed syllables are shortened even though postlexical epenthesis opens them,

(3)	a.	/ʃáaf-at/	[ʃáaf-at]	'she saw'	(transparent retention of length)
	b.	/ʃáaf-t/	[ʃifit] (*[ʃaafit])	'I saw'	(opaque shortening)

> and epenthetic *i* differs from underlying vowels in not blocking the spread of "emphasis" (Erwin (1963, p. 83), for Iraqi Arabic).

(4)	a.	/rubaṭ-at/	[rubaṭ-at]	'she fastened'	(spreading blocked by *a*
	b.	/rubaṭ-t/	[rubaṭiṭ]	'I fastened'	(opaque spread across *i*)

Kiparsky (2000) mentions that Sympathy Theory suffers the same problem: it may be able to describe the facts, but it does not explain why epenthesis is invisible to all of word phonology. He therefore proposes to differentiate two levels within the lexical component, a *stem* level and a *word* level. This may seem like an arbitrary move, but Kiparsky (2000) claims that

> The categories "stem" and "word" are special in being anchored in the universal prosodic hierarchy, their status in UG is comparable to the status of such categories as "noun" and "verb". Unlike classical rule ordering theory and sympathy theory, where the orderings and rankings respectively are unconstrained, this imposes a small upper limit on the depth of opaque interactions.

The difference between subject endings and object clitics is that the former are attached at the stem level and the later at the word level. We thus have the following derivations:

(114)				
	stem level	fíhim	fíhim	fihím-na
	word level	fíhim	fíhim-na	fhím-na
		he understood	he understood us	we understood

The idea thus is that stress is assigned at the stem level, and does not change on the word level; on the former, faithfulness of stress constraints have to outrank prosodic well-formedness.

All in all, the points in favour of an LP version of OT seem quite strong: it provides some level of opacity which is not extremely strong, but still available. This does not mean that there are no problems. We have already noted

that the differences in ranking between components need to be restricted in a principled way — we do not want to predict grammars which combine the lexical phonology of English with the postlexical phonology of Chinese. Second (and maybe connected to this), we have also seen that we probably want to still restrict the power of the model, e.g. to exclude cases of DY derivation.

There are also a few other problems with LP, which seem to point in a different direction, viz. that the theory may be too restrictive. For instance, Anttila *et al.* (2004) discuss some facts from Singapore English. In this dialect, various process are active which serve to avoid consonant clusters, including Epenthesis (115a) and Metathesis (115b). Metathesis opacifies Epenthesis, however: the form in (115c) has a geminate [sː] rather than an epenthetic vowel.

(115) a. *Epenthesis* lap/s+z/ → lap[səz]
b. *Metathesis* li/sp/ → li[ps]
c. *Epenthesis made opaque* li/sp+s/ → li[psː] (*lip[səz])

Within LP, we would assume that Metathesis comes at a later level than Epenthesis. Anttila *et al.* (2004) note that Epenthesis must be a word-level (or later) process for morphological reasons: it is triggered by word-level suffixes, e.g. /læps+z/ → [læpsəz]. This implies that Metathesis must be postlexical. Yet Anttila *et al.* (2004) show that there are at least three reasons to reject this assumption. First, Metathesis is sensitive to whether the following segment is a consonant or a vowel when it occurs in the middle of a word, but it is not sensitive to this distinction when it occurs at the end of a word (followed by another word). Secondly, there is another process in Singapore English (Fricativization, p→f) which counterbleeds Metathesis (*lisp→lips→lifs*). Fricativization would thus have to be ordered after Metathesis, but nothing comes after the postlexical level. And finally, metathesis does not seem to occur postlexically in any other known language of the world (which in itself is an interesting observation).

It should be noted that there is no alternative which really works well. OO Faithfulness has the problem that the crucial property is in the input, not in some output (since both [lɪps] and [læps] exist). Anttila *et al.* (2004) offer a solution in terms of Comparative Markedness: Epenthesis resolves underlying sibilant clusters ('old' clusters), but not ones created through Metathesis ('new' clusters).

(116) a. lap/s+z/ → lap[səz] (s-z is 'old', repaired by Epenthesis)
b. li/sp+z/ → li[psz] → li[psː] (s-z is 'new', not repaired)

This works, but only on a crucial assumption: that the order of affixes is also present underlyingly. This is a questionable assumption, however. For

instance, a standard analysis of OT has it that the order of affixes can be determined by ranked constraints.

8 Coloured Containment

8.1 An Evaluation

It is now time to evaluate what we have seen so far. Broadly speaking, there are two theories of faithfulness: one which is based on the assumption that the input is part of the output, and another is based on the idea that input and output are completely independent representations. The first theory is instantiated by Containment Theory, and it has many problems; the most difficult puzzle is that does not offer a satisfactory theory of epenthesis or of the insertion of features. On the other hand, the theory is constrained by principles such as Containment (definition 4 on p. 12) and Consistency of Exponence (definition 10 on p. 47).

The second theory, instantiated by Correspondence Theory, seems much less constrained: any input can correspond to any output. We have concluded in chapter 3 that such a move can only be justified if there is independent evidence for correspondence relations in natural language. The last ten years have seen the search for such independent evidence. But we have also seen that all of the cases of Correspondence Theory which have been put forward, have also been questioned on serious grounds:

1. OO Faithfulness is fraught with problems, mostly because it is not clear how it can be constrained. Furthermore, most analyses can be replaced by IO Faithfulness constraints under the assumption of Lexical Phonology. Such an analysis seems more constrained, and better adapted to well-established theories of morphology. For LP, we do not need Correspondence Theory, however.
2. Similarly, Sympathy Theory can be replaced at least in part by theoretical intstruments such as Comparative Markedness, which does not necessarily depend on Correspondence Theory, and (again) on Lexical Phonology. Furthermore, we will see below (section 8.3) that within Containment Theory there also are other devices for handling apparent cases of opacity.
3. The best candidate for a correspondence relation outside input-output faithfulness therefore still is found in reduplication. But we have seen there that alternative analyses are available in this case. Let us for instance, return briefly to the case of Javanese overapplication in (29) repeated here for convenience.

   (29) a. *putul* ‘cut (n.)’

b. *pang-putul* 'that used for cutting' >[pamutul]

c. *pa-mu-mutul* 'a cutting in quantity' (reduplication; **pa-mu-putul*)

Remember that the prefix *pang* nasalises the immediately following obstruent; but in reduplicated forms it nasalises the first segments of both the base and the reduplicant.

In the preceding sections, we have developed an alternative terminology for describing these forms: we could say that the nasalisation has applied both opaquely (to the base *mutul*) and transparently (to the reduplicative prefix *mu*). We have seen that Inkelas & Zoll (2005) propose that the reduplicant is not a prefix but an infix, and faithfulness applies in two steps (example (35), also repeated here):

(35)
putul
↓ + pang
pang-mutul
↓ + RED
pang-mu-mutul

We have seen now that there is faithfulness machinery independent of Correspondence Theory that is also able to handle this, for instance Lexical Phonology. (Inkelas & Zoll (2005) use a theory of cyclic representations as discussed in section 5.3.) It would be worth finding out whether all cases of overapplication could be subsumed to such an analysis.

We have seen that a case of underapplication could potentially also be handled in a different way: nasalisation of velar stops does not apply to the second half of Japanese mimetic compounds, simply because both components of such compounds are independent Prosodic Words, and nasalisation simply does not apply in this configuration.

The last point means that we have different solutions for different aspects of correspondence: there is a derivational solution (invoking LP) for overapplication and a representational for underapplication. As long as we do not have a real indication that these processes are unified, this is not necessarily a problem, however.

We conclude that reduplication is not necessarily an argument in favour of a correspondence approach. Whether or not two phenomena should be seen as 'similar' or even 'the same' depends on our theory to a large extent. It is important to see this, since some rhetorics in the OT literature seems to claim that the best theory is one in which every single intuition on natural language can be captured under the same rubric (the same constraint). But the least we can say is that such a theory is not very restrictive.

8.2 Morphological colouring

In any case, we have seen that there is not very strong evidence in favour of Correspondence Theory. My conclusion from this is that we need a more restricted theory. We have seen that Containment Theory has many problems, at least in its PARSE/FILL implementation.

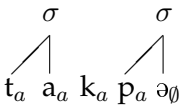
Let us try to find out where these problems lie. We have already established that they basically have to do with the theory of epenthesis. In the implementation of Prince & Smolensky (1993), this is affected by FILL constraints: epenthetic segments are empty and this is why they are disallowed. There is no real problem with the PARSE component.

In section 6.4 above, we have seen that a potential theory of faithfulness based on Comparative Markedness has the inverse problem. It is very easy to disallow epenthesis (by a 'new' version of the constraint against all structure, $*_N$STRUC, which thus disallows all inserted structure), but it is not clear how we can ban deletion in these terms — we would need to count those violations in the input structure which are not present in the output, but this is a mechanism that does not seem necessary for anything beyond faithfulness.

We could reach a solution if it were possible to combine the two approaches. At the end of section 6.4, we have already noted that Containment Theory would be able to incorporate Comparative Markedness if it would be possible to distinguish old from new structure. My claim is that this is indeed possible, without even extending the general framework already proposed in Prince & Smolensky (1993), in particular, by taking the principle Consistency of Exponence (def. 10 on p. 47) seriously. What does it mean to say that 'No changes in the exponence of a phonologically-specified morpheme are permitted'? This can only have a meaning if the 'exponence' of morphemes are visible in the surface structure.

One way to visualize this, is to assume that every morpheme has a specific colour, that every element in the underlying specification of morphemes also has this colour, and that Gen cannot change the colour of segments. Since colours are a little bit hard to use in modern print (and we would need a large number of colours for natural languages with large numbers of morphemes) we will use the descriptive notation of subscripts. (In return, we no longer need the subscripts for correspondence relations, obviously.)

Epenthetic material will now be 'colourless': it doesn't belong to any morpheme and therefore it does not have a subscript (or a subscript $\emptyset$). Constraints against insertion will therefore be constraints against colourlessness. Obviously, such constraints can be combined with a containment model. Output structures in this 'Coloured Containment' (CC) model will look as follows (cf. (13) on p. 14 and (40) on p. 37):

(117) 

As in ordinary Containment, we know that k_a is deleted because it has not been parsed in the phonological structure. Like in Correspondence Theory, the epenthetic vowel is phonologically fully specified (with whatever the features of schwa are); but like in Containment Theory, it is also empty, viz. in its morphological affiliation. The most important faithfulness constraints are thus:

(118) a. PARSE-$\phi(\alpha)$: The morphological element α must be incorporated into the phonological structure. (No deletion.)
b. PARSE-$\mu(\alpha)$: The phonological element α must be incorporated into the morphological structure. (No insertion.)

We have to assume that the phonetic component (and possibly cleanup rules between the lexical and the postlexical component) will apply Stray Erasure, and erase the morphological colours, so that the phonetic output will look (approximately) as:

✓ t a . p ə

Notice that we did not distinguish here between segments and (autosegmental) features. It is not necessary to do so in this model, although it would be possible (we could restrict the definitions above to phonological segments and then introduce the equivalent of IDENT constraints). It would also be possible to model some of the more specialized constraints, such as ANCHOR

✓ I-ANCHORING-(L/R) in CC
No phonologically unparsed elements may occur at the left/right to the input string.
✓ O-ANCHORING-(L/R) in CC
No morphologically unparsed elements may occur at the left/right to the input string.

These constraints have the flavour of positional markedness to them, and in general, this is how they can be treated. CC furthermore can also incorporate most of the findings of Comparative Markedness, as becomes clear if we take another look at the example from the Makassarese example (95), repeated here:

(95)	a.	/rantas/	[rántasaʔ]	'dirty'
		/jamal/	[jámalaʔ]	'naughty'
	b.	/lompo/	[lómpo]	'big'

In order to distinguish the a- and b-cases, McCarthy (2003a) proposes to distinguish two cases of the constraint FINAL-C. In terms of CC, we could do this in the following way:

- ✓ $_N$FINAL-C: No morphologically unparsed vowel at the end of the word.
- ✓ $_O$FINAL-C: No morphologically parsed vowel at the end of the word (i.e. words should end in a syllable boundary).

In other words, $_N$FINAL-C is a special case of O-ANCHORING-(R) in this approach; $_O$FINAL-C is a case of what used to be called ALIGNMENT (McCarthy & Prince, 1995b).

It might be instructive to look more precisely at the CC implementation of CM. We will return to another case of derived environment effects, Vowel Harmony in Turkish. Remember from (59a) that this language has vowel harmony progresses for the features [±back] and [±round]. We have not mentioned yet that many stems are disharmonic:

(119) *vali* 'governor', *ḵitap* 'book', *hareket* 'movement', *hesap* 'bank account', *bobin* 'spool', *pilot* 'pilot', *otel* 'hotel', *petrol* 'petrol', *zigurat* 'ziggurat', *muzip* 'mischievous', *buḵet* 'bouquet', *mebus* 'MP'

Most of these stems are loanwords. We may observe that loanwords are often adapted to other aspects of Turkish phonology; for instance, in pairs like *biftek-biftei* 'steak - his steak', /k/ disappears in intervocalic position, in accordance with a general rule, and in disharmonic *ḵitap* 'book' (<Ar. kitab), the /k/ gets fronted because of the vowel and the final plosive is devoiced. The question is why this did not happen to root-internal vowel harmony, and it seems sensible to say that vowel harmony is *blocked* in these cases.

However, colloquial varieties of Turkish show epenthesis: if a word (again, a loanword) starts with a cluster of consonants, an epenthetic vowel is inserted. It is important to see that this vowel is harmonic:

(120)

	careful form	*colloquial form*
'fetters'	pranga	pıranga
'prince'	prens	pirens
'test'	prova	purova
'announcer'	spiker	sipiker
'cruiser'	kruvazör	kuruvazör

There is a relation between the existence of disharmonic stems and the possibility that affixes and epenthetic vowels can receive harmony: within a stem a feature cannot be given to 'old' segments. We can only make a vowel harmonic if it is in some sense a 'new' vowel.

(121) a. *pilot, otel, kruvazör*: none of the vowels is new, they have always belonged to the same word, therefore they need not be harmonized
b. *pilot+lar, otel+ler*: the vowel in the suffix is new, it should be harmonized
c. *kuruvazör*: the epenthetic vowel is new, it should be harmonized

The conclusion of this is that new vowels should be harmonized. Old vowels do not need to be, although over the course of the years they will tend to do so. (Intuitively, this is why disharmonic roots are loanwords: they did not have enough time yet to adapt themselves to the phonological system of Turkish.)

A problem with the CM framework in cases like this is that it is completely symmetric. We predict that there will be cases of 'anticyclicity'. Thus, assume a hypothetical language L with roundness harmony, a stem kitap, and suffix -ler/lar and -en/an. Given high-ranking ${}_O$SPREAD (and low-ranking other SPREAD constraints), we would have a language Turkish$^\neg$ with the following properties:

- Underived form: *kitep* (${}_O$SPREAD is applicable, since ${}_N$SPREAD is not).
- Derived form: *kitep-lar* (${}_O$SPREAD applies to stem element, but not to suffixes).
- Derived form: *kitep-ler-an* (${}_O$SPREAD applies to kitepler, but not to the whole word)

I am not aware of any language that has this type of harmony, and, intuitively, it seems quite absurd. ${}_O$SPREAD has more of these strange 'anti-cyclic' consequences, where things happen only to forms once they are fully embedded in other forms. For instance, a language which allows voiced obstruents in the middle of an underived word, but not if an affix is attached to it, giving alternations like *pobin/popini*; or making all syllables open in a derived environment, giving alternations like *pambin/pabina*, etc.

I therefore propose another option: general markedness constraints such as SPREAD do *not* come in two versions: they do not see the difference between old and new structure. This also seems more plausible. Why would constraints on surface well-formedness care about the origin of the material it has to evaluate? Rather, there is a range of constraints which regulate the relation between morphological structure and phonological structure. The basic idea behind all of these constraints is the following (the constraint is named after Kaye (1974)):

Definition 19 (Morphological recoverability (MR)) *Phonological structure mirrors morphological structure as closely as possible.*

In the case at hand, one such MR constraint could be the following:

✓ INTEGRITY (first definition): Old vowels may not contain new material.

We find evidence for this in Icelandic. In this language, /a/ turns to [ö] when it is followed by an [ü] (122a). The epenthetic vowel happens to be [ü] as well, but this vowel has no effect on the preceding /a/ (122b). Notice that in this case, the epenthetic vowel is not a potential undergoer of the spreading, but a potential trigger.

(122) a.

barn 'child-ACC.SG.'	*börn-um* 'child-DAT.PL'
dag 'day-ACC.SG.'	*dö-um* 'day-DAT.PL'
vatn 'water-ACC.SG.'	*vötn-um* 'water-DAT.PL'
tala 'I speak'	*töl-um* 'we speak'
baka 'I bake'	*bök-um* 'we bake'
kalda 'cold-ACC.SG.'	*köld-um* 'cold-DAT.PL'

b. *dag-ur* 'day-NOM.SG' (/dag/+/r/)
snarp-ur 'rough-MASC.NOM.SG.' (/snarp/+/r/)

Notice that we have to differentiate in this case between vowels which are new because they are in a suffix and vowels which are new because they are epenthetic; we will not go into this difference here. The most important thing is that a language Icelandic¬ with the following properties does not exist:

- Underlying vowels do not act as triggers for spreading (/barn/ + /um/ >[barnum]),
- but epenthetic vowels do (/agr/>[ögur]).

The non-existence of Icelandic¬ can be explained in the same way as the non-existence of Turkish¬: the inverse of the constraint INTEGRITY (which would read 'New vowels cannot contain old material') is no part of the universal inventory of constraints. Of course, this begs the question: why does the principle of Morphological Recoverability lead to INTEGRITY and not to ¬INTEGRITY? We will briefly return to this in section 9.1.

8.3 Opacity and output representations

We have seen that most of the arguments for the power of Correspondence Theory derive from opacity, especially if we consider that many cases of overapplication and underapplication in reduplication can also be derived from it. In this section, we will show that CC is also quite powerful and can handle quite a large number of phenomena, albeit not in a uniform fashion. Generally speaking, we have (i) INTEGRITY and other Recoverability constraints and (ii) enriched representations at our disposal.

In the first place, we have already seen that CC can mimick many aspects of CM theory. This applies to opacity effects as well. McCarthy (2003a) shows that CM can deal with cases of counter-feeding opacity such as the following, from Barrow Inupiaq (an Inuit language):

(123) a. Palatalisation after /i/

Stem	-lla	'be able'
/niʁi/	[niʁiλλa|]	'eat'
cf. /sisu/	[sisulla]	'slide'

b. No palatalisation after /ɪ/
/tiŋʁ/ [tiŋilla] 'take flight'

Palatalisation of /l/ to [λ] is opaque in this language, since it does not apply after a 'derived' [i] (one which is the result of fronting an epenthetic ɪ). Within CM, we can analyse this as the result of an 'old' version of a constraint against palatalisation: every [l] next to an [i] is a violation, if /li/ were adjacent already underlyingly. In CC, we would have one Palatalisation constraint, but INTEGRITY would do the required work. It would state that old l's may not acquire new palatalisation features.

Also, many apparent cases of opacity actually seem to disappear if we assume a somewhat more sophisticated view of phonological representations, taking into account the literature on prosodic organization, autosegmental structure and the interaction with morphological and syntactic boundaries. One representation, which is enriched by independently necessary elements, may then do the work of two poorer representations.

In the Antwerp dialect of Dutch, for instance, we have a process velarising a nasal consonant in coda position. We also have a process shortening a vowel before the resulting velar nasal (Taeldeman, 1982). Both processes can be seen at work in the examples in (124a). Interestingly, the velarisation process only applies to words with underlyingly long vowels, and not by words which have short vowels already underlyingly, as (124b) shows:

(124) a. i. *grune* 'green' [ɣrynə] ∼ *gruun* 'green' [ɣryŋ][18]
ii. *schoenen* 'shoes' [sxunə] ∼ *schoen* 'shoe' [sxuŋ]

b. i. *kin* 'chin' [kin] ∼ *tien* 'ten' [tiŋ]
ii. *zon* 'sun' [zɔn] ∼ *zoon* 'son' [zon]

This process clearly looks opaque: we could claim for instance that velarisation only applies after long vowels, but this vowel length is not visible on the surface. On closer inspection, there is evidence that the velar nasal, different from the other nasal consonants, is a moraic segment in varieties of Dutch (Trommelen, 1982; van Oostendorp, 2001; van der Torre, 2003). This could explain, for one thing, the fact that velar nasals can only occur after short

[18] Apart from some cases of optional schwa deletion, the form without schwa can only be used in the singular neuter of adjectives in indefinite noun phrases. The form with schwa can be used in all other inflections (plural or non-neuter, or both).

vowels: we could posit a bimoraic maximum on syllables.[19] A velar nasal after a long vowel would then be prohibited:

(125)

There undoubtedly are other ways to capture the same intuition: that both long vowels and velar nasals need space in the syllable and that if we would have both, this would be too much. Under the one chosen here, the opacity of the Antwerp Dutch velarisation process disappears, if we assume that there is a strong faithfulness requirement on the number of mora's in this dialect — or in rule-based terms, that we are not allowed to insert any mora's in the underlying representation. A change from /tiːn/ — two underlying mora's attached to the vowel — to [tiŋ] (two surface mora's, one for the vowel and one for the nasal) is then allowed, but a change from /kin/ (one underlying mora attached to the vowel) to [kiŋ] (two surface mora's) is not. If we allow ourselves to introduce a few ad hoc constraints to make things work technically, an OT analysis might then run along the following lines. We need the constraints in (126a), and the ranking in (126b) in order to get the tableau in (126c):

(126) a. i. FAITH(μ): Do not add or delete mora's

ii. VELAR: Nasal consonants in coda position shoul be ŋ.

iii. *$\mu\mu\mu$: No trimoraic syllables

b. FAITH(μ)≫VELAR

c. i.

/tiːn/	FAITH(μ)	*$\mu\mu\mu$	VELAR
☞[tiŋ]			
[tiːn]			*!
[tiːŋ]	*!	*!	
[tin]			*!

ii.

/kin/	FAITH(μ)	*$\mu\mu\mu$	VELAR
☞[kin]			*
[kiːn]	*!		*
[kiːŋ]	*!*	*	
[kiŋ]	*!		

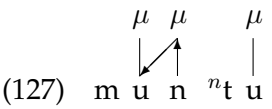
[19] It is sometimes assumed that the reason for this restriction is that velar nasals underlyingly are /nɡ/ or /nɣ/, just like this is assumed for English. The Antwerp facts actually show that this analysis cannot be correct: here we find the same restriction but there is absolutely no possibility for postulating an underlying obstruent.

All three constraints are known from the literature. No special mechanisms, such as rule ordering, Sympathy Theory, levels, etc., thus are necessary for Antwerp Dutch, given the appropriate assumptions on the representation of the velar nasal.

An alternative solution to some other cases of opacity, which uses even richer representational devices has been proposed under the rubric of 'turbidity' of Goldrick (2000). His analysis is based on the opaque vowel length we find in Luganda and which has been discussed within Cumulativity Theory on p. 77. The relevant facts are in (93), repeated here:

(93) /ku+linda/ → [kuliː^{n}da] 'to wait'
/mu+ntu/ → [muː^{n}tu] 'person'
/ba+ntu/ → [baː^{n}tu] 'people'

Goldrick (2000) proposes to picture the output phonological structure of *muntu* in the following way:

(127)


The [n] and [u] maintain different relations with the mora. The relation between n and mora is called *Projection*, and Goldrick (2000) notes that this is roughly equivalent to what is called licensing. It is denoted by an arrow pointing upwards. The relation between the vowel and this mora is called *Pronunciation*; it is denoted by an arrow pointing downwards. In the default case, Projection and Pronunciation relation will be maintained by the same pair of elements (this is true for the other mora's in this representation; the lines drawn there could also be interpreted as arrows pointing in both directions). The idea is that there is a constraint which makes the nasal project a mora, but this mora can only be pronounced by a vowel.

Notice that Turbidity has an empirical advantage over Sympathy Theory (even with Cumulativity) since the latter does not explain why the mora stays in the first syllable (why we have [muː.^{n}tu] rather than [mu.^{n}tuː]. Even though Goldrick (2000) does not discuss this contrast, it seems clear that it would not be hard to formalize the intuition that a the segment that projects a mora and the segment which pronounces it have to be maximally local (e.g. adjacent).

This approach looks kindred in spirit to CC — we could see the two arrows as lines with different 'colours', where lines of only one colour are visible: it presupposes a phonetic component which automatically suppresses all Projection relations. On the other hand, Turbidity has properties that CC does not have. In particular, the 'projection' colour does not correspond to

any morphological level: it is not necessarily the case, for instance, that the projected mora's are present underlyingly: this is why the case is opaque in the first place. The reason why it did not meet a lot of success seems mainly that it runs against the non-representational trend in most of the OT literature. Nevertheless it expresses an intuition which is real: that parts of the representation which are there in order to keep one segment happy, may be themselves happier when they are pronounced on a different segment. We have now one representation which is a little bit more complex, rather than two simpler representations, as in Sympathy or OO Faithfulness. Turbidity is clearly more succesfull in describing the *locality* of the relations involved.

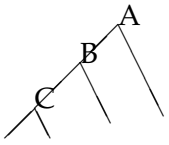
9 Faithfulness in the interface with Morphology

9.1 Derived Environments

We return to Turkish vowel harmony once more, since we left the discussion in the preceding chapter with the quesion why there seems to be a ban on old vowels dominating new material, but no similar ban on new vowels dominating old material. We argued that this can be seen as a derived environment effect, and that it is caused by something like INTEGRITY. To see how this work, we will first turn back to the examples in (59b), repeated here.

(59b) a. *üç* 'three', *üç-gen-ler* 'triangles'
b. *altı* 'six', *altı-gen-ler* 'hexagonals'
c. *çok* 'many', *çok-gen-ler* 'polygonals'

What these examples show, is that Turkish is a so-called stem-controlled vowel harmony language, where features spread from the inside out. If an affix such as *-gen* contains a feature that may spread in principle, it does so only to the affixes which are more peripheral. The morphological structure of *altı-gen-ler*, for instance, is something like:



(128) al t ı gen l er

Turkish instantiates one of two types of vowel harmony that are usually recognized in the literature, viz. stem control (sometimes incorrectly called *root control*). The other type is called *dominant recessive*; in languages of this type the morphology does not seem to matter. Features spread from any morpheme to any other morpheme. Absent from our typology are languages

with *affix control*, where features spread only from affixes inwards (Bakovic, 2000, and references cited there).

We have discussed the Turkish above in terms of IDENT-ROOT constraints, but it is clear that this is not satisfactory, since roots are not the categories that matter (*gen* is not a root, but still it is faithful). Also our definition of INTEGRITY given above is not sufficient. In light of what we have just seen, the definition of 'old' and 'new' is not very precise. We propose to slightly revise it in the following way:

Definition 20 (INTEGRITY) *A segmental node may not dominate features outside its morphological domain.*

The idea is that every underlying segment belongs to a certain morphological domain. For all intents and purposes, this corresponds to the lowest node in the picture in (128) which dominates the segment: node C for the segments in *altı*, node B for those in *gen* and node A for those in *ler*. Segments are not allowed to dominate something which comes from outside those their: the vowels in *altı* may not attract the feature [-back] from the suffix, because that feature is from a larger domain. A segment is bigger than a feature, and therefore the domain of the feature may not be bigger than that of the segment. This is how Recoverability explains INTEGRITY: it says that smaller elements cannot dominate bigger elements.

How about epenthetic segments and their features? Epenthetic segments are purely phonological; therefore we may say that they are outside all morphological domains. Hence there is no barrier to them dominating features. This is why epenthetic vowels can attract harmony even if they occur between other vowels that are disharmonic. On the other hand, their features are of course also outside all morphological domains, so that they cannot spread to other vowels. This explains the behaviour of epenthetic vowels in Icelandic. More importantly, Turkish$^{\neg}$ and Icelandic$^{\neg}$ cannot exist, since the reverse of INTEGRITY would not conform to Recoverability.

Notice that we have strictly speaking not yet explained the non-derived environment blocking: if we would spread a feature from /i/ to /a/ within the stem *kitap* 'book', the result would be a segment in the root dominating another feature which also within the root. We need a stricter version of INTEGRITY to rule this out:

Definition 21 (Strict Integrity) *A segment may only dominate features that are* strictly *within its domain.*

A feature [F] is strictly *within the domain of a segment S, if the domain of F is D_1 and the domain of S is D_2 and $D_1 \subset D_2$.*

This definition says that if something which is relatively big like a segment dominates something which is smaller (like a feature), the big thing should have a bigger morphological domain than the small thing.

Łubowicz (2000) proposes a slightly different way of looking at Derived Environment effects. One of her examples is from Campadinian Sardinian (the data are from Bolognesi, 1998). In this language, underlyingly voiceless fricatives get voiced when they are preceded by a vowel (129a). Voiceless stops in the same context do not merely get voiced, but spirantize as well (129b). Underlyingly voiced stops however do not spirantize (129c).

(129) a. dɛɔ /f/uɛɖːɔ /s/ɛmprɛ → dɛu [v]uɛɖːu [z]ɛmpri 'I speak always'
sːa /f/amilːia → sːa [v]amilːia 'the family'

b. bɛlːu /p/iʃːi → bɛlːu [β]iʃːi 'nice fish'
sːu /t/rintadus → sːu [ð]rintaduzu 'the thirty-two'
dɛ /k/uatːru → dɛ [ɣ]uatːru 'of four'

c. bɔʒɛ /b/ɛlːa → bɔʒi /b/ɛlːa 'voice beautiful'
dɔnːia /d/ɔminiɣu → dɔnːja /d/ominiɣu 'every Sunday'
dɛ /g/ɔma → dɛ /g/ɔma 'of rubber'

Spirantisation is subject to a Derived Environment effect: it only applies to stops that have been actively voiced, not to stops that are voiced already underlyingly. Łubowicz (2000) proposes that DEE effects such as these are the result of a *constraint conjunction*. The markedness constraint against voiced plosives (*VCD/STOP) which is dominated by the faithfulness constraint IDENT-[continuant]. This ranking explains why voiced stops do not spirantize normally. We also have a faithfulness constraint IDENT-[voice], which is dominated by a markedness constraint against voiced obstruents after vowels; this explains the voicing process.

However, constraints can also be conjoined. A conjoined constraint C=A&B is violated whenever constraint A and constraint B are violated at the same time (see Kirchner, 1996; Alderete, 1997; Kager, 1999a; Itô & Mester, 2003, and references cited there for discussion of the theory of constraint conjunction which is often referred to as 'Local Conjunction'). Łubowicz (2000) proposes to conjoin the markedness constraint *VCD/STOP with a faithfulness constraint IDENT-[voice]. Although both constraints are violated individually, their conjunction is ranked very highly. It forbids voiced stops which are not faithful with respect to voicing. This is why exactly these can then violate IDENT-[continuant] and spirantize.

A severe problem for local conjunction theory is that it is not very restrictive: there are no principled limits to which constraints can be conjoined. It is basically a coincidence, within this framework, that the conjoined markedness constraints both refer to the feature [voice]. In principle it would be possible to conjoin *VCD/STOP with a faithfulness constraint against, say, place

assimilation (IDENT-[Place]), so that only voiced stops that would change their place of articulation would be sensitive to the pressure to spirantize. In other words, we do not have a theory of locality.

If we use INTEGRITY, the locality comes for free:

(130) INTEGRITY-[voice]: A segment cannot dominate a feature [voice] outside its domain.

INTEGRITY constraints obviously are in some sense combinations of faithfulness and markedness constraints, just like conjoined constraints and comparative markedness constraints. The scope of INTEGRITY is far more restricted, however, so that we have a more predictive theory.

9.2 Realize Morpheme

In section 6.2 above, we have already seen a different type of constraint which might be implemented using morphological colouring: REALIZE-MORPHEME (RM). This constraint was responsible for the fact that the Rendaku morpheme, which is a feature [voice] only, in Japanese surfaces.

RM obviously is a faithfulness constraint. We can state it informally as follows: every morpheme in the input has to contribute to the phonological surface structure. A more formal version, using morphological colours is as follows:

✓ REALIZE-MORPHEME: For every morphological colour {i, j, k, ...} which are present in a candidate, at least some phonological element with that colour has to be phonologically parsed.

There is again a clear relation between this formulation of REALIZE-MORPHEME and the metaprinciple of Recoverability (def. 19 on page 98): morphemes have to be seen in order to be present.

In some cases, RM might be subsumed under more general faithfulness. For instance, Itô & Mester (2002) use this constraint for their analysis of Japanese because they are working in a classical correspondence theoretic model. In such a model, there can be no faithfulness constraints to ensure the faithfulness of floating features, since all feature faithfulness is mediated through segments by IDENT constraints. However, if we allow direct reference to faithfulness of individual features, the need to a specific RM constraint may disappear.

There are other cases, however, where certain phonological elements seem to be really more faithful than they usually are, simply because they have to express the morpheme. The strongest cases are those where we find some marked structure only in derived contexts, and phenomena such as these are actually abundant. But under close scrutiny many examples disappear.

One example we have already seen, in a different context: Singapore English (presumably) does not have (word-final) geminates except in one context: in plurals such as *lip[s:]* (from *lips*). Given Richness of the Base, we have to assume that monomorphemic /lɪps:/ is also an option; but it will never surface as such, indicating that a constraint *GEMINATE outranks the relevant Faithfulness constraints. In order to express the fact that geminates are allowed in this case would then be a ranking RM≫*GEMINATE≫Faithfulness. Similar observations can be made about other inflected structures in English and other languages. Kaye (1992) observes, for instance, that there are no underived words which have the phonological form of *dreams* (with a nasal-obstruent cluster which is not homorganic, plus a long vowel before the consonant cluster).

The reason why we have to be careful is that alternative analyses may also be possible, as always. For instance, we could assume that plurals such as *lip[s:]* have a special phonological word structure, which is unavailable to monomorphemes:

(131) $[_{PWd}$ lips $]_{PWd}$ s $]_{PWd}$

We could posit that such an adjoined structure is only possible in polymorphemic cases, e.g. because only segments which function as (inflectional) affixes are allowed to occur in such positions. The reason for this could be that the prosodic structure in (131) reflects the morphological structure of this word (van Oostendorp, 2003). This is as a matter of fact kindred in spirit to the proposal of Kaye (1992), who argues that the morphological and phonological structure are isomorphic in cases such as these. This can then also be seen as an instance of Recoverability, but a different one from REALIZE-MORPHEME.

In the formulation we have given above, it is assumed that all morphology is additive. Kurisu (2001), the longest discussion of REALIZE-MORPHEME phenomena to date, uses the constraint for different phenomena, such as truncation and non-concatenative morphology.

✓ REALIZE MORPHEME (RM) (formulation of Kurisu, 2001):
Let α be a morphological form, β be a morphosyntactic category, and F(α) be the phonological form from which F(α+β) is derived to express a morphosyntactic category β. Then RM is satisfied with respect to β *iff* F(α+β)≠F(α) phonologically.

This formulation is very different from the one cited above; it claims that the addition has to be 'visible', that a form *with* a morpheme should look different from a form without that morpheme. This difference does not have to be the addition of material; it can also be the deletion of material. In this sense, the proposal of Kurisu (2001) is kindred in spirit to Alderete (1999b)'s *Anti-*

Faithfulness, which states that certain output forms have to be different from other output forms. Like Alderete, Kurisu needs a theory of OO Faithfulness.

However, we could wonder whether alternatives are not sometimes available. For instance in some Limburg Dutch dialects we find alternations like the following:[20]

(132)

	Singular	Plural	Singular	Plural
Southern Limburg	vrʌŋk	vrʌŋ	hɑŋk	hɛŋ
Middle Limburg	vrʌn^{j}t^j	vrʌn^j	hɑn^{j}t^j	hɛn^j
	'friend'	'friends'	'hand'	'hands'

Apart from the umlaut process sometimes happening to the vowel (which we will disregard here), this looks very much like subtractive morphology. Yet this view might be mistaken if we look more closely. We then find out that the difference between singular and plural is often expressed by tonal contrast:

(133) *béín* 'leg' - *béìn* 'legs'

If we somewhat simplify matters here, we can assume that the plural suffix consists of a low tone (L). The plural form for *bein* is then formed as follows:

	H				HL
✓	b ɛ i n	+	L_{plur}	→	b ɛ i n

This is a clear case of additive morphology, which however could also be responsible for the alternation in (132). The fact that the consonant disappears in this case might be a result of interaction with normal phonology. Limburg Dutch phonology is governed by the following principle (Hermans & van Oostendorp, 2001):

✓ Syllables with a low tone do not have a coda with a sonorant and a voiceless obstruent.

This is in itself a curious statement, but it can be made insightful if we see that there is a clear connection between low tone and voicing cross-linguistically. This principle explains why there are no morphologically simple form in Limburg Dutch of the shape *lamp* 'id.' or *bank* 'id.' with a low tone. But in interaction with the principle of REALIZE-MORPHEME it can also explain why the final obstruents have to disappear in the plurals in (132). Plural has to be expressed by a Low tone, but this is incompatible with a voiceless obstruent. Therefore this has to disappear.

[20]The following data are based on research in progress carried out in collaboration with Frans Hinskens.

Note that for this analysis we do not need Kurisu (2001)'s definition of REALIZE-MORPHEME; our restricted, colour-based version of this constraint will do.

9.3 Nouns and Other Categories

We have established that certain phonological constraints at least need to see the difference between old and new material. Are there other properties which should be visible to the phonology? Almost since the inception of generative grammar (see for instance Postal, 1968) it has been claimed that also categorial information needs to be available for inspection.

Smith (2001) has worked out this claim within Optimality Theory. She suggests that the basic difference is one between nouns and other categories. We have seen in chapter 5.5 that such differences may sometimes be reduced to differences between the structures of nominal and verbal paradigms, but Smith (2001) gives cases which might not be amenable to such a reanalysis (we will concentrate here on the differences between nouns and verbs and leave out the interesting behaviour of adjectives).

For instance, the location of stress for nouns in Spanish is lexically constrastive (although restricted to one of the last three syllables of the word. However, the location of the stress in a verb is completely predictable, given its conjugational class and form

(134) a. Nouns: *página* 'page', *amíga* 'friend FEM.'

b. Verbs:

3sg. present indicative	3sg. preterite indicative	
hábla	habló	'speak'
cóme	comió	'eat'
Penultimate stress	Final stress	

While in nouns the position of the accent can be determined for a (small) part by the underlying structure, hence by faithfulness, the stress in verbs seems to be completely determined by well-formedness considerations. Smith (2001) claims that this is a universal pattern: differences between nouns and verbs can be described by higher-ranking special faithfulness for nouns. In other words, she extents the positional faithfulness framework and introduces special FAITH(Noun) constraints. It remains to be seen whether this is a true generalisation; some of the Mohawk cases discussed by Postal (1968) seem to indicate that it is verbs which are sometimes more faithful than nouns. For instance, it is noted that there are morphemes []Zoic (*wa*), []Feminine (*yaka*) and []Objective (*wa*), which can occur initially in both nouns and verbs; but in the former category the glides drop. More research into Mohawk morphophonology would be necessary to resolve this issue.

In Sinhala (Letterman, 1997), underlying vowel hiatus at root-suffix boundaries is always repaired, but the repair mechanism depends on the category. Nouns always resolve hiatus by glide insertion; no input material is deleted (135a). Verbs, on the other hand, preferentially resolve hiatus by deletion of an input vowel (135b). If both morphemes are monosyllabic, glide epenthesis does occur as a last-resort strategy; see (135b-iii)).

(135) a. Nouns repair hiatus by glide insertion

/ræ+a/	[rækjə]	'night SG.DEF.'
/toppi+a/	[toppijə]	'hat SG.DEF.'
/aɻu+a/	[aɻuwə]	'attic SG.DEF.'
/maaligaa+a/	[maaligaawə]	'palace SG.DEF.'

b. i. Polysyllabic verbs: root-final vowel deletes

/bala+ili/	[bælØili]	'look PL.NOMINAL'
/kora+ili/	[kerØili]	'do PL.NOMINAL'

ii. Monosyllabic verbs: suffix vowel deletes

/da+ilaa/	[daaØlaa]	'burn PAST PART.'
/we+ilaa/	[weØlaa]	'become PAST PART.'

iii. Monosyllabic verb and suffix: Glide insertion

/e+e+.../	[ewe...]	'come PASSIVE'
/ka+e+.../	[kæwe...]	'eat PASSIVE'

Smith (2001) proposes that these cases are handled with a special constraint MAX-Noun. Because this constraint is high-ranked, it prevents the deletion of nominal material. Of course, in this particular case it is less obvious that nominal faithfulness wins, since the nouns are still unfaithful: they have an epenthetic glide. Smith (2001) has an interesting footnote about this:

> The insertion of a glide to avoid hiatus is also a faithfulness violation (violating DEP). However, this is probably not a violation of the noun-faithfulness constraint DEP_N, because the inserted glide appears outside the noun root itself (as well as outside the suffix).

This remark only makes sense under Consistency of Exponence: constraints against insertion of specifically nominal material can never be violated if Gen does not have the power to make epenthetic segments 'nominal' or 'verbal'. This seems true for most cases discussed in the literature. Formulating the relevant constraint seems to be particularly straightforward in Coloured Containment:

✓ Nominal material needs to be phonologically parsed.

The counterpart of DEP_N cannot even be formulated in this approach: it would stipulate that colourless material cannot be part of nouns. But since

being a noun is part of the morphological colour, this demand is always vacuously satisfied. To the extent that observations about differences between nouns and verbs make sense, then, they lend further support to a view of faithfulness which is based on Containment rather than Correspondence theory.

Bibliography

Al-Mozainy, Hamza Q. (1981). *Vowel alternations in a Bedouin Hijazi Arabic dialect: abstractness and stress*. Ph.D. thesis, University of Texas, Austin, Austin, TX.

Alderete, John (1997). 'Dissimilation as Local Conjunction'. *NELS*, 27: 17–31.

——— (1999a). 'Faithfulness to Prosodic Heads'. In: Hermans, Ben & Marc van Oostendorp (eds.), *The Derivational Redidue in Phonological Optimality Theory*. Amsterdam: John Benjamins.

——— (1999b). *Morphologically Governed Accent in Optimality Theory*. Ph.D. thesis, University of Massachusetts at Amherst.

Anderson, S.R. (1992). *A-Morphous Morphology*. Cambridge: Cambridge University Press.

Antilla, Arto (2002). 'Variation and Phonological Theory'. In: Jack Chambers, Peter Trudgill & Natalie Schilling-Estes (eds.), *The Handbook of Language Variation and Change*, pp. 206–243. Oxford: Blackwell.

Anttila, Arto, Vivienne Fong, Stefan Benus, & Jennifer Nycz (2004). 'Deriving Consonant Cluster Phonotactics: Evidence from Singapore English'. Appeared as ROA 649-0404.

Bakovic, Eric (2000). *Harmony, Dominance and Control*. Ph.D. thesis, Rutgers.

——— (2003). 'Vowel Harmony and Stem Identity'. Appeared as ROA-540-0902.

Beckman, Jill (1998). *Positional Faithfulness*. Ph.D. thesis, University of Massachusetts at Amherst.

Benua, Laura (1997). *Transderivational Identity: Phonological Relations between Words*. Ph.D. thesis, University of Massachusetts at Amherst.

Blaho, Sylvia (2004). 'Featural faithfulness, feature geometry and privativity'. Handout of a presentation given at GLOW, Thessaloniki, Greece.

Blutner, Reinhard (1999). 'Some aspects of optimality in natural language interpretation'. *Journal of Semantics*. URL `http://www.blutner.de/optimal.pdf`.

Boersma, Paul (1998). *Functional Phonology*. Ph.D. thesis, University of Amsterdam.

——— (1999). 'On the need for a separate perception grammar'. URL `http://www.fon.hum.uva.nl/paul/papers/percgram.pdf`. Manuscript, University of Amsterdam.

——— (2005). 'Some listener-oriented accounts of hache aspiré in French'. ROA 730.

Bolognesi, Ricardo (1998). *The phonology of Campidanian Sardinian: A unitary account of a self-organizing structure*. Ph.D. thesis, University of Amsterdam.

Booij, Geert (1997). 'Non-derivational Phonology Meets Lexical Phonology'. In: Roca, Iggy (ed.), *Derivations and Constraints in Phonology*, pp. 261–288. Clarendon Paperbacks.

Brame, Michael (1974). 'The cycle in phonology: stress in Palestinian, Maltese and Spanish'. *Linguistic Inquiry*, 5: 39–60.

Burzio, Luigi (1994). *Principles of English Stress*. Cambridge: Cambridge University Press.

——— (1998). 'Multiple Correspondence'. *Lingua*, 103: 79–109.

——— (2000). 'Cycles, Non-Derived Environment Blocking, and Correspondence'. In: Dekkers, Joost, Frank van der Leeuw, & Jeroen van de Weijer (eds.), *Optimality Theory. Phonology, Syntax and Acquisition*. Oxford: Oxford University Press.

——— (2003). 'Output-to Output Faithfulness in Phonology: The Italian Connection'. *Lingue e Linguaggio*.

Bye, Patrik (2002). *Virtual Phonology: Rule-Sandwiching and Multiple Opacity in North Saami*. Ph.D. thesis, University of Tromsø.

Chomsky, Noam (1995). *The Minimalist Program*. Cambridge, MA: The MIT Press.

Chomsky, Noam & Morris Halle (1968). *The Sound Pattern of English*. Cambridge, MA: The MIT Press.

Chomsky, Noam, Morris Halle, & Frank Lukoff (1956). 'On Accent and Juncture in English'. In: *For Roman Jakobson*. The Hague: Mouton.

Churchward, C.M. (1940). *Rotuman Grammar and Dictionary*. Sydney: Australasia Medical Publishing Co. Repr. New York: AMS Press, 1978.

Cole, Jennifer (1995). 'The Cycle in Phonology'. In: Goldsmith, John (ed.), *The Handbook of Phonological Theory*. Cambridge, UK: Basil Blackwell.

Dixon, R.M.W. (1972). *The Dyirbal Language of North Queensland*. Cambridge: Cambridge University Press.

Dols, Nicolau (2000). *Teoria fonològica i sillabificació. El cas del català de Mallorca*. Ph.D. thesis, Universitat de les Illes Balears.

Duanmu, San (1999). 'Alignment and the Cycle are Different'. In: Hermans, Ben & Marc van Oostendorp (eds.), *The Derivational Residue in Phonological Optimality Theory*. Amsterdam: John Benjamins.

Dudas, Karen (1976). *The Phonology and Morphology of Modern Javanese*. Ph.D. thesis, University of Illinois, Urbana-Champaign.

Erwin, Wallace M. (1963). *A Short Reference Grammar of Iraqi Arabic*. Washington: Georgetown University Press.

Féry, Caroline & Gisbert Fanselow (2003). 'Ineffability in Grammar'. *Linguistische Berichte*, Sonderheft 11: 288–310.

Frampton, John (2001). 'What Kind of Thing is a Language Faculty? A Critical Evaluation of OT Phonology'. *GLOT International*, 6, 1.

——— (2004). 'Distributed Reduplication'. Available at `http://www.math.neu.edu/ling/dr/dr.html`.

Fudge, Eric C. (1967). 'The nature of phonological primes'. *Journal of Linguistics*, 14: 157–177.

Goldrick, Matthew (2000). 'Turbid Output Representations and the Unity of Opacity'. *Proceedings of NELS*, 30: 231–245. Also available as ROA 368-1299.

Hargus, Sharon & Ellen Kaisse (1993). *Studies in lexical phonology*. Orlando: Academic Press.

Hermans, Ben & Marc van Oostendorp (2001). 'Voice-tone interaction in a Limburg dialect: evidence for feature licensing'. In: de Hoop, Helen & Ton van der Wouden (eds.), *Linguistics in the Netherlands*, pp. 81–92. Amsterdam/Philadelphia: John Benjamins.

Hooper, Joan (1976). *An introduction to natural generative phonology*. New-York: Academic Press.

Horne, Elinor (1961). *Beginning Javanese*. New Haven, CT: Yale University Press.

van der Hulst, Harry (1993). 'Units in the analysis of signs'. *Phonology*, 10, 2: 209–241.

Hyman, Larry (1988). 'Underspecification and vowel height transfer in Esimbi'. *Phonology*, 5: 255–273.

Inkelas, Sharon (1990). *Prosodic Constituency in the Lexicon*. New York: Garland.

——— (1995). 'The consequences of optimization for underspecification'. *NELS*, 25: 287–302.

Inkelas, Sharon & Orhan Orgun (2001). 'Reconsidering Bracket Erasure'. In: Booij, Geert & Jaap van Marle (eds.), *Yearbook of Morphology 2001*. Dordrecht: Kluwer.

Inkelas, Sharon & Cheryl Zoll (2005). *Reduplication. A Morphological Theory*. Cambridge: Cambridge University Press.

Itô, Junko & Armin Mester (1995). 'The core-periphery structure of the lexicon and constraints on reranking'. *University of Massachusetts Occasional Papers*, 18: 181—210.

——— (2001). 'Covert generalizations in Optimality Theory: the role of stratal faithfulness constraints'. *Studies in Phonetics, Phonology and Morphology*, 7: 261–295.

——— (2002). 'Lexical and postlexical phonology in faithfulness theory: Evidence from Japanese'. *Linguistische Berichte*, Sonderheft II: 183–207.

——— (2003). *Japanese Morphophonemics. Markedness and Word Structure*. Cambridge, Mass.: MIT Press.

Iverson, Gregory (1981). 'Rules, constraints, and paradigm lacunae'. *Glossa*, 15: 136–144.

Jakobson, Roman (1942). *Kindersprache, Aphasie und allgemeine Lautgesetze*. Uppsala: Lundequist.

Jun, Jongho (1999). 'Generalized sympathy'. In: P. N. Tamanji, M. Hirotani & N. Hall (eds.), *Proceedings of NELS 29*, pp. 121–135. Amherst, MA: GLSA.

Kager, René (1999a). *Optimality Theory*. Cambridge: Cambridge University Press.

——— (1999b). 'Surface opacity of metrical structure in Optimality Theory'. In: Hermans, Ben & Marc van Oostendorp (eds.), *The Derivational Redidue in Phonological Optimality Theory*. Amsterdam: John Benjamins.

Kager, René, Joe Pater, & Wim Zonneveld (2004). *Fixing Priorities: Constraints in Phonological Acquisition*. Cambridge: Cambridge University Press.

Kaye, Jonathan (1974). 'Opacity and Recoverability in Phonology'. *Canadian Journal of Linguistics*, 19: 134–149.

——— (1992). 'On the interaction of theories of Lexical Phonology and theories of phonological phenomena'. In: Dressler, Uli, Hans Luschützky, Oskar Pfeiffer, & John Rennison (eds.), *Phonologica 1988*, pp. 141–155. Cambridge: Cambridge University Press.

Keenan, Edward (2002). 'Representing Over-application Sequentially'. Available online at http://www.linguistics.ucla.edu/people/keenan/keenan.htm.

Kenstowicz, Michael (1996). 'Base identity and uniform exponence: Alternatives to cyclicity'. In: Durand, Jacques & Bernard Laks (eds.), *Current trends in phonology: Models and methods*, pp. 363–393. Paris-X and Salford: University of Salford Publications. Available as ROA-103.

Kenstowicz, Michael & Kamal Abdul-Karim (1980). 'Cyclic Stress in Levantine Arabic'. *Studies in the Linguistic Sciences*, 10: 55–76.

Kenstowicz, Michael & Charles Kisseberth (1979). *Generative Phonology: Description and Theory*. New York: Academic Press.

Kiparsky, Paul (1982a). *Explanation in Phonology*. No. 4 in Publications in Language Sciences. Dordrecht: Foris.

——— (1982b). 'Lexical Morphology and Phonology'. In: Yang, I.-S. (ed.), *Linguistics in the Morning Calm*, pp. 3–91. Seoul: Hanshin.

——— (1983). 'Word formation and the lexicon'. In: *Proceedings of the 1982 Mid- America Linguistics Conference*, pp. 3–29.

——— (1985). 'Some consequences of Lexical Phonology'. *Phonology Yearbook*, 2: 85–138.

——— (2000). 'Opacity and Cyclicity'. *The Linguistic Review*, 17: 351–367.

——— (to appear). *Paradigmatic Effects and Opacity*. Stanford: CSLI.

Kirchner, Robert (1996). 'Synchronic Chain Shifts in Optimality Theory'. *Linguistic Inquiry*, 27: 341–350.

Kurisu, Kazutaka (2001). *The Phonology of Morpheme Realization*. Ph.D. thesis, University of California at Santa Cruz.

Labov, William (1993). *Principles of Language Change. I: Internal Factors*. Blackwell: Oxford.

Letterman, Rebecca (1997). *The Effects of Word-Internal Prosody in Sinhala: A Constraint-Based Analysis*. Ph.D. thesis, Cornell University.

Lloret, Maria-Rosa (2004). 'The phonological role of paradigms: The case of insular Catalan'. Appeared as ROA 646-0404.

Łubowicz, Anna (2000). 'Derived Environement Effects in Optimality Theory'. *Lingua*, 112: 243–280.

Maiden, Martin (1991). *Interactive Morphonology: Metaphony in Italy*. Routledge.

Malone, Joseph (1993). *Tiberian Hebrew Phonology*. Winona Lake, IN: Eisenbrauns.

Mascaró, Joan (1983). 'Three Spanish Variations and a Majorcan Theme'. Ms., Universitat Autònoma de Barcelona.

McCarthy, John (1999). 'Sympathy and Phonological Opacity'. *Phonology*, 16: 331–399. Also available as ROA 252-0398.

——— (2000). 'Extensions of Faithfulness: Rotuman Revisited'. *Natural Language and Linguistic Theory*, 18: 147–197. A different version is available as ROA 110-0000.

——— (2003a). 'Comparative Markedness'. *Theoretical Linguistics*, 29: 1–51.

——— (2003b). 'Optimal Paradigms'. Available on ROA 482-1201.

——— (2003c). 'Richness of the Base and the Determination of Underlying Representations'. ROA 616-0903.

——— (2003d). 'Sympathy, Cumulativity, and the Duke-of-York Gambit'. In: Féry, Caroline & Ruben van de Vijver (eds.), *The Optimal Syllable*, pp. 23–76. Cambridge: Cambridge University Press.

——— (to appear). 'OT constraints are categorical'. To appear in *Phonology*.

McCarthy, John & Alan Prince (1993). 'Prosodic Morphology. Constraint Interaction and Satisfaction'. Available on ROA 485-1201.

——— (1994). 'The emergence of the unmarked: optimality in Prosodic Morphology'. *NELS*, 24: 333–379.

——— (1995a). 'Faithfulness and Reduplicative Identity'. *UMOP*, 18: 249–384.

——— (1995b). 'Generalized Alignment'. *Morphology Yearbook*.

McCarthy, John & Matthew Wolf (2005). 'Less than zero: Correspondence and the null output'. URL `http://roa.rutgers.edu/view.php3?id=998`. Ms. University of Massachusetts at Amherst. Published as ROA 722.

Meade, Rocky (2001). *Acquisition of Jamaican Phonology*. Ph.D. thesis, Universiteit van Amsterdam.

Mester, Armin & Junko Itô (1989). 'Feature predictability and underspecification: Palatal prosody in Japanese mimetics'. *Language*, 65: 258–293.

Mohanan, K.P. (1986). *Lexical phonology*. Dordrecht: Kluwer.

van Oostendorp, Marc (1997). 'Style levels in conflict resolution'. In: Frans Hinskens, Roeland van Hout & Leo Wetzels (eds.), *Variation, Change and Phonological Theory*, pp. 207–229. Amsterdam: John Benjamins.

——— (2000). *Phonological Projection*. Berlin/New York: Mouton de Gruyter.

——— (2001). 'Nasal Consonants in Variants of Dutch and Some Related Systems'. *Neerlandistiek.nl*. URL `http://www.neerlandistiek.nl/01/08/index.html`.

——— (2003). 'The Phonological and Morphological Status of the Prosodic Word Adjunct'. *Linguistische Berichte*, Sonderheft 11.

——— (in press). 'An Exception to Final Devoicing'. In: van der Torre, Erik Jan & Jeroen van de Weijer (eds.), *Voicing in Dutch*. Amsterdam: John Benjamins.

Orgun, Cemil Orhan (1996). *Sign-Based Morphology and Phonology with Special Attention to Optimality Theory*. Ph.D. thesis, UC Berkeley.

——— (1998). 'Cyclic and Noncyclic Phonological Effects in a Declarative Grammar'. In: Booij, Geert & Jaap van Marle (eds.), *Yearbook of Morphology 1997*, pp. 179–218. Dordrecht: Kluwer.

Orgun, Cemil Orhan & Richard Sprouse (1999). 'From MParse to Control: Deriving ungrammaticality'. *Phonology*, 16: 191–220.

Pesetsky, David (1979). 'Russian Morphology and Lexical Theory'. Manuscript, MIT.

Postal, Paul (1968). *Aspects of phonological theory*. New York, Evanston and London: Harper & Row.

Potts, Christopher & Geoffrey K. Pullum (2002). 'Model theory and the content of OT constraints'. *Phonology*, 19, 3: 361–393.

Prince, Alan & Paul Smolensky (1993). 'Optimality Theory: Constraint Interaction in Generative Grammar'. Manuscript, Rutgers University and University of Colorado at Boulder. Available at ROA.

Pullum, Geoffrey (1976). 'The Duke of York gambit'. *Journal of Linguistics*, 12: 83–102.

Raimy, Eric (2000). *The morphology and morphophonology of reduplication*. Berlin: Mouton de Gruyter.

Rice, Curt (2005). 'Optimal gaps in optimal paradigms'. *Catalan Journal of Linguistics*. URL `http://ling.auf.net/lingBuzz/000055`.

Ringen, Catherine & Robert Vago (1988). 'Hungarian vowel harmony in Optimality Theory'. *Phonology*, 15: 393–416.

Shaw, Patricia (1976). *Dakota Phonology and Morphology*. Ph.D. thesis, University of Toronto.

Siegel, Dorothy (1974). *Topics in English Morphology*. Ph.D. thesis, MIT.

——— (1978). 'The Adjacency Condition and the Theory of Morphology'. In: *Proceedings of NELS 8*, pp. 189–197. Amherst, MA.

Smith, Jennifer (2001). 'Lexical category and phonological contrast'. In: Kirchner, Robert, Joe Pater, & Wolf Wikely (eds.), *Papers in Experimental and Theoretical Linguistics 6: Workshop on the Lexicon in Phonetics and Phonology*, pp. 61–72. Edmonton: University of Alberta.

Smolensky, Paul (1996). 'The Initial State and 'Richness of the Base' in Optimality Theory'. Johns Hopkins University Technical Report CogSci 96-4.

Steriade, Donca (1999). 'Lexical conservatism in French adjectival liaison'. In: *Proceedings of the 25th Colloquium on Romance Languages*. Amsterdam: John Benjamins.

——— (2001). 'The Phonology of Perceptibility Effects: The P-map and its consequences for constraint organization'. Ms., UCLA.

Taeldeman, Johan (1982). 'Regelordening, taalverandering en ruimtelijke taalvariatie'. *Taal en Tongval*, 34, 3/4: 120–131.

van der Torre, Erik Jan (2003). *Dutch Sonorants: The Role of Place of Articulation in Phonotactics*. Ph.D. thesis, Leiden University.

Trommelen, Mieke (1982). *The Syllable in Dutch: With Special Reference to Diminutive Formation*. Ph.D. thesis, University of Utrecht. Published at Dordrect: Foris, 1984.

Walker, Rachel (2001). 'Positional Markedness in Vowel Harmony'. In: *Proceedings of HILP 5. Linguistics in Potsdam*.

——— (2004). 'Weak Triggers in Vowel Harmony'. *Natural Language and Linguistic Theory*.

Wunderlich, Dieter (2001). 'Birectional OT in morphology'. URL `http://web.phil-fak.uni-duesseldorf.de/ wdl/Bidirectional-OT.pdf`. Manuscript, University of Düsseldorf.

Zoll, Cheryl (1998). 'Positional asymmetry and licensing'. 'Expanded handout' of a talk presented at the LSA meeting. ROA 282-0998.

——— (2002). 'Vowel reduction and reduplication in Klamath'. *Linguistic Inquiry*, pp. 520 – 527.