Alignment, syllable and metrical structure in German

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Ever since I have read the original manuscripts by Prince and Smolensky and McCarthy & Prince, I have tried to exploit the potentials offered by the Optimality Theory for the stress pattern, the foot and the syllable structure of German. This work is the result of my efforts.

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Contents

Introduction

The present work is one of the first applications of Optimality Theory (OT) to a large domain of German phonology: in the following chapters, syllabification, both in monomorphemes and in complex words, as well as lexical stress patterns will be examined from an OT point of view. OT is a new theory of grammar developed by Prince & Smolensky (1993) and McCarthy & Prince (1993), who apply it to phonological facts from different languages in the same works, as well as in subsequent publications (McCarthy & Prince 1993, 1994a, b). So far, the theory has been very successful in accounting for many different aspects of phonology in many languages (Buckley 1994, Hammond 1994, Hung 1993, 1995, Itô & Mester 1994, Itô, Mester & Padgett 1994, Kager 1994a, Kenstowicz 1994a, b, Pierrehumbert 1993 and Rosenthall 1994 among others); this is particularly so in the area of stress and related phenomena. According to OT, universal grammar provides a set of universal constraints and the grammars of individual languages consist of one or several rankings of these constraints, which interact to select, for each input form, the optimal surface structure from a set of candidates. The details of the theory will be explained in Chapter 1. Because of its flexibility, OT can account for phonological regularities that are not entirely rigid or obligatory. In particular, the technique of ranking constraints can be shown to solve some of the problems posed by an account of German lexical stress, which has long been a vexing domain because it does not comply to any easily expressible generalization (see Chapter 3 and especially section 3.3. for a summary of the properties of lexical stress).

This introduction gives a short review of the literature on German metrical phonology in the generative framework, followed by an overview of the present study.

The frameworks that have been used to account for German word stress are extremely varied and reflect the history of phonology itself. The first approaches to German suprasegmentals in a generative framework are Bierwisch (1966) and Kiparsky (1966). They both use generative rules like the ones proposed by Chomsky & Halle (1968) for English. Unfortunately, neither Bierwisch nor Kiparsky are interested in lexical stress: Bierwisch

concentrates on intonation and prosodic parsing of whole sentences, while Kiparsky restricts himself to stresses of prefixes and rhythmic stresses.

Wurzel (1980a, b), whose phonological work is also carried out in a generative framework, gives a rather descriptive account of lexical stress. He divides German words into two classes, the native and the nonnative vocabulary, and then gives two separate sets of rules for each class. These rules use some aspects of the generative rules proposed by Chomsky & Halle (1968), like the Stress Subordination Convention, which posits that when [1 stress] is assigned, all other stresses in the relevant string (here the word) are reduced by one. The rules responsible for the native vocabulary assign stress to the first syllable. Suffixes like *-en, -em, -er, -es, -est, -end, -chen* are always unstressed. And main stress is assigned to some nominal prefixes like *un-, miß-, ur-* and *erz-*. All native inflectional and derivational affixes (*-en, -er, -isch, -ig,* etc.) are unstressable. In contrast, the rules relevant for the nonnative vocabulary assign stress to the last heavy syllable if there is one, and to the first syllable otherwise. Since a heavy syllable is one with a long vowel or a diphthong or a final consonant, Wurzel is forced to exclude syllables like *-on, -us,* and *-um,* as well as some occurrences of *-or* and *-ik,* which are heavy, according to his classification, but never stressed. Thus, the native vocabulary has unmarked stress on the first syllable, and the nonnative vocabulary on the last (heavy) syllable. One of the main consequences of Wurzel's rules is that the nonnative vocabulary is quantity-sensitive, whereas the native one is not. And though his rules tend to make the right predictions, they lack coherence and assume too many classifications, ad hoc statements, and exceptions.

Benware (1980) is purely descriptive: the nonnative vocabulary is split into three groups and the following rules are given.[1]

(1) 1. ABR: The firstmost possible syllable is stressed.
2. EBR: The lastmost possible syllable is stressed.

[1] In the original:
1. ABR: Die erstmögliche Silbe wird betont.
2. EBR: Die letztmögliche Silbe wird betont.
3. LR: Eine Lateinregel weist Wörtern auf gewissen Endungen (z.B. *-um, -us, -is* u.a.) die Betonung je nach der Silbenstruktur des Wortes und anderen Merkmalen zu.

3. LR: A Latin Rule assigns stress to words with certain endings (e.g. *-um, -us, -is,* among others), according to the syllable structure of the words and other features.

As an example, the second rule accounts for words having a syllable with a tense vowel plus a consonant or a lax vowel plus at least two consonants (in the orthography). (Strangely, this rule is said to also apply to words like *Petersílie* 'parsley', which does not correspond to its structural description, since it does not have such a syllable.) Words can undergo more than one rule. Thus, like Wurzel, Benware assumes that some words have initial stress and others have final stress.

Giegerich (1985) is probably the most extensive study on German stress until now, and the first one within an explicit theoretical framework. Lexical stress is described in a purely metrical framework, using only metrical trees. The following generalization accounts for lexical stress:

> "[...] the main stress in German words falls on the final syllable if it is heavy: it falls on the penultimate syllable if the final one is light and the penultimate heavy; it falls on the antepenultimate syllable if both syllables that follow are light." Giegerich (1985:23)

Giegerich analyzes German as a quantity-sensitive language in all parts of the vocabulary. The examples he considers are listed here.

Words with a 'heavy' final syllable:
(5) Magazin 'magazine', Disziplin 'discipline', Miliz 'militia', Indiz 'clue', Offizier 'officer', Konsum 'consumption', Paket 'parcel', Dekan 'dean', Moral 'moral', Fraktion 'faction', Rasur 'shave', Skandal 'scandal', Salat 'salad', Fasan 'pheasant', Organ 'organ', Ökonom 'economist', Peru 'Peru', Büro 'office', Chemie 'chemistry', Trikot 'stockinette', Kamerad 'comrade', Allee 'avenue', konfus 'confused', solid 'decent', abstrus 'abstruse', naiv 'naive'

(6) Konzert 'concert', Konzept 'concept', Infarkt 'heart attack', Instanz 'instance', Instinkt 'instinct', Talent 'talent', Element 'element', Präsent 'present', Präsenz 'presence', korrupt 'corrupt', korpulent 'corpulent',

abstrakt 'abstract', intakt 'intact', präsent 'present', grotesk 'grotesque', rasant 'sweeping'

(7) Metall 'metal', Pedell 'janitor', Rebell 'rebel', Hotel 'hotel', Karussell 'merry-go-round', Duell 'duel', Diagramm 'diagram', Tyrann 'tyrant', Prozeß 'process', Regreß 'recourse', Kongreß 'congress', Fagott 'bassoon', Zermatt 'place name', Kompott 'stewed fruit', Schafott 'scaffold', Skelett 'skeleton', Kattarrh 'catarrh'

Words with a 'heavy' penultimate syllable:

(8) Amok 'amok', Arrak 'arrak', Atlas 'atlas', Fazit 'result', Herpes 'herpes', Konsul 'consul', Kognak 'brandy', Slalom 'slalom', Tenor 'gist', Limes 'Limes', Kustos 'custodian'

(9) Baby 'baby', Gummi 'rubber', Hobby 'hobby', Nazi 'nazi', Profi 'professional', Auto 'car', Akku 'storage battery'

(10) Franziskus 'Francis', Chiasmus 'chiasmus', Orgasmus 'orgasm', Organismus 'organism', Epidermis 'epidermis', Logarithmus 'logarithm', Epitaxis 'epitaxis', Epos 'epic'

(11) Angina 'angina', Arena 'arena', Korona 'corona', Konto 'account', Saldo 'bank balance', Dementi 'denial', Esperanto 'Esperanto', Agenda 'agenda', Veranda 'porch'

Words with two 'light' final syllables:

(12) Drosophila 'drosophila', Harmonika 'harmonica', Pandämonium 'pandemonium', Kompositum 'compound', Uvula 'uvula', Uterus 'uterus', Claudius 'Claudius'

(13) Akkordeon 'accordion', Homunkulus 'homunculus', Polyptoton 'polyptoton', Analeptikon 'analeptic', Lexikon 'dictionary', Onomastikon 'onomastic', Opuskulum 'opuscule', Ultima 'ultimate', Kamera 'camera', Zeppelin 'airship'

Unlike Wurzel and Benware, Giegerich manages to come up with a homogeneous account of all German words. According to him, the words with two or more stressable syllables are generally nonnative, and only in this part of the vocabulary is it possible to formulate rules and generalizations (the native vocabulary consists of words that are too short to be in need of stress rules). Hence, there is no need to make a distinction between the native and nonnative vocabulary. However, the data presented in Chapter 3 reveal too many exceptions to his rules, especially in disyllabic words. Moreover, the characterization of the words in (7) as having a heavy penult is based on orthography, not phonetics (see section 3.2.2 for a detailed discussion of these words). See also Kaltenberg (1994) for a critical overview of Giegerich and other accounts.

Vennemann (1992) formulates a few very accurate descriptive generalizations (called rules) which are intended to account for the whole German vocabulary.

(14) [R1] FULL SYLLABLE RULE
Only full syllables can be accented.

[R2] REDUCED SYLLABLE RULE
A covered reduced ultima arrests the accent on the last full syllable.

[R3] THREE SYLLABLE RULE
Only the last three full syllables can be accented.

[R4] PENULT RULE
The accent does not retract beyond a heavy penult.

Since these rules will be commented on in some detail in Chapter 3, the mere listing of them must suffice here. A critical survey of the literature focusing on Vennemann's rules can be found in Jessen (1994).

A further approach to word stress which deserves mentioning here is Eisenberg (1991). Eisenberg claims that the canonical accentual structures of German are the trochee and the dactyl, in that order. According to him, the penult and the antepenult are the normally stressed syllables, but never the

ultima or a syllable before the antepenult. He leaves the question of quantity-sensitivity explicitly open. His exclusion of the final stress does not conform to the data, as will be shown in Chapter 3. However, the insight that trochees are the unmarked stress patterns is in accordance with the position taken in this work. Grewendorf, Hamm & Sternefeld (1987) also come to the conclusion that a trochee is canonically built in German. In their account, nontrochaic patterns are explained by heaviness of the last syllable, extrametricality and exceptionality. However, Eisenberg goes a step further by considering not only monomorphemic words, but also complex words.

From this short overview of the literature, one can see that there is no consensus on what should be regarded as the best account of lexical stress in German. Some authors take German to be a quantity-sensitive language, others think that German is quantity-insensitive; some divide the vocabulary into two classes, others give a uniform account; some claim that stress tends to be initial, others that it is rather final; and still others give accentual templates. But, so far, no author has looked into the data in a systematic way.

One of the goals of the present work is to remedy this situation by giving a reliable description of word stress patterns based on large database of German words (see Chapter 3 for details). The descriptive results thus obtained will then be accounted for by an OT approach, offering new insights into the organization of grammar. The main focus will be on the constituent of the foot, which is taken to be the domain of both stress assignment and some phonologically-conditioned morphological operations.

The present study is organized as follows. The first chapter is an introduction to Optimality Theory. It simply describes the theory as proposed by its originators.

The second chapter is devoted to syllable structure. The main focus lies on the syllable weight, measured in moras, and on the lax-tense distinction for vowels. We will show that, as far as syllable structure is concerned, German syllables are non-, bi- or trimoraic (translatable into non-, mono- and bimoraic: see section 2.1). Though most attention will be paid to monomorphemic words, the syllabification of complex words will be examined, too.

The third chapter is about the metrical structure of monomorphemic words. Di-, tri- and polysyllabic words are the objects of different sections. First, the data will be studied carefully and classified according to relative

syllable structure and weight. Second, an optimality-theoretic account will be developed, using mainly constraints that have already been proposed for other languages; this is considered an advantage because, according to Optimality Theory, grammar consists of a ranking of *universal* constraints. The fact that a special ranking and very few new constraints are needed for German clearly confirms the whole theory. Consequently, we have tried to avoid the creation of new constraints; and we have also avoided giving new names to old constraints.

The analysis given for German word stress involves a nonexhaustive footing. It is proposed that two feet, one initial and one final, are sufficient.

No attention at all is given to the realization of stress, which is still a poorly understood domain (but see Dogil (forthcoming) for some experiments in this direction).

In the fourth chapter, some aspects of the stress patterns of complex words will be discussed, most of all of inflected and derived words. It is shown that the syllabic trochee deserves a special place in the German phonology, not only because it helps to give a unified account of stress phenomena, but also because some morphology refers to the foot, as well.

Chapter 1
Optimality Theory

1. 1 General principles

This first chapter is an introduction to Optimality Theory. The principles and examples discussed in the following pages are mainly taken from McCarthy & Prince (1993a, 1993b, 1994a) but also from Prince & Smolensky (1993) and McCarthy & Prince (1994b), as well as from other sources (Itô, Mester & Padgett 1994, Cohn & McCarthy 1994). McCarthy & Prince (1993a) offer a detailed exposition of the theory, which clearly states the main principles and changes with respect to earlier phonological theories. I will concentrate on those aspects of the theory that are of relevance for the present work. In particular, no reference is made to reduplication, though this phenomenon is the main theme in different works of McCarthy and Prince.

Traditional generative phonological theories assume that the surface structures of well-formed phonological representations are derived from underlying representations by means of ordered rules of the form $X \rightarrow Y / A \_ B$, the so-called *re-write rules*. It has long been observed that not every possible structure is actually derived, but only well-formed ones, though in principle every kind of structure can be derived by *re-write rules*. Phonotactics, metrical structure, feature geometry, etc. restrict their power.

Although Optimality Theory (OT) does not deny the existence of both underlying structures and surface structures (they are called 'inputs' and 'outputs', respectively), it does away with rules and their orderings, derivations and the like. Its aim is to explain relations between morphology and phonology on the basis of very general, both universal and language-dependent principles. Universal grammar provides a set of constraints, *Con*, out of which grammars are constructed, a function *Gen*, which defines for each possible input *i* the range of candidate linguistic analyses available to *i*, and a function *Eval*, which comparatively evaluates sets of forms with respect to a given constraint hierarchy Γ, a ranking of Con.

The grammar has the general form given in (1) (McCarthy & Prince 1994a:4).

(1) a. Gen (in_i) = {$cand_1$, $cand_2$, ...}
b. Eval (Γ_m, {$cand_1$, $cand_2$, ...}) –> {$cand_k$}

(1 a) and (1b) are thought of as two subsequent steps:
1. Generation of candidates: For each input (in_i), an infinite set of candidates {$cand_1$, $cand_2$, ...}, consistent with the input, is generated by (1a). Various linguistic assumptions must be made in order to specify which structures can be generated by Gen. Gen is restricted by very general principles of linguistic form: how can phonological forms be represented? Which primitives can combine? and the like. Examples are:
- Moraic representation: the syllable node dominates moras.

(2)

- Long/short distinction: a vocalic root can be mono- or bimoraic. Moraic structure comes from the lexicon.

(3)

Apart from such general principles of phonological representation and combination, McCarthy & Prince (1993a) and Prince & Smolensky (1993a) introduce three principles which underlie Gen.

1. **Freedom of Analysis.** Any amount of structure may be posited.
2. **Containment.** No element may be literally removed from the input form. The input is thus contained in every candidate form.
3. **Consistency of Exponence.** No changes in the exponence of a phonologically-specified morpheme are permitted.

True Freedom of Analysis means that Gen produces candidates with any amount of structure, i.e., candidates with moraic, syllabic or other prosodic structure, with association lines and with epenthetic segments. This principle

is important in that the generation of a great number of candidates ensures that no repair strategy (as in Paradis's Theory of Constraints and Repair Strategies, Paradis 1988a, b, 1993, LaCharité & Paradis 1993) or other specific rule is needed. There is no rule like 'add a mora', because candidates with an additional mora already exist.

In McCarthy & Prince (1993a), Containment restricts this freedom: the input must be contained in each legal candidate. However, as suggested in McCarthy & Prince (1994b), where the notion of Correspondence is developed in some detail, Containment is not absolutely necessary.[1] In principle, each conceivable candidate can be generated (which makes the number of candidates enormous), and the task of eliminating suboptimal candidates is undertaken by the Faithfulness constraints (see below).

Consistency of Exponence says that morphological affiliation cannot be altered by Gen, in other words, that the phonological specifications of a morpheme (like segments or moras) cannot be touched by Gen. In particular, epenthetic segments which are generated by Gen have no morphological affiliation. In the same way, underparsing (phonetic non-realization) does not change the make-up of a morpheme, though it does change its phonetic form. In sum, the phonological exponents of a morpheme must be identical in the underlying and in the surface structures, except if it does not have any phonological specification (as in reduplication).

2. Evaluation of the candidates: The function Eval (1b) estimates the well-formedness of each member of the set of candidates with the help of a set of constraints (Con) that are ranked relatively to each other according to a hierarchy Γ, and chooses the optimal candidate ($\{cand_k\}$).

[1] McCarthy & Prince (1994a) discuss reduplication and list different constraints responsible for the correspondence between the base and the reduplicant. The constraints they formulate are grouped in two classes: those that deal with the structural integrity or quality of the reduplicant (ANCHORING and CONTIGUITY), and those that deal with the extent of correspondence between base and reduplicant, and the quantity of copying (BASE-DEPENDENCE and MAX). The idea is that between each base and each candidate reduplicant there exists a correspondence relation that must be evaluated. There is absolutely no restriction as to what the reduplicant can be, because an underlying reduplication morpheme RED_i has no phonetic content.

(4) Principles of OT (McCarthy & Prince 1993a:1-2, 1994a:3)

a. Universality. UG provides a set *Con* of constraints that are universal and universally present in all grammars.
b. Violability. Constraints are violable; but violation is minimal.
c. Ranking. The constraints of Con are ranked on a language-particular basis; the notion of minimal violation is defined in terms of this ranking. A grammar is a ranking of the constraint set.
d. Inclusiveness. The constraint hierarchy evaluates a set of candidate analyses that are admitted by very general considerations of structural well-formedness.
e. Parallelism. Best-satisfaction of the constraint hierarchy is computed over the whole hierarchy and the whole candidate set. There is no serial derivation.

Violability

The best candidate is the one that fulfills all constraints. But the theory allows constraints to be violated. Typically, the optimal output of a phonological form does not satisfy all constraints and can violate several constraints at once. Control over violations is obtained through the notion of *best-satisfaction* or *minimal violation*. The candidate that best-satisfies or minimally violates the constraints is called *optimal*, and is by definition the output chosen by the grammar.

Ranking

The constraints are ranked. Low-ranking constraints can be violated to ensure fulfillment of higher-ranking constraints. There is a universal set of constraints and the grammars of the individual languages define a ranking of these individual constraints. Differences between languages can be explained by the different hierarchies of constraints.

Parallelism

All candidates that are fully-formed output representations are simultaneously compared with respect to the whole hierarchy of constraints. Prince & Smolensky distinguish parallelism of constraint satisfaction from serial harmony, which involves determining a surface form by applying an evaluation procedure to produce a candidate that is then evaluated again

until the surface form is attained. In serial harmony, each candidate is limited to one phonological operation, and the winning form is resubmitted to Gen. Thus, parallelism is not intrinsic to Optimality Theory.

The theory can be illustrated by an abstract grammar consisting of two constraints, A and B. Assume that, through Gen, the underlying form /in_k/ delivers a pair of candidates {k-cand$_1$, k-cand$_2$}. If one of these candidates fulfills both A and B, then it is optimal. A suboptimal candidate would have to violate both constraints, or at least one. Now consider the more interesting case illustrated in Tableau 1:

Candidates	A	B
k-cand$_1$		*
k-cand$_2$	*	

Tableau 1

Violation of a constraint is indicated by *. In Tableau 1, k-cand$_1$ fulfills A but violates B, and k-cand$_2$ fulfills B but violates A. If k-cand$_1$ is the grammatical output, constraint A has priority over constraint B in the sense that A is decisive when the two constraints conflict. In terms of Optimality Theory, A *dominates* B (in symbols: A >> B). The following tableau shows how the constraints are ranked. Tableau 2 also illustrates what Prince & Smolensky call "the strictness of strict domination". No amount of success on low-ranking constraints can offset failure on a high-ranking one.

Candidates	A	B	C
☞ k-cand$_1$		*	*
k-cand$_2$	* !		

Tableau 2

Conventions for reading the tableaux:

- Left-to-right columns give the dominance sequence of the constraints.
- Satisfaction of a constraint is shown by an empty cell.
- The exclamation mark indicates fatal violations.

- The index ☞ points to the optimal candidate.
- Shadowing of cells shows the irrelevance of a constraint for the evaluation of a candidate.

Constraints must be ranked only when they conflict with each other, i.e., when they give different results for a candidate pair (which does not mean that they give different results for all candidate pairs). We will see that two constraints can have the same rank: this is indicated by a dotted line between the two columns.

Two more cases can arise in which A and B give contradictory results. In one case, A allows both candidates and B makes the decision, because only one candidate satisfies B. This is illustrated in Tableau 3.

Candidates	A	B
k-cand$_1$		* !
☞ k-cand$_2$		

Tableau 3

In the second case, A permits neither of the candidates. In this case, too, B decides between the two candidates. This illustrates an important property of the theory: violation of a constraint is never *per se* fatal. It only becomes fatal when other candidates fare better.

Candidates	A	B
k-cand$_1$	*	* !
☞ k-cand$_2$	*	

Tableau 4

A single constraint can be violated several times. To see what happens then, consider the next tableau from McCarthy & Prince (1994a:5). The two candidates tie on all constraints ranked higher than C in the hierarchy. It is thus C that decides between them: k-cand$_1$ is optimal because it violates C less than k-cand$_2$.

Candidates	...	C
☞ k-cand$_1$	...	*
k-cand$_2$	...	** ! *

Tableau 5

1.2 Syllable structure

Following McCarthy & Prince (1993a), we will use syllable structure to illustrate the theory. The function Gen generates candidate syllables from a string of segments. Consider the segment sequence /CVCV/ and the syllable affiliation of the medial C. If the language admits CVC syllables, then at least the two candidates in (5) are possible (out of an infinite number of candidates). A dot stands for a syllable boundary.

(5) Possible syllabifications of the sequence /CVCV/

a. .CVC.V.

b. .CV.CV.

The first syllable in (5a) has a coda. Syllables with a coda are universally less desirable, which is expressed by a constraint called NOCODA:

(6) NOCODA

Syllables have no coda.

The first syllable in (5a) violates NOCODA. The second syllable in (5a) has no onset and again, syllables without an onset are universally less preferred. Again we have a constraint to this effect:

(7) ONSET

Syllables have an onset (or *[$_\sigma$ V).

The second syllable in (5a) violates ONSET. In contrast, (5b) violates neither NOCODA nor ONSET – both syllables have an onset but no coda – and so it is optimal, disregarding the ranking of these two constraints. Every grammar

has these two constraints, which means that, other things being equal, each chooses (5b), two open syllables, as the optimal candidate.

A family of constraints called PARSE forces the forming of prosodic constituents. PARSE is parameterized: PARSE-seg requires that segments have a moraic or syllabic structure; PARSE-μ requires moras to be dominated by σ (i.e. they must belong to syllables); PARSE-σ requires syllables to belong to feet, etc. All grammars have these constraints. An unparsed element is called extrametrical or extraprosodic.

A string <CVCV> without any structure violates PARSE. Consider now how PARSE-seg and NOCODA can deliver contradictory results. To be syllabified, a string <CVC> must violate either NOCODA or PARSE. The following tableau shows what happens in case PARSE has priority:

/CVC/	PARSE	NOCODA
☞ .CVC.		*
.CV.<C>	* !	
<CVC>	*** !	

Tableau 6

In this case, violation of PARSE is fatal. Languages which allow closed syllables choose this ranking. On the other hand, languages which allow only open syllables have the opposite ranking:

/CVC/	NOCODA	PARSE
.CVC.	* !	
☞ .CV.<C>		*
<CVC>		*** !

Tableau 7

However, ideal syllabification can be achieved through the insertion of epenthetic elements. As a consequence, the set of candidates must contain syllabifications with empty positions. The following syllabifications are also possible candidates:

(9) a. .CV. C□.
b. .CV□. C□.
c. .CV. C□□ .
d. .CV. C□. □□.

But the presence of such positions violates a constraint called FILL (McCarthy & Prince 1994a:11):

(10) FILL
Epenthetic structure is prohibited.

When FILL dominates NOCODA, each candidate containing an empty position is rejected; the only acceptable candidate does not violate FILL. In this case, a single violation of FILL is fatal. Notice that there is always a candidate that doesn't violate FILL in the set of generated candidates.

Candidates	FILL	NOCODA
☞ .CVC.		*
.CV□.C□.	* ! *	*
.CV. C□□.	* ! *	*
.CV. C□. □□.	* ! **	
.CV. C□.	* !	

Tableau 8

With the opposite ranking of NOCODA and FILL, a different result is obtained. In this case, no violation of NOCODA is tolerated and a violation of FILL makes it possible to generate a candidate that fulfills NOCODA.

Candidates	NOCODA	FILL
.CVC.	* !	
.CV□.C□.	* !	**
.CV. C□□.	* !	**
.CV. C□. □□.		** ! *
☞ .CV. C□.		*

Tableau 9

Here, /CVC/ is analyzed as two open syllables. The last candidate is chosen because it does not violate NOCODA and offers the minimal violation of FILL.

The interaction between FILL and ONSET is similar. When FILL is dominant, empty positions are not allowed. But when ONSET dominates FILL, a vowel-initial /V/ is syllabified with an empty onset ([.□V.]).

/V/	ONSET	FILL
☞ .□V.		*
.V.	* !	

Tableau 10

PARSE and FILL are examples of the so-called *faithfulness* constraints, which require a tight relationship between input and output.

Until now only a small number of possible candidates have been considered: those violating PARSE, and others violating FILL. But when Gen admits unparsed elements as well as empty elements, then, for each input, the candidate set must contain all kinds of violations of all faithfulness constraints. Now consider the interaction between PARSE and FILL on the one hand, and NOCODA and ONSET on the other. Since ONSET and NOCODA have no immediate influence on each other, only two cases are relevant: first, the interaction of PARSE, FILL and ONSET and, second, the interaction of PARSE, FILL and NOCODA. In both cases, the lowest-ranking constraint makes the final decision between the candidates, because the optimal candidate fulfills two constraints and violates only one. Tableau 11 illustrates this with ONSET as the lowest constraint and with the candidate /.V./.

/V/	FILL	PARSE	ONSET
☞ .V.			*
<V>		* !	
.□V.	* !		

Tableau 11

The dotted line between FILL and PARSE means that the ranking between the two is irrelevant in this particular case. The angled brackets around V mean that the vowel represented by V is not parsed, in other words, it has no phonetic realization.

The faithful candidate [.V.] violates ONSET, but fulfills both PARSE and FILL. The unsyllabified [<V>] violates only PARSE. Otherwise it vacuously fulfills all constraints, since it has no structure. Finally, the epenthetical candidate [.□V] violates only FILL. Thus, when the faithfulness constraints dominate ONSET, syllable well-formedness is sacrificed: the language allows onsetless syllables.

It must be clear that ONSET could not be eliminated from the set of constraints altogether because this constraint is only violated when absolutely necessary. In a string /CVCV/, it is ONSET that forces the syllabification [.CV.CV.].

Next consider the case where FILL is the dominated constraint. ONSET and PARSE may not be violated. These two constraints are fulfilled when an epenthetic segment is added, as in the last candidate of Tableau 12. Thus, when FILL is lowest-ranking, epenthesis is allowed. The structural constraints which dominate FILL determine the conditions under which epenthetic material can appear.

/V/	ONSET	PARSE	FILL
.V.	*!		
<V>		*!	
☞ .□V.			*

Tableau 12

The last possibility is domination of PARSE. In this case, the vowel – at least its phonetic material – is deleted or 'unparsed'. ONSET is vacuously fulfilled, and FILL is also obeyed, since there is no epenthesis.

/V/	ONSET	FILL	PARSE
.V.	*!		
☞ <V>			*
.□V.		*!	

Tableau 13

In sum, when ONSET dominates at least one of the faithfulness constraints, the syllables of the language must have onsets. When both faithfulness constraints dominate ONSET, an onset is only required in case enough phonetic material is around.

A similar interaction exists between PARSE, FILL and NOCODA. Codas are not allowed when NOCODA dominates. Codas are allowed when both faithfulness conditions dominate and when the syllabifiable string contains a segment which is forced to be a coda, as in /CVC/.

1.3 The Emergence of the Unmarked

In McCarthy and Prince (1994a) it is observed that, even if a constraint *C* is generally violated in a language, it can be obeyed in a particular domain in which the structure unmarked with respect to the constraint *C* emerges. This phenomenon is called *emergence of the unmarked*, because a form that violates *C* can be seen as marked with respect to *C*. A constraint can be more or less violated depending on its rank. This effect is peculiar to OT, according to which no constraint is turned off completely. Some languages have only the *C*-unmarked structures and some have both the marked and the unmarked structures, but no languages have only the *C*-marked ones.

Problems appear when constraints conflict, which is inherent and fundamental to Optimality Theory. There are different dimensions of the evaluation, each of which has an unmarked structure (see also Vennemann 1986:33). A striking case of unmarkedness with respect to some constraints has just been illustrated: a syllable is unmarked if it has an onset but no coda. Unmarkedness with respect to faithfulness means 'identity between in- and output'. But a string /V/ or /CVC/ cannot receive an unmarked syllabification with respect to both syllable structure and faithfulness. However, even in a language allowing codas and syllables without onsets, syllables without codas but with onsets are unmarked relative to syllables with codas and without onsets.

Notice that syllable structure and faithfulness are just two dimensions along which strings can be marked or unmarked. Other dimensions cited by McCarthy & Prince (1994a:2) are: segmental harmony (segments can be

marked or unmarked), alignment (coincidence of edges of morphological and phonological constituents: see below), and metrical parsing (satisfaction of constraints on exhaustivity and alignment of metrical feet; see below), as well as others responsible for reduplication: Template Satisfaction (meeting shape or constituency requirements imposed on the reduplicated string) and exactness of copying relation (identity between the reduplicated string and the base to which it is attached).

The ranking of the constraints imposes a ranking of markedness. Phonological outputs are unmarked relative to higher constraints and marked relative to lower ones, since they typically fulfill the former but violate the latter.

The next section introduces the theory of Generalized Alignment (GA), which is directly relevant for the topic of the present work, metrical analysis.

1.4 Generalized Alignment

Though the first alignment constraint was proposed by Prince & Smolensky (1993), McCarthy and Prince (1993b) have truly developed the theory of Generalized Alignment (GA), which formalizes the fact that the edges of the morphological and prosodic constituents often coincide. This theory is very successful, as attested by the enormous amount of literature in the GA which has recently appeared. Coincidence of edges is called 'alignment' and it is formulated in terms of constraints. GA has its source in works on the edge-based theory of the syntax-prosody interface (Clements 1978, Selkirk 1986, Chen 1987, Hale & Selkirk 1987, Selkirk & Shen 1990, Selkirk & Tateishi 1991, Selkirk 1995).

Phenomena that have something to do with edges of constituents have received various treatments in the literature: directionality of footing, extrametricality of syllables or segments, prosodic circumscription, etc. Consider the following examples, taken from McCarthy and Prince which are discussed below:

a. The infix *um* in Tagalog appears as near to the left edge as possible.

b. In English, as well as in other languages, the normal right-to-left alternation of stresses is interrupted in the initial position. The edge of a Prosodic Word (PrWd) coincides with the edge of a foot, as shown in (11). (It is, however, violated in many cases, like in *Amánda, políce* ....)

(11) English: (Tàta)ma(góuchee) *Ta(tàma)(góuchee)
German: (Ábso)lu(tísmus) * Ab(sólu)(tísmus)

GA tries to unite all edge phenomena in one framework, the formalization of which is given in (12):

(12) Generalized Alignment
Align (Cat1, Edge1, Cat2, Edge2) $=_{def}$
$\forall$ Cat 1 $\exists$ Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide, where
Cat1, Cat2 $\in$ PCat $\cup$ GCat (Prosodic and Grammatical categories)
Edge1, Edge2 $\in$ {Right, Left}

The definition says that two prosodic or grammatical categories are aligned when they share an edge. Examples of aligned structures are listed in (13); some of them align two prosodic or two grammatical categories, others one prosodic and one grammatical category (see also McCarthy & Prince 1994a: 5-6).

(13) a. $[_{PrWd}\ [_{Ft}$ i. Align(Ft, L, PrWd, L)
'Every foot is initial in a Prosodic Word.'
ii. Align(PrWd, L, Ft, L)
'A PrWd is foot-initial.'
b. $[_{Stem}\ [_{Af}$ Align(Af, L, Stem, L)
'Every Affix is a prefix in Stem.'
c. $]_{\sigma}\ ]_{Stem}$ Align(Stem, R, Syll, R)
'Every Stem ends on a syllable edge.'
d. $]_{PrWd}\ [_{Af}$ Align(Af, L, PrWd, R)
'Every Affix subcategorizes for a preceding PrWd.'

As an illustration, consider again the two edge effects mentioned above and how they are treated in the Generalized Alignment framework. In the case of English stress, only prosodic categories are necessary in the formulation of the constraint. (13aii) is relevant for the formation of feet in English.

(14) English stress
Align (PrWd, L, Ft, L)

In the two versions of (13a), it is conspicuous that the arguments of the constraint are reversed. The definition (12) 'Align (Cat1, Edge1, Cat2, Edge2)' quantifies universally over the edges of all Cat1s and existentially over the edges of Cat2s. Thus, the first version of (13a) says that for each foot, it is initial in some Prosodic Word, whereas (13b) says that each Prosodic Word must begin with a foot. (14) captures the fact that there is a secondary stress on the initial syllable in the English words, ensuring that there is an initial foot in each Prosodic Word. As a constraint, it can be violated. And it does not say anything about the regular right-to-left pedification, which is expressed by another constraint of the Align format.

(15) English stress
Align (Ft, R, PrWd, R)

If this second constraint is ranked lower than the first one, the desired output is guaranteed. Before the exact working of these constraints is explained in detail, let us first look at the Tagalog infix *um* (McCarthy & Prince 1993a, 1993b).

In Tagalog, the infix *um* is located after the onset of the first syllable, if it has one (see also French 1988).

(16)

Root	*um* + Root	
aral	*um*-aral	'teach'
sulat	s-*um*-ulat	'write'
gradwet	gr-*um*-adwet	'graduate'

The infix is analyzed as a prefix. In OT, the notion of a prefix can be formulated as a violable constraint: a prefix is an affix whose left edge must coincide with the left edge of some constituent. However, due to the effect of other constraints in the grammar, the leftmost possible position is not necessarily the initial one. In the grammatical (17a), infixation leads to a better syllable structure. The locus of the infix is prosodically defined.

(17) /um + sulat/ –>
a. su.*m*ulat
b. **um*.sulat

In the grammatical form (17a), affixation creates an open syllable, whereas as a pure prefix (17b), the affix gives rise to a closed syllable. Two constraints are responsible for the infixation in Tagalog, namely NOCODA and ALIGN-*um* , with that ranking. In other words, a prosodic constraint dominates a morphological one (P >> M). Notice that the constraint (18) is identical to (13b) – except for the fact that the infix is mentioned explicitly in (18).

(18) ALIGN-*um*
Align ([*um*]$_{af}$, L, Stem, L)

Tableau 14 below accounts for *gr-um-adwet*, whose input is {[um]$_{af}$, [gradwet]$_{Rd}$}$_{Stem}$. In this tableau, all candidates with more than two violations of the dominant NOCODA are rejected. (When the infix is between the two elements of the onset, as in the second candidate, there is no advantage over the location of the infix after the entire onset, as in the third candidate.) The lower-ranked ALIGN-*um* decides between the two remaining candidates. Each segment that stands between the left edge and *um* counts as a violation against ALIGN-*um*. Since the candidate **gradwumet* violates ALIGN-*um* five times in having five segments between the left edge and *um*, whereas the candidate *grumadwet* violates this constraint only twice, the latter wins.

Candidates	NoCoda	Align-*um*
-*um*.grad.wet.	*** !	Ø
g-*um*.rad.wet.	*** !	g
☞ gr-*u.m*ad.wet.	**	gr
grad.w-*u.m*et.	**	gradw !

Tableau 14

The behavior of vowel-initial stems is also interesting. Tableau 15 shows the evaluation of *um-aral*, whose input is {[um]$_{Af}$, [aral]$_{R}$}$_{Stem}$. In this case, *um* is optimal as a prefix, because no other candidate violates NoCoda fewer times than the candidate *umaral*. The decision on the optimality of a candidate is again taken by Align-*um*. Prefixation does not violate this constraint at all, thus the first candidate wins.

Candidates	NoCoda	Align-*um*
☞ -*u.m*a.ral.	*	Ø
a.-*um*.ral.	** !	a
a.r-*u.m*al.	*	ar !
a.ra.-*um*l.	*	ara !
a.ra.l-*um*.	*	aral !

Tableau 15

It has already been mentioned that the ranking of the constraints is language-dependent. It must be clear that another ranking would give rise to another optimal candidate. In our case, dominance of Align-*um* would force prefixation in all cases, as shown in the next tableau. The asterisk in the upper left corner shows that the tableau displays a false constraint ranking. A language like German, with obligatory peripherality of the affixes, chooses this ranking.

✳ Candidates	Align-*um*	NoCoda
☞ -*um*.grad.wet.	Ø	***
g-*um*.rad.wet.	g !	***
gr-*u.m*ad.wet.	gr!	**
grad.w-*u.m*et.	gradw !	**

Tableau 16

In Tagalog infixation, two morphological constituents are aligned. McCarthy & Prince show that typological variation in the align constraints can appear in the edges of constituents (L for prefixes, R for suffixes) as well as in the active prosodic constraint. For Tagalog it is NoCoda, but in Timugon Murut reduplication, Onset is the relevant prosodic constraint, being ranked above the morphological constraint. This can be gathered from the data in (19); I refer the interested reader to the discussion in McCarthy & Prince (1993b).

(19) Timugon Murut Reduplication

a. C-initial stems: prefixation

bulud	bu-bulud	'hill/ridge'
limo	li-limo	'five/about five'

b. V-initial stems: infixation

ulampoy	u-la-lampoy	no gloss
abalan	a-ba-balan	'bathes/often bathes'
ompodon	om-po-podon	'flatter/always flatter'

Descriptively, a light syllable (reduplicative morpheme, RED = σ_{μ}) is infixed after an onsetless syllable, but otherwise it is prefixed. It is the same as in Tagalog, except that in this case Onset does the job, rather than NoCoda. Onset and Align-R-Left are decisive.

(20) Align-R-Left
The left edge of the reduplicant R coincides with the left edge of the stem.

Consider the two following tableaux that illustrate the constraint ranking for *bubulud* and *ulalampoy*.

Candidates	ONSET	ALIGN-R-LEFT
☞ [bu.-bu.lud.		
[bu.-lu.lud.		**!

Tableau 17

Candidates	ONSET	ALIGN-R-LEFT
[u.-u.lam.poy.	**!	
☞ [u.-la.lam.poy.	*	*

Tableau 18

To be viable, GA assumes a morphological and a prosodic constituency. The relevant prosodic constituency is the (relatively uncontroversial) prosodic hierarchy (21).

(21) PrWd
|
Ft
|
σ

Two deviations from the direct dominance hypothesis, which is taken for granted by many authors, are possible. First, if feet must be binary, as McCarthy & Prince (1993b) assume, syllables which would be parsed as unary feet are not footable, or at least they cannot form syllabic trochees: the first syllable of English [po$_{\sigma}$(lice)$_{Ft}$] is unfootable.

Secondly, recursion of PrWd, as illustrated in the following example, is possible.

(22) a. [[light]$_{PW}$[house]$_{PW}$]$_{PW}$
b.[[[help]$_{PW}$ less]$_{PW}$ ness]$_{PW}$

As for the morphology, McCarthy & Prince assume the following structures:

(23) Morphological Word –> Stem
Stem –> Stem, Affix (no linear ordering)
Stem –> Root

Consider now how the theory of Generalized Alignment accounts for the metrical structure in different languages. For clarity of exposition, the constraint Ft-BIN is assumed to be undominated and thus unviolated in all cases below. Ft-BIN says that feet are always binary.

(24) Ft-BIN
Feet must be binary under syllabic or moraic analysis.

The constraint FOOT-FORM (TROCHAIC) is true of all feet considered in this section. It says that feet are syllabic trochees, which indicates quantity-insensitivity (Hayes 1980, 1995).

(25) FOOT-FORM (TROCHAIC)
Ft –> σ_S σ_W

Another constraint necessary for the following discussion is PARSE-SYLL, which says that all syllables must be parsed into feet. Though it is frequently obeyed, it can also be dominated and violated.

(26) PARSE-SYLL
All syllables must be parsed by feet.

If Ft-BIN dominates PARSE-SYLL, exhaustivity of footing can no longer be achieved in strings with an odd number of syllables. To see this, notice first that parsing of an even-parity input is uniquely determined: /σσσσσσ/ –> [(σσ) (σσ) (σσ)]; but for odd-parity inputs the parsing varies, as illustrated in Tableau 19, where FT-BIN dominates and PARSE-SYLL is minimally violated in both optimal candidates.

Candidates	FT-BIN	PARSE-SYLL
☞ (σσ) σ		*
☞ σ (σσ)		*
(σσ)(σ)	*!	
(σ)(σσ)	*!	

Tableau 19

Since more than one candidate is optimal in Tableau 19, other principles must play a role, too, in order to decide which candidate is the grammatical output in each language. In traditional metrical theory, directionality is used to create the right metrical structure, but iterative foot parsing is not a possible option here, because the candidates are fully structured forms. Different languages have different options, some of which are illustrated in (27).

(27) a. L –> R: Wankumara [(σ́σ) (σ́σ) σ]
b. R –> L: Warao [σ (σ́σ) (σ́σ)]
c. Initial dactyl - final trochee + R –> L: Garawa [(σ́σ) σ (σ́σ) (σ́σ)]
d. L –> R + Final trochee: Polish [(σ́σ) (σ́σ) σ (σ́σ)]

In Garawa (see also Kenstowicz 1994a), for example, we find the so-called *initial dactyl* pattern, the properties of which are:

- main stress of the initial syllable,
- secondary stress of the penult,
- tertiary stress on every other syllable preceding the penult.

(28)	[(σ́σ)]	yámi	'eye'
	[(σ́σ) σ]	púnja.la	'white'
	[(σ́σ) (σ́σ)]	wátjim.pàŋu	'armpit'
	[(σ́σ) σ (σ́σ)]	káma.la.rìnji	'wrist'
	[(σ́σ) (σ́σ) (σ́σ)]	yáka.lâka.làmpa	'loose'
	[(σ́σ) σ (σ́σ) (σ́σ)]	ŋánki.ri.kîrim.pàyi	'fought with boomerangs'
	[(σ́σ) (σ́σ) (σ́σ) (σ́σ)]	ŋámpa.lâŋin.mûkun.jìna	'at our many'
	[(σ́σ) σ (σ́σ) (σ́σ) (σ́σ)]	nári.ŋin.mûkun.jîna.mìra	'at your own many'
	[(σ́σ) (σ́σ) (σ́σ) (σ́σ) (σ́σ)]	nímpa.lâŋin.mûku.nânji.mìra	'from your own two'

As can be seen from the data in (28), the first two syllables must always form a foot together. The constraint ALIGN-PRWD (Garawa) in (29) takes care of this fact.

(29) ALIGN-PRWD (Garawa)
Align (PW, L, Ft, L)

This constraint says that the left edge of each PrWd must coincide with the left edge of a foot. There is also a right Alignment effect, which is taken care of by ALIGN-FT (Garawa) in (30). This constraint requires that each foot be aligned on its right with the right edge of some PrWd.

(30) ALIGN-FT (Garawa)
Align (Ft, R, PW, R)

The decisive difference between the two constraints ALIGN-PRWD (Garawa) and ALIGN-FT (Garawa) lies in the side and in the ordering of the arguments. The two constraints are in conflict in trisyllabic words, as shown in Tableau 20. ALIGN (Cat1, ..., Cat2,...) quantifies universally over the edges of the constituents C1 and existentially over the edges of the constituents C2. Each C1 must share an edge with C2. In Garawa each [PrWd must be aligned with a (Ft, and each)Ft with a]PrWd. In other words, ALIGN-PRWD is unviolated but ALIGN-FT is violated by each nonfinal foot. This decides between [(σ́σ) (σ́σ) σ (σ́σ)] and [(σ́σ) σ (σ́σ) (σ́σ)]. ALIGN-FT subsumes the iteration of traditional metrical phonology.

Candidates	ALIGN- PRWD	ALIGN- FT
☞ [(σ́σ) σ]		*
[σ (σ́σ)]	* !	

Tableau 20

Up to now, nothing has been said about metrical prominence – only footing, i.e. constituency, has been considered. Typically, one foot must be chosen as the strongest one, the one chosen by the End Rule in traditional metrical phonology. In GA, it is also a constraint of the Align format that determines the strongest foot.

(32) ALIGN-HEAD
Align (PRWD, Edge, H(PW), Edge)

In Garawa, Edge = L. There is no interaction of the ALIGN-HEAD constraint with the other two Align constraints.

English, too, has the ranking ALIGN-PRWD >> ALIGN-FT, as illustrated in Tableau 21, but ALIGN-HEAD must dominate ALIGN-PRWD (Edge = R). For each Cat, there is an H (Cat), i.e. each PrWd has a head.

Candidates	ALIGN-HEAD	ALIGN-PRWD
☞ [Ma(nína)]		*
[(Máni)la]	* !	

Tableau 21

A final point that is important for the following chapters concerns the unmarked Prosodic Word. In 'Emergence of the Unmarked', McCarthy & Prince show that the minimal Prosodic Word is identical with the unmarked one. As a case in point, consider reduplication in Diyari in (33).

(33) Diyari

wiḻa	wiḻa-wila	'woman'
kanku	kanku-kanku	'boy'
kuḻkuɲa	kuḻku-kuḻkuɲa	'to jump'
ṯilparku	ṯilpa-ṯilparku	'bird sp'

All reduplicants end in a vowel, and they are all disyllabic. These properties derive from the fact that they are free-standing Prosodic Words having their own stress. Furthermore, all Diyari words end in a vowel, and all PrWds are minimally disyllabic: a PrWd must contain at least one foot, and feet which are syllabic trochees are minimally binary. Thus a PrWd is minimally binary, too.
So the reduplication template is a minimal word (which is a trochaic foot). FT-BIN is undominated in Diyari. Other constraints that also play a role are ALL-FT-LEFT (34) and PARSE-SYLL (26).

(34) ALL-FT-LEFT
Align(Ft, L, PrWd, L)

The pattern [(σσ) (σσ) σ] comes from the ranking FT-BIN >> PARSE-SYLL >> ALL-FT-LEFT, but in a five-syllable string, both PARSE-SYLL and ALL-FT-LEFT are violated, because FT-BIN is undominated. However, and this is crucial, both constraints can be obeyed when the following conditions are fulfilled: every syllable belongs to a foot (PARSE-SYLL is obeyed) and every foot is initial (ALL-FT-LEFT is obeyed). Only the Minimal Word fulfills both requirements because it has a single foot which parses all syllables: $[\text{Ft}]_{\text{PW}}$ i.e. $[(\sigma\sigma)_{\text{Ft}}]_{\text{PW}}$ or $[(\mu\mu)_{\text{Ft}}]_{\text{PW}}$.
The following templatic constraint is sufficient:

(35) Templatic Constraint
Red = PrWd (The reduplicant is a Prosodic Word)

Finally, consider the following tableau in which MAX, a constraint responsible for the quantity of the reduplicated material, is dominated by PARSE-SYLL:

Candidates	PARSE-SYLL	MAX
☞ $[(\text{ṯilpa})_{\text{Ft}}]_{\text{PW}}$ - $[(\text{ṯilpar})_{\text{Ft}}\ \text{ku})_{\text{Ft}}]_{\text{PW}}$	*	****
$[(\text{ṯilpar})_{\text{Ft}}\ \text{ku}]_{\text{PW}}$ - $[(\text{ṯilpar})_{\text{Ft}}\ \text{ku}]_{\text{PW}}$	**!	

Tableau 22

Chapter 2
Syllable structure

This chapter is about German syllable structure. It is mainly devoted to monomorphemes, but in the final part complex words will be considered, too. After some general considerations on the syllable in the first section, it will be shown in the second section that tense vowels are always bimoraic and that they are long in a stressed syllable, whereas lax vowels are always monomoraic and thus remain short, both in stressed and unstressed positions. German syllables can be nonmoraic, bimoraic or trimoraic. Nonmoraic syllables have a schwa or a syllabic sonorant in their nucleus and bimoraic syllables are either open with a tense vowel (VV), or else closed with a lax vowel and one closing, possibly ambisyllabic consonant (VC). Trimoraic syllables are closed with a tense vowel (VVC) or with a lax vowel and at least two closing consonants (VCC). The bimoraic status of tense vowels explains why they can appear in a final open unstressed syllable, as in *rosa*, *Taxi* and *Motto*, where they are not necessarily long, but rather half-long. Syllables which do not contain a schwa but a full vowel are minimally bimoraic, which explains why the lax vowels, being monomoraic, are excluded from final open unstressed syllables.

The third section is devoted to nonmoraic syllables with nuclear schwa or syllabic sonorants. These syllables show some peculiarities: they are always unstressed and do not play any role in the metrical structure of the words they appear in; their coda is occupied by coronals exclusively; and they are the unstressed allophone of [ɛ], as has been shown by Wurzel (1970), Ramers & Vater (1992) and others. They are obligatorily nonmoraic, disregarding the number of segments in their coda. A constraint NOMOSCH (Nonmoraic Schwa) is responsible for this property.

Section 4 and 5 examines two optimality-theoretic constraints to the effect that syllables are minimally bimoraic (except for schwa syllables) and maximally trimoraic: the Bimoraic Minimum (BIMOR) and the Trimoraic Maximum (TRIMAX), respectively. BIMOR can be violated: there are nonmoraic syllables as well as trimoraic ones. However, TRIMAX is crucially ranked higher than BIMOR, since there are no syllables heavier than the trimoraic ones, but there are syllables with fewer than two moras.

The final sections of this chapter take a look at complex words. As has been repeatedly shown in the literature, affixes do not behave homogeneously with respect to syllabification: some affixes are treated as if they were part of the roots, whereas others require a syllable boundary coinciding with the morpheme boundary. Inflection, derivation and compounding are each the subject of a different section.

Since the claim that German syllables are non-, bi- or trimoraic is a serious deviation from the usual assumption in the literature that syllables are universally mono- or bimoraic (Kenstowicz 1994c, Hulst 1995 among others), our position requires an explanation. First, the fact that schwa syllables are nonmoraic is well motivated by both the absolute unstressability of these syllables as well as their frequent lack of a realized vowel. (See section 2.1.3 for some discussion.) Second, the claim that unmarked syllables are bimoraic and 'superheavies' trimoraic is easily translated into a framework in which they are mono- and bimoraic, respectively. As Hubert Truckenbrodt (p.c.) has suggested, lax vowels could be analyzed as half-moraic and in need of a half-moraic consonant to form a monomoraic syllable; tense vowels are then monomoraic. The absence of lax vowels from open syllables can be accounted for by a constraint banning half-moraic syllables. Besides its lack of elegance, this proposal strikes us as unintuitive and unnatural: universally, vowels and consonants are whole moras, not half ones. For this reason, the bimoraic analysis of unmarked syllables is preferable. Trimoraic heavy syllables are sometimes analyzed as bimoraic exactly as the unmarked syllables, at least in Dutch, where relative syllable weight is very similar to German. (But the majority of authors working on Dutch assume a weight difference between the two kinds of syllables: Zonneveld 1983, Dijkstra 1982, Kager & Visch 1983, Visch & Kager 1984, Hulst 1984, Kager 1985, etc.) Kager (1989), e.g., notices that final 'superheavy' syllables often attract stress. In his account, however, these syllables are not heavier than the other ones; they are all bimoraic, but the 'superheavies' escape final extrametricality which is the common lot of final syllables. In other words, 'superheavies' are exceptions to an exceptional behaviour. He motivates his analysis by stating that there are lexical exceptions to the stressability of superheavies, and thus stress on such syllables should not be treated as regular. It will be shown in Chapter 3 that, although there are also exceptions in German (albeit apparently fewer, restricted to disyllabic

words), the generalization that trimoraic syllables attract stress is a very powerful one. In sum, we do not think that stress on final trimoraic syllables should be treated as exceptional, but rather that it should be given a legal status. In an approach like the one sketched above, according to which lax vowels are half moras, they could be bimoraic. In our approach, however, which considers unmarked syllables as bimoraic, they are analyzed as trimoraic.

2.1 Syllable structure of monomorphemes

2.1.1 Preliminaries

The German consonants[1] are listed in (1). The vowels fall into two classes, lax vs. tense ones, and there are three diphthongs[2] plus a schwa (2). There are also nasal vowels, not listed in (2); they are found only in (mostly French) loanwords, and nearly only in stressed final position, as in *Ballon* 'balloon', and *Parfum* 'perfume'.

(1) German consonants

	voiceless	voiced
Stops	p, t, k	b, d, g
Fricatives	f, s, ʃ, ç, x	v, z, ʒ, ʝ
Affricates	pf, ts, tʃ	
Nasals		m, n, ŋ
Liquids		l, ʀ
Glides	j	
Laryngeals	h, ʔ	

[1] [x] and [ç] are in complementary distribution: [x] occurs only after tautomorphemic back vowels and [ç] elsewhere. [ʒ] appears only in some loanwords. Some other consonants have a defective distribution:/b, d, g, s, h/. [ʔ] is inserted foot-initially before vowels. [ŋ] can be analyzed as derived from a sequence /n/ +/g/ (Isačenko 1963). The reader is referred to Kloeke (1982) and Ramers and Vater (1992) for synopses of German segmental phonology.

[2] Vater (1992:117) analyzes a sequence of a vowel followed by a glided /ʀ/ as a diphthong and, as a result, counts a total of 18 German diphthongs. In our opinion such sequences should not count as diphthongs, even if they are phonetically realized as such, since phonologically /ʀ/ behaves as a consonant. For instance, in a word like *Morchel* [mɔɐ̯ç̩l] 'morel' the dorsal fricative is realized as a palatal (after consonant) and not as a velar as it should after a back vowel.

(2) German vowels[3]

a. tense vowels	b. lax vowels	c. diphthongs
i, y u	ɪ ʏ ʊ	aɪ̯, ɔʏ̯, aʊ̯
e ø o	ɛ œ ə ɔ	
ɑ	a	

Syllable structure has been the subject of a great number of studies in the recent German literature (Giegerich 1985, Hall 1992, Vennemann 1982, 1988, 1992, Wiese 1986, 1988, Yu 1992, and the articles in Ramers and Wiese 1991 and in Eisenberg, Ramers and Wiese 1992). The present chapter is a contribution to this line of research. It presents an analysis of the German syllable structure in the framework of OT. Since the main concern of the present work is to examine stress and foot in German, this chapter only discusses those aspects of the syllable which throw light on the calculation of syllable weight, namely the structure of the rhyme. We are only marginally interested in the possible segments or sequences of segments appearing in the onsets, or in the compliance with or defiance of the sonority hierarchy by prefixes and appendices, for which we refer the interested reader to the above-mentioned literature and some other references cited below.

In quantity-sensitive languages like German[4], syllables are heavy (H) or light (L). Heavy syllables attract stress, whereas light syllables do not. Only trimoraic syllables are considered here to be truly heavy, since only they systematically attract stress. Bimoraic syllables are neither heavy nor light and nonmoraic syllables are light. A second distinction is made between open and closed syllables, according to their final segment. Syllables ending in a vowel (C_0V or C_0V:) are open, and syllables ending in a glide and/or one or more consonants ($C_0V\underline{V}$, C_0VC, $C_0V\underline{V}C$, C_0VCC, etc) are closed. In the following, glides are systematically classified as consonants.

Independently of their weight and openness vs. closedness, syllables have an internal structure. Most phonologists recognize at least three parts in the syllable, not always granting them a constituent status: onset, nucleus and coda. The onset is that part of the syllable that precedes the nucleus. In

[3] Some phonologists of German do not recognize the tense/lax opposition between /ɑ/ and /a/. For the majority, however, it is very clear (see, for instance, Moulton 1962:92 and Vater 1992:114).

[4] Some researchers (for instance Wiese 1988:102, and to a lesser extent Giegerich 1985) assume that German is not a quantity-sensitive language.

German, only consonants, and marginally glides (see Vater 1992), appear in the onset. The nucleus is the peak of the syllable, its most sonorous segment: it is generally a vowel, but it can also be a syllabic sonorant. The coda is that part of the syllable that comes after the nucleus: in German, glides or consonants. The only obligatory constituent of the German syllable is the nucleus. This generalization, which has been observed by most German phonologists[5], can be formulated as in (3):

(3) German syllable
A German syllable consists of an obligatory nucleus and optional onset and coda.

In the OT framework, obligatoriness of the nucleus takes the form of a constraint.

(4) NUC (Nucleus)
Syllables have nuclei.

As for the onset and the coda, they are not obligatory parts of German syllables. However, syllables with onsets are universally preferred, as expressed by the constraint ONSET introduced by Prince & Smolensky (1993) and McCarthy and Prince (1993a) and already mentioned in Chapter 1.

(5) ONSET
Syllables have onsets.

The onset consists of a consonant plus an optional glide or liquid, though *kn* (*Knast* 'clink'), *gn* (*Gnade* 'favor'), *kv* (*Quark* 'curd cheese') and *ʃv* (*schwimmen* 'to swim') are possible onsets, too. Onsets generally respect the sonority hierarchy (see below and Hall 1992a:69 for some exceptions). [ʃ] and [s] can appear at the leftmost edge of syllables (in general the first of a morpheme), as in *Strumpf* 'sock', *Skelett* 'skeleton' and *Skat* 'skat'. These segments do not respect Vennemann's (1986, (10)) sonority hierarchy.

[5] However, some phonologists assume an obligatory onset constituent (for instance Giegerich 1992 and Yu 1992).

Open syllables (without codas) are universally preferred. To account for this, Prince & Smolensky (1993) have proposed a constraint called NOCODA (see Chapter 1), counting each segment in the coda as a violation.

(6) NOCODA
Syllables have no codas.

However, codas are very frequent in German, which implies that NOCODA is often violated and must rank low in the hierarchy of constraints. Codas consist of a glide, a glide plus a consonant, or one or two consonants respecting the sonority hierarchy. At the right edge of the syllable, coronal segments called appendices can be added. An appendix only appears in the word final position, where it can occupy up to three voiceless coronal obstruents, [s], [t] and exceptionally [ʃ]: *spielt* '(he/she) plays', *wärmst* '(you) warm', *Herbsts* 'autums, gen. sg.', *Bachsch* 'Bachian'. Appendices are usually suffixes (mostly inflectional) and are impossible within morphemes: **Arstbeit*, **leugtsnen*. Not only appendices are excluded in these positions, but some consonant sequences which appear in the coda of certain morpheme-final syllables are prohibited morpheme-internally, too: **leumgnen* (see section 2.1.6).

The following syllable structures are well-formed (see also Hall 1992a:48).

(7) Well-formed German syllables
a. Onset + nucleus + coda (C_1VC, C_1VCC, C_1VV etc)

kalt	'cold'
Müll	'garbage'
Bein	'leg'
kam	'came'
Kälte	'coldness'
President	'president'

b. Nucleus + coda (VC_1)

Aal	'eel'
Ost	'East'
Museum	'museum'

c. Onset + nucleus (C_1V, C_1VV)

Kreol	'creole'
Alkohol	'alcohol'
musikalisch	'musical'
Januar	'January'
Stuhle	'chairs'

d. Nucleus (V, VV)

Uhu	'owl'
Ehe	'marriage'
Theater	'theater'
Radio	'radio'

Since onsets are not obligatory in German and codas are frequent, it is not the case that a candidate with an onset but without a coda will always be chosen as optimal as compared to one without an onset or with a coda: it depends on the input. The word *Uhr* 'clock' is well-formed in German, and the evaluation algorithm must take the absence of an onset (leaving aside the nonphonemic glottal stop realized before a stressed vowel) and the presence of a coda into account, in order to decide which candidate is optimal. Thus, additional constraints are necessary to make sure that the segments in the input reappear in the optimal candidate. Tableau 1 shows that FILL and PARSE, the faithfulness constraints introduced in Chapter 1, must be ranked higher than ONSET and NOCODA. The input is given in the upper left corner.

/uʀ/ 'Uhr'	FILL	PARSE	ONSET	NOCODA
a. ☞ uɐ̯			*	*
b. u<ʀ>		*!	*	
c. □uɐ̯	*!			*

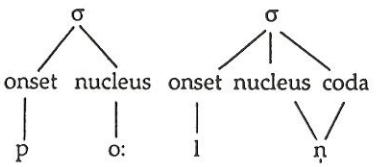
Tableau 1

The two candidates with epenthesis or deletion (b. and c.) are not optimal because they violate the high-ranking faithfulness constraints. The candidate that violates both ONSET and NOCODA wins, because there is a close correspondence between input and output. In this candidate, FILL and PARSE are not violated. However, a word like *Oma* 'granny' with a VCV sequence of

segments is syllabified as *O.ma* (never as *Om.a*). In contrast, the word *Raglan* 'raglan sleeve' has the preferred syllabification *Ra.glan* (and not *Rag.lan*). In such cases, the effects of ONSET and NOCODA are visible.

To illustrate the interaction of the three constraints introduced so far (NUC, ONSET, and NOCODA), consider the second syllable of the word *Polen* 'Poland' in Tableau 2. The optimal candidate satisfies NUC and ONSET, but not NOCODA. The faithfulness constraints have been left out, since in this example and in the subsequent ones they are always undominated. The input of the word *Polen* consists of the unsyllabified string of segments /poln/. This string cannot be monosyllabic because the only syllable would then contain three moras and an appendix *n*, which is never found in German monomorphemes (see below). So two syllables must be realized. The word *Polen* has the tentative syllable structure in (8). It is tentative since the status of the syllabic sonorant is not clear. It could be just a nucleus, or both nucleus and coda, as shown in (8). Since there are words in which a syllabic sonorant is at the same time part of a syllable and the onset of the following one (as in *trockene* 'dry', see 2.2.1.1), we assume that in those cases it is ambisyllabic and thus coda of the first syllable. By analogy, *n* in *Polen* is also a coda.

(8)



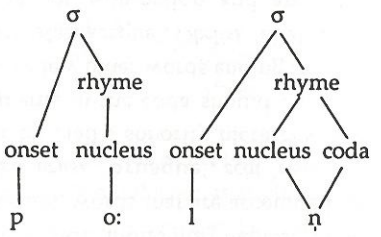
NUC is unviolable and unviolated: there are no syllables without a nucleus. But, as we just saw, ONSET and NOCODA are violable, and, as a consequence, they rank below NUC. In Tableau 2, the optimal candidate (a.) violates no constraint at all, or only violates one if [n] is a coda as well as a nucleus.

/poln/	NUC	ONSET	NOCODA
☞ .po.l̩n.			(*)
.po.ln.	*!		*
.pol.n̩.		*!	
.pol.n.	*!		*
.po.l̩n.		*!	*
.po.l̩.n̩.		*!*	

Tableau 2

In addition to the three parts of the syllable, it is often assumed that nucleus and coda together form a rhyme. The rhyme has a maximal number of positions (see the next section), and it determines the syllable's weight. If the rhyme is taken into account, the syllable structure in (8) must be replaced by the one in (9).

(9)



There are, of course, constraints as to which segment can appear in which position. The sonority hierarchy (here adapted from Sievers 1901 and Vennemann 1986) plays a major role in determining which sequences are permitted. The hierarchy classifies segments on the basis of their sonority: vowels are more sonorous than glides, which in turn are more sonorous than liquids, and so on. German consonants are arranged along the following hierarchy:

(10) Consonant Sonority Hierarchy

---------->

p	b	f	v	m	l	ʀ	glides
t	d	s	z	n			
k	g	ʃ	ʒ	ŋ			
pf		ç	j				
ts		x					
tʃ							

The laryngeals [h] and [ʔ] have not been included here because they constitute an entire onset and are never found in a consonant cluster or in a coda (the glottal stop is not phonemic anyway). Thus, the sonority hierarchy does not play any role in determining their occurrence.

An alternative which must be considered here is illustrated by the Sonority Sequencing Principle proposed by Clements (1990:292). Clements proposes the following universal ranking of segments.

(11)

Obstruents	<	Nasals	<	Liquids	<	Glides	
–		–		–		–	'syllabic'
–		–		–		+	vocoid
–		–		+		+	approximant
–		+		+		+	sonorant
0		1		2		3	rank (relative sonority)

Clements proposes analyzing sonority as derived from the major class features of standard phonological theory. Though the details of his theory are not relevant for the present study, one important aspect of his proposal is his assumption that all obstruents have the same ranking in the sonority hierarchy. However, Clements establishes a universal sonority hierarchy and does not exclude that some languages can introduce sonority differences between stops and fricatives, as assumed in the present work for German.

Hall (1992b), adopting Clements's proposal, proposes that, in German, all obstruents (stops and fricatives, voiced and voiceless alike) are equally sonorous. This allows syllabifications like *abs.trakt* 'abstract', *Obs.tru.ent* 'obstruent', *ab.strakt* and *Ob.stru.ent* without violation of the sonority

hierarchy. Hall's main argument (1992b:222) comes from the existence of words like *Blut-s* 'blood, gen. sg.', *Hof-s* 'yard, gen. sg.', *Blech-s* 'tin, gen. sg.', *Fisch-s* 'fish, gen. sg.', *hübsch* 'pretty', *Schnaps* 'schnaps' and *Lachs* 'salmon', which allow coronal fricatives to follow a stop. (Notice that the first four words are inflected forms.) However, the only coronals that appear in this position are the coronals /s/ and rarely /ʃ/, never the labial /f/ or the dorsal /x/ç/. This is exactly what is expected if the extrasyllabic /s/or /ʃ/ at the end of syllables (in the vast majority of words at the periphery of the morpheme) is analyzed as an appendix (see section 2.1.6 for details). Hall proposes syllabifying all coronals at a later level than the segments occupying the 'regular' coda. They are syllabified by a rule also responsible for the syllabification of appendices, called Coronal Obstruent Adjunction. His proposal poses two problems. First it assumes the existence of levels of syllabification inside monomorphemes. In an OT framework, this is impossible. Second, words that are accounted for by Vennemann's sonority hierarchy, like *brüsk* 'brusque', *echt* 'real' and *Haft* 'custody' are not accounted for by Hall's sonority hierarchy, but are treated as exceptions (because segments in the coda should have different sonority rankings). *Brüsk* and a very few other words ending in *-sk*, with a final dorsal like *Kiosk* 'kiosk', *kafkaesk* 'Kafkaesque', *Obelisk* 'obelisk', etc., are not covered by the Coronal Obstruent Adjunction and are considered to be exceptions. Vennemann's and Hall's sonority hierarchies both have some advantages and both present some problems. Since this question does not affect the main theme of this chapter, the question of which sonority hierarchy best captures the German arrangement of segments is left open, with a slight preference for Vennemann's hierarchy.

The nucleus is generally the most sonorous element of the syllable. From the nucleus to the edges of the syllable, the sonority decreases.[6]

The behavior of /ʀ/ in German is rather puzzling. In order to account for the fact that tautocodaic glides and /ʀ/ are impossible (**Baur*, **Geir*: such sequences force /ʀ/ to be syllabic; *Bauer* 'peasant' and *Geier* 'vulture' are disyllabic), German /ʀ/ and glides could be analyzed as ranking equally on the sonority hierarchy. However, two different facts speak against this

[6] Or, at least, it does not increase. Some sequences of equal sonority are allowed in the coda but not in the onset, as attested by the following words: *Abt* [apt] 'abbot' and *Akt* [akt] 'act'. It is not entirely clear whether the final coronal in those words is an appendix or not (see section 2.1.6 for a short discussion of this problem).

proposal. First, it becomes untenable once onsets are taken into consideration. In words like *Radio* 'radio' or *Italien* 'Italy', with a hiatus between an [i] and a following vowel, [i] is often realized as a nonnuclear onset glide (as in *Thýmian* 'thyme' [ty:.mia:n]), and the first part of the onset can be /ʀ/: *Káries* 'caries' [kɑ:. ʀi̯ɛs], *Árie* 'aria'. On the contrary, a sequence of a glide plus /ʀ/ in the onset is impossible. This speaks against an equal sonority of /ʀ/ and glides in German, and for the hierarchy in (10) and (11), in which glides are more sonorous than /ʀ/. However, as Clements (1990) convincingly argues, sonority restrictions apply at an abstract level of syllabification. In regard to *Karies* it may be objected that the abstract syllabification involves three syllables: *Ka.ri.es*, where /i/ is a full vowel. The second fact is that in a great number of cases /ʀ/ is vocalized. In such cases, the syllable of which it is a nucleus can have a glide in its onset: *Bayern* [bai̯ɐn] 'Bavaria', Meier [mai̯ɐ] (a name), Reiher [ʀai̯ɐ] 'heron'. The glide is ambisyllabic. In sum, /ʀ/ is either less sonorous than a glide or more sonorous, depending on its status as a consonant or a vowel. More study is necessary to understand the characteristics of /ʀ/.

The following constraint, originally proposed by Smolensky & Prince (1993:16), is directly relevant to the present discussion:

(12) HNUC (The Nuclear Harmony Constraint)

A higher sonority nucleus is more harmonic than one of lower sonority.

HNUC accounts only for the nucleus. Another constraint, which we call SON (13), is responsible for the sonority of the edge elements.

(13) SON (The Decreasing Sonority Constraint)

From the nucleus to the edges the sonority must not increase.

The sonority hierarchy offers an explanation of why the words *Kerl* or *Helm* are monosyllabic, whereas *Keller* and *Hammel* are disyllabic. The sonority of *rl* and *lm* is decreasing, whereas the sonority of *lr* and *ml* is increasing. Thus, since German allows syllabic sonorants, *l* in *Hammel* and *r* in *Keller* become syllabic, forming new syllables. As already mentioned, a schwa can be facultatively inserted before *l* or *r* in these words, as reflected by the

orthography. The following tableau shows how the constraints decide between different candidates for the word *Leber* 'liver' (input: /lebr/. In Tableau 3, nothing forces the ranking of HNUC and SON relatively to each other.

/lebʀ/	HNUC	SON
☞ .le.bɐ.		
.lebʀ.		*!
.le.bʀ.	*!	

Tableau 3

There is one context in which HNUC is not respected and this is the last syllable of some words with a syllabic sonorant as nucleus. In (14a), the onset of the final syllable is less sonorous than the nucleus, but in (14b), it is more sonorous, thus contradicting HNUC.

(14) Syllabic sonorants

a.		b.	
Atem	'breath'	Pollen	'pollen'
Segel	'sail'	Polen	'Poland'

Monomorphemic examples as in (14b) are hard to come by, but the problem is more common when inflection is at play, as in (15). Syllabic *n* is a frequent inflection suffix and many stems end in *r* or *l*.

(15) Violations of the sonority hierarchy

roll-n̩	'to roll'
Ball-n̩	'balls, dat. pl.'
knurr-n̩	'to growl'
stur-n̩	'obstinate, infl.'

Some authors (for instance Wiese 1986 and Giegerich 1987) avoid this difficulty by assuming a consonantal sonorant plus an epenthetic schwa which are then partly deleted and partly replaced by a syllabic sonorant at a later phonetic level. We believe that this step is unnecessary, and in Optimality Theory it is even impossible, since there are no such derivations. The solution we propose is to admit violations of the sonority hierarchy for

these cases only. A syllabic sonorant can be the nucleus of a syllable in order to fulfill NUC, even if it violates the sonority hierarchy, as shown in the first candidate of Tableau 4. A candidate that fulfills HNUC is shown in the second candidate of Tableau 4, but it violates ONSET. The third candidate has no nucleus and thus violates the high-ranking constraint NUC.

/poln/	NUC	ONSET	HNUC
☞ po.l̩n			*
po. l̩n		*!	
po.ln	*!		

Tableau 4

Tableau 4 has an undesirable consequence: with the ranking ONSET >> HNUC, it is more preferable that a word like *Uhr* 'clock', with no onset, have an onset than that is respects HNUC. In other words, according to the ranking of Tableau 4, the long vowel should be the onset and *l* the syllabic nucleus. This is not a welcome result! To avoid this syllabification, an additional constraint is necessary: VOCNUC in (16), a positive constraint which makes a syllabic nucleus of each vowel. This constraint is ranked above ONSET and forces the correct syllabification of *Uhr*. The second syllable of *Polen* is not affected since it does not contain a vowel.

(16) VOCNUC
Each vowel is a syllabic nucleus.

VOCNUC is unviolated, like NUC. These two constraints are not ranked.

/uʀ/	NUC	VOCNUC	ONSET	HNUC
☞ .u̯ʁ.			*	
.u̯ɐ.		*!		*

Tableau 5

It will be shown in the next section that full vowels are underlyingly moraic: lax vowels are monomoraic and tense ones bimoraic. In consequence, VOCNUC could be expressed in such a way as to make each moraic segment

a syllabic nucleus. However, VOCNUC is to be preferred, because although schwas are nonmoraic segments (see 2.1.3), they are nevertheless syllabic nuclei. One may wonder whether the words in (14b) should be disyllabic at all: *Pollen*, at least, could be monosyllabic and still be well-formed. ([po:ln] is too long to be disyllabic, as already mentioned.) As a matter of fact, monomorphemes like the ones in (14b) are rare, and maybe *Pollen* is lexicalized as disyllabic. On the other hand, suffixed words like those listed in (15) are extremely frequent. It has been shown in Féry (1991, 1995) that some inflectional affixes obligatorily add a syllable. In such cases, *-n* is syllabic, no matter which segment forms the onset of the newly created syllable. Since there is no vowel, *n* is in many cases the only segment that can function as the nucleus (see 2.2.1.1).

After these preliminaries, vowels and their weight will be discussed in the following two sections. Vowels are always nuclear and crucially contribute to the syllable weight. It will be shown that tense vowels are bimoraic and lax vowels are monomoraic.

2.1.2 Tense and lax vowels

Though tense vowels can also be short, they are often long, while lax ones are always short (with the exception of [ɛ], which can be long).[7] There is general agreement among phonologists of German in the generative derivational tradition that only one of these oppositions is necessary and that the other one should be expressed by redundancy rules of the form shown in (17). The first alternative, (17a) (length is distinctive, tenseness is predictable) is defended by Hall (1992a), Ramers (1988), Ramers and Vater (1992), Vater (1992), Wiese (1988) and Yu (1992); the second, (17b) (tenseness is distinctive, length is predictable), is supported by Kloecke (1982), Moulton (1962), Reis (1974) and Wurzel (1970).

(17) Redundancy rules
a. [long] –> [tense], [short] –> [lax]
b. [tense] –> [long], [lax] –> [short]

[7] In some dialects of Standard German [ɛ] has a special status in the vowel system: it can be long or short. Thus, there is an opposition between *Lehm* [le:m], *Bett* [bɛt] and *kämst* [kɛ:mst]. We assume that some occurrences of [ɛ] are bimoraic and become long when stressed, exactly like the other bimoraic vowels.

We reject both redundancy rules in (17) and instead propose explaining the difference between the two classes of vowels by their moraic structure which is underlyingly specified (Hyman 1985, Hayes 1989): vowels are underlyingly bimoraic or monomoraic. Monomoraicity implies laxness, and bimoraicity tenseness, except for the front mid unrounded vowel [ɛ], which can be both mono- and bimoraic.

Some phonologists (e.g., Giegerich 1985, Hall 1992, Ramers 1988, Wiese 1986, 1988 and Yu 1992) have suggested that long vowels are associated with two syllable positions.[8] According to our proposal, the distinction is made in the moraic structure, and only indirectly in the syllable structure (for Dutch see Hulst 1984, Kager 1989, Hulst and Van Lit 1987 and the literature cited there). Hence, not only are tense vowels bimoraic and lax vowels monomoraic, but tense vowels also have a lengthening potential, whereas lax vowels do not. Thus both length vs. shortness and tenseness vs. laxness are predictable from the moraic structure. A monomoraic vowel is always lax and short. A bimoraic vowel is always tense: it is long in a stressed position and short in an unstressed one. In a secondary stressed position, it is half-long (Ramers 1988, Reis 1974, Vater 1992). The following redundancy rules take the place of (17):

(18) Redundancy rules for lax and tense vowels
a. If a vowel is monomoraic, it is lax and short.
b. If a vowel is bimoraic, it is tense.
c. If a bimoraic vowel has main stress, it is long.
d. If a bimoraic vowel has secondary stress, it is half-long.
e. If a bimoraic vowel has no stress, it is short.

Moraic structure is specified in the lexicon, and all other properties of vowels are derived from it. In the following, the moraic structure is given with the input of the morphemes.

The following properties of vowels confirm (18):

1. Short lax vowels (except for schwa) do not occur in open syllables, but only in closed ones (Moulton 1956). This is illustrated in (19). In words like *Ótto* and *Káffee*, the final vowel in the open syllable is always tense. A lax

[8] All these authors assume that segmental roots are associated with skeletal positions, and do not consider the relevance of moras for the syllable's structure.

vowel cannot be realized in this position (19a). In closed syllables like in (19b), lax vowels occur freely.[9] A dot under a consonant signalizes its ambisyllabicity. Also the fisrt vowel in a hiatus always is a tense vowel (19c).

(19) Lax vowels

a.	Otto	[ɔ t̤ o·]	*[ɔ t ɔ]	name
	Kaffee	[kaf̤e·]	*[kafɛ]	'coffee'
b.	Helm	[hɛlm]		'helmet'
	Müll	[mʏl]		'garbage'
	Birne	[bɪʁ.nə]		'pear'
	Robbe	[ʀɔb̤ə]		'seal'
c.	Dia	[di:. ɑ·]		'slide'
	Oase	[o:.ɑ:.zə]		'oasis'

2. Tense vowels, in contrast, do appear both in open (19c, 20a and b) and in closed syllables (20c). The length of the tense vowels in unstressed word-final position is not well-defined: they are neither long, nor short (20a). Short tense vowels appear in unstressed word-internal position (20b).

(20) Tense vowels in closed and open syllables

a. open syllables in final position:

Mútti	[mo̤ti·]	'mum'
Káffee	[kaf̤e·]	'coffee'
Áuto	[au̯.to·]	'car'

b. open syllables in word-internal position:

Ökonomíe	[ø.ko.no.mi:]	'economy'
hebrä́isch	[he.bʀɛ:.ɪʃ]	'Hebrew'

[9] Vennemann (1992) uses another terminology, first introduced by Jakobson (1937) and Trubetzkoy (1939). Syllables with a tense vowel are called smoothly cut and those with a lax vowel are abruptly cut. In his own words: "The intuitive correlates of these prosodies are the ways *the end of the nucleus is reached*: in abrupt syllables the nucleus ends on an intensity crescendo, the decrescendo, if there is one, occurring either in the coda or in the following syllable; by contrast, in smooth syllables the intensity decrescendo begins in the nucleus itself. According to phonetic measurement, the acoustic intensity decrescendo of an abrupt syllable is short and steep and occurs at the very end of the nuclear vowel; by contrast, the acoustic intensity decrescendo of a smooth syllable is long and flat and begins long before the end of the nuclear vowel. These phonetic characterizations, both the intuitive one and the one based on experiments, establish the cut properties as prosodic properties, because the same sequence of speech sounds may in principle occur with one or the other of the syllable cuts" (1992:401) (emphasis in the original).

Metáll	[me.tal]	'metal'
Kolónne	[ko.lɔn̤ə]	'row'
kulinárisch	[ku.li.nɑ:.ʀʃ]	'culinary'
binär	[bi.nɛ:ʁ]	'binary'
Harmónika	[haʁ.mo:.ni.ka·]	'harmonica'

c. closed syllables:

Hut	[hu:t]	'hat'
Lohn	[lo:n]	'salary'

3. Finally, stressed tense vowels are long (21a), both in primary stressed positions (21a) and in secondary stressed ones (21b), though in the latter context they are half-long. The length of the tense vowels directly correlates with stress. Unstressed tense vowels are short, as illustrated in (20b).

(21) Long tense vowels in stressed syllables

a. primary stress:

Bésen	[be:.zn̤]	'broom'
Hut	[hu:t]	'hat'
Nóte	[no:.tə]	'note'
Höhle	[hø:.lə]	'cave'
Míete	[mi:.tə]	'rent'

b. secondary stress:

Báhnhòf	[bɑ:n.ho·f]	'railway station'
árbeitslòs	[aʁ.baɪ̯ts.lo·s]	'unemployed'
Éigentùm	[aɪ̯.gn̤.tu·m]	'property'
Démùt	[de:.mu·t]	'humility'
Mónàt	[mo:.n ɑ·t]	'month'

The generalization that emerges has been observed by Moulton (1962) and by Reis (1974). Moulton says:

> To sum up: though the opposition "long-short" is a striking phonetic feature of the German vowel system, it affects vowels only when they are stressed. The one constant feature which distinguishes the two sets of vowels in both stressed and unstressed position is the opposition "tense-lax". In formal speech this opposition is suspended in unstressed position only for the

> pair /ạ/-/ạ/; in the informal speech of many persons, however, it is suspended for all other pairs as well. (1962:64)

And Reis (1974:192):

> The crucial argument for the distinctivity of the vowel quality in German is to be found in the secondary stressed syllables. There, the difference in quantity vanishes, but the difference in quality remains. [...] The vowel length appears to be primarily dependent on the word stress and secondarily dependent on the vowel quality: under main stress length is automatically tense.[10] (quoted after Vater 1992:115)

If lax vowels are monomoraic and tense vowels bimoraic, the difference in length in primary stressed vowels can be explained. Bimoraic vowels exploit their length potential under stress, whereas monomoraic vowels, having no length potential, remain short. Our proposal to make the primary distinction between tense and lax vowels a distinction in their moraic structure also accounts for the fact that short vowels cannot appear in open syllables. In a framework in which segments are associated with skeletal positions, there is an unsolvable contradiction between the requirement that syllables have at least two positions, which is necessary to explain the non-occurrence of final open syllables with a lax vowel, and the fact that tense vowels can be short, and thus occupy only one skeletal position. In our approach the problem does not even appear. The minimal syllable is measured in moras and not in positions. Even if skeletal positions are necessary, they do not express restrictions on syllable weight. The constraint (22), BIMOR, expresses the fact that German syllables, with the exception of schwa syllables, are at least bimoraic: see the next section and Kager (1989: Chapter 3) for a similar generalization about Dutch.

(22) BIMOR (Bimoraic syllables)
Syllables are minimally bimoraic.

[10] In the original: "Das entscheidende Argument für den distinktiven Status des qualitativen Kontrastes im Deutschen liegt im Zeugnis der Nebensilben. In diesen verschwinden die Quantitätsunterschiede, die qualitativen Kontraste bestehen jedoch weiter. [...] Damit erweist sich die Vokallänge als primär abhängig vom Wortakzent und sekundär von der Vokalqualität: Unter Hauptton tritt sie automatisch zu gespannt hinzu."

Syllables with less than two moras violate BIMOR. This constraint accounts for the fact that no syllable ends in a short lax vowel, since a short vowel, being monomoraic, cannot fulfill the bimoraicity condition. Short tense vowels can appear in open syllables, since they fulfill (22). There is some evidence that short tense vowels are indeed bimoraic.[11]

As already mentioned in section 2.1, nucleus and coda together form a rhyme. Different reasons can be invoked for the existence of the rhyme, a crucial one being the rhyme in poetry, another one being directly relevant to the discussion about the status of tense vs. lax vowels: rhymes have a maximal number of positions. Lax vowels can be followed by more tautosyllabic segments than tense vowels (Moulton 1956). More exactly, tense vowels (and diphthongs) behave like a sequence of a lax vowel plus one consonant. Whereas a lax vowel can be followed by two consonants (23a), this is not the case for long tense vowels and diphthongs (23b), nor for short tense vowels (23c).

(23) Restrictions on the number of positions in rhymes

a. A lax vowel can be followed by maximally two moraic consonants (μCC)

Lump	[lʊmp]	'scoundrel'	*[lʊʀmp]
flink	[flɪŋk]	'nimble'	*[flɪʀŋk]
Helm	[hɛlm]	'helmet'	*[hɛlmp]
Hirn	[hɪɐ̯n]	'brain'	*[hi:ʀn]
Tempo	[tɛmpo·]	'tempo'	*[tɛlmpo·]

b. A long tense vowel can be followed by only one moraic consonant (μμC)

Hehl	[he:l]	'secret'	*[he:lk]
Lohn	[lo:n]	'salary'	*[lo:mp]
Bein	[baɪ̯n]	'leg'	*[bailn]

c. A short tense vowel can be followed by only one moraic consonant (μμC)

Me̲táll	[me.tal]	'metal'	*[me̲ɐ̯l.tal]
ku̲linárisch	[ku.li.nɑ:.ʀʃ]	'culinary'	*[ku̲mp.li.nɑ:.ʀʃ]
Harmóni̲ka	[haɐ̯.mo:.ni.kɑ]	'harmonica'	*[haɐ̯.mo:.ni̲ft.kɑ]

[11] Recall that tense vowels are long under stress, which implies that, in this case, their bimoraic status is uncontroversial. The same is true for lax vowels: since they are always short, their monomoraic status is uncontroversial, too.

If a vowel is followed by a tautosyllabic dorsal nasal [ŋ], it is always lax, as illustrated in (24). No tense vowel, long or short, occurs in this position. The dorsal nasal is often analyzed as being the phonetic realization of a sequence of a nasal + [g] (Isačenko 1963, Kloecke 1982), thus a sequence of two consonants, except if it is the result of an assimilation to the following velar stop, like in *Bank* [baŋk] 'bank'. It is monomoraic only in the latter case (a monomoraic [n] has become /ŋ/ as the result of an assimilation). In the former case, it is bimoraic. This restriction also shows that tense vowels are in some sense heavier, i.e. they occupy more positions than lax vowels.[12]

(24) Restrictions on the number of positions of rhymes in syllables with a dorsal nasal

a. Lax vowel

lang	[laŋ]	'long'
sing	[zɪŋ]	'sing'

b. Long tense vowel

*o:ŋ, *a:ŋ

c. Short tense vowel

*oŋ, *aŋ

The crucial data are those in (23c) and (24c), which show that a short tense vowel cannot be followed by more than one consonant or by the bimoraic dorsal nasal in the same syllable. So a short tense vowel behaves like a long tense vowel in terms of the number of consonants it can be followed by. Vennemann (1992, footnote 1), criticizing Wiese's claim that all German syllables contain at least VC at the syllabic level, writes:

> Wiese's second reason for his VC requirement is the well-known fact that syllables with a lax vowel in general tolerate longer codas than syllables with a tense vowel (or diphthong). But this can easily be interpreted as merely a structural property of Standard German, no more in need of an explanation in synchronic terms than the other fact that of the three nasal consonants only the labial and the alveolar but not the velar may occur in word-initial position, or the further fact that the labial and the alveolar nasal may occur both after a tense and a lax vowel but the velar only after a lax vowel. If one insists on a synchronic explanation, one may relate the different coda restrictions to the fact that one of the phonetic accompaniments of tenseness is length: A coda of several consonants would make syllables with a tense vowel phonetically over-long.

[12] See also Anderson (1984) who proposes that tense vowels are internally more complex than lax ones. More precisely he says that tense vowels occupy "two segmental positions within the syllabic Nucleus, as opposed to lax vowels, which occupy only one" (p.95).

Vennemann's comment contains two weaknesses, the first one being that the difference in tolerated codas after lax and tense vowels needs no explanation: it can be interpreted as a mere structural property (whatever that means). His analogy with the velar nasal is strange, since, according to most phonologists, the fact that the velar nasal does not appear word-initially and the fact that it does not appear after a tense vowel are correlated: both properties are explained if [ŋ] is phonologically a sequence [n] + [g], or simply the result of a word-internal assimilation of [n] to a following velar, as illustrated in *Triangel* [ŋ]/*triangulär* [ŋg]. Secondly, he gives an explanation (for those who insist) based on phonetics: "A coda of several consonants would make syllables with a tense vowel phonetically over-long." This explanation works only for long tense vowels, but says nothing about short tense vowels.

Contrary to Vennemann's point of view,we think that the absence of long codas after tense vowels *is* in need of an explanation. The difference between codas after tense and lax vowels can be easily explained if rhymes have a maximal number of positions: it consists of maximally three moras in word-final syllables, and preferably two in word-internal syllables. If the nucleus is bimoraic (tense vowel), it can be followed by one moraic consonant in the same syllable. If the nucleus is monomoraic (lax vowel), two tautosyllabic moraic consonants can follow. The constraint on the occurence of the consonants can be expressed in a simple way, as a constraint on the maximal number of moras that a syllable may have (25). Appendices are not moraic, and thus do not count for (25). This point is developed in section 2.1.6.

(25) TRIMAX (Trimoraic maximum)
Syllables are maximally trimoraic.

Taken together, (22) and (25) claim that syllables contain two or three moras. However, as shown in Tableau 6, TRIMAX is ranked higher than BIMOR. In fact TRIMAX is unviolable: there are no quadrimoraic syllables, whereas BIMOR is often violated: all schwa syllables are nonmoraic (see next section).

/lɔytnant/ 'Leutnant'	TRIMAX	BIMOR
σ / | \ μ μ μ | | | ☞ lɔ ɣ t.n a n t		
σ / | \ \ μ μ μ μ | | | | *l ɔ ɣ n t.nant	*!	

Tableau 6

Let us summarize the main findings of the present section. We have seen that tense vowels are bimoraic and lax vowels are monomoraic. Different facts of German phonotactics have confirmed this view. A constraint BIMOR has been introduced, which requires the German syllables to be bimoraic, as well as a constraint TRIMAX, which prohibits syllables with more than three moras.

In the next section a class of syllables which systematically violate BIMOR is discussed: those with a nuclear schwa or a nuclear syllabic sonorant. These syllables are nonmoraic, irrespective of the number of consonants in their coda.

2.1.3 Nonmoraicity: the schwa syllables

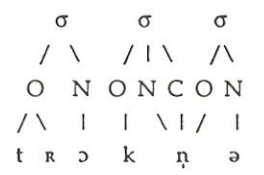
So far, only full vowels have been considered. But German also has a reduced mid central vowel, schwa [ə], which has a special status: it is always unstressed, and in many cases, schwa plus consonantal sonorant is an alternative realization of a syllabic sonorant (see Féry 1991, Giegerich 1987,

Höhle & Vater 1978, Isačenko 1974, Noske 1992, Wiese 1986, Wurzel 1970). As already mentioned, we take the default pronunciation of the last syllable's nucleus in words like *Polen*, *Leber* and *Segel* to be a syllabic sonorant. On this point, our position differs from the literature on German schwa which considers schwa + consonantal sonorant to be the default realization (Giegerich 1987, Hall 1992a, Wiese 1986, among others).[13] Schwa is obligatorily pronounced only in case there is no consonant in the coda, or if the following consonant is not a sonorant and cannot be syllabic, like [t] in *redet* 'speaks'. A schwa followed by [ʀ] is realized as a vocalic [ɐ] (sometimes transcribed as [ʌ], as in Ramers 1992 and Hall 1993).

In this section, no clear line between syllables whose nucleus is a schwa and syllables containing syllabic sonorants is drawn, since they have the same properties, as far as their weight is concerned: they all are light and monomoraic.We distinguish between them only when necessary. Following a proposal by Kager (1989), we call them 'schwallables'.

Like full vowels, schwallables are real syllables[14]: they can have an onset, or a coda, or both, or neither. But not all types of schwallables can appear in all word-positions: a schwallable without an onset never appears word-initially. Word-internally and -finally, onsetless schwallables are exceptional (*Ehe* 'marriage' is an example), at least in monomorphemic words, and no word consists of a single schwallable. As already mentioned, in the list (27), and everywhere else, syllabic sonorants form both the nucleus and the coda of the syllable they are in, and sometimes even the onset of the following syllable as, e.g., in *trockene* [tʀɔkn̩ə] 'dry, infl.', where *n* is syllabic and the nucleus and coda of its own syllable as well as the onset of the next one.

(26)



[13] These authors assume an epenthetic schwa in the lexical component of the grammar which is deleted at the postlexical level. Such derivations cannot be expressed in OT.

[14] Even if the syllable they form is sometimes deleted in connected speech: *fahren* –> *[fa:n]*, *holen* –> *[ho:ln]*.

The possible German schwallables are listed in (27).

(27) Possible German schwallables

a. Onset + nucleus + coda (CəC, CəCC)

verbléiben	[fɐ.blaɪ̯.bn̩/m̩]	'stay'
Ábend	[ɑ:.bn̩t]	'evening'

b. Nucleus + coda (əC)

éher	[e:.ɐ]	'rather'
káuerte	[kaʊ̯ɐ.tə]	'chewed'
báuen	[baʊ̯n̩]	'to build'

c. Onset + nucleus (Cə)

Beámte	[bə.am.tə]	'civil servant'
Páderborn	[pɑ:.dɐ.bɔɐ̯n]	name of a town
Kárre	[kaɾə]	'heap (for a car)'

d. Nucleus (ə)

Böe	[bø:.ə]	'squall'
Éhe	[e:.ə]	'marriage'
Státue	[ʃta:.tu.ə]	'statue'

An interesting aspect of schwallables is that their codas (and their syllabic sonorant nuclei) are generally coronals, except for palato-alveolars and palatals (where, however, [ɐ] is completely vocalized), and, in few cases, the labial nasal (Kiparsky 1966). No schwa occurs before a palatal or dorsal, though [ɪ] does: compare the data in (28) to (30).

(28) Schwallables have an [anterior] coda

Róggen	[n̩/ŋ]	'rye'
geárbeitet	[ət]	'worked'
édel	[l̩]	'noble'
Rúder	[ɐ]	'oar'

(29) Schwallables have a labial nasal coda

Átem	[m̩]	'breath'

(30) Unstressed [ɪ] before alveo-palatals, palatals and velars

hérrlich	[ɪç]	'marvellous'
flüssig	[ɪç]	'liquid'
néidisch	[ɪʃ]	'envious'
Jüngling	[ɪŋ]	'youth [= boy]'

Wurzel (1970:182) formulates a derivational rule changing an unstressed [e] into [ə] before a tautomorphemic coronal and into [ɪ] before a palatal or a dorsal. He also convincingly argues that schwa is in many cases an allophone of [ɛ] (or of [e], which is itself an allophone of [ɛ]), as shown by the alternations in (31).

(31) Schwa alternates with [ɛ] or [e]

a. lebéndig [ɛ]/Lében [ən/n̩/m̩]		'alive/life'
b. Charaktére [e:]/Charákter [ɐ]		'characters/character'

As observed by Kloeke (1982:21), schwa alternates not only with [ɛ] or [e] but also with other full vowels. Some of these alternations are listed in (32).

(32) Schwa seems to alternate with other vowels

a. [u]

Fórmel/formulíeren	'formula/to formulate'
Triángel/triangulär	'triangle (musical instrument)/triangular'

b. [i]

Ómen/ominös	'omen/ominous'
sensíbel/Sensibilität	'sensitive/sensitivity'
Álpen/alpín	'Alps/Alpine'

c. [o]

Metápher/metaphórisch	'metaphor/metaphoric'
Apóstel/apostólisch	'apostle/apostolic'

However, even if alternations between schwa and vowels other than [ɛ] or [e] do exist, as attested by (32), it is not the case that schwa is the reduced vowel of all full vowels in German – as it is in English – and this is for the following reasons:

1. In the pairs (32), the first four examples do not involve alternations between a stressed vowel and an unstressed one, but between two unstressed ones, since the relevant vowels in *formulíeren, triangulär, ominös*

and *Sensibilität* are not main stressed. Only the last three examples involve stressed vowels, which do alternate with unstressed ones.

2. All alternations listed in (32) and others of the same kind are not original to German, but are found in other languages as well. Thus, the alternations are not German, in the sense that they did not originate in this language. Furthermore, some of these alternations, though etymologically related, are no longer semantically related (for instance *Omen/ominös* or *Triangel/triangulär*).[15]
3. The unstressed vocalic counterpart of a stressed vowel usually has the same quality as the stressed vowel. Thus, numerous counterexamples of the alternation full vowel/schwa exist:

(33)	Ökonóm/Ökonomíe	'economist/economy'
	nationál/Nationalität	'national/nationality'
	Kultúr/kulturéll	'culture/cultural'
	románisch/Romaníst	'Romance/romanist'
	máchen/zúmachen	'to do/to close'
	Prósa/prosáisch	'prose/prosaic'
	Tráuma/traumátisch	'trauma/traumatic'

Thus, contrary to the situation in English, the fact that a vowel is not stressed in German does not imply that its vocalic nucleus is reduced. The quality of the vowel remains generally unaffected. However, as Kohler (1977) and Vennemann (1992) observe, a vowel may lose its distinctivity in connected speech, especially between two stressed vowels: *Apparát* 'apparatus' is often pronounced *App[ə]rát*, and *Chólera, Chol[ə]ra*.[16]

[15] Thanks to Ede Zimmermann who drew our attention to this point.

[16] Another remark is in order here, which has nothing to do with schwa, but rather with the unstressed counterpart of a stressed vowel: the following alternations are very common in German:

(i)	Molekül/molekular	'molecule/molecular'
	nervös/Nervosität	'nervous/nervousness'
	binär/Binarität	'binary/binarity'

The left member of each pair has a stressed umlauted vowel. Its counterpart in the right member is an unstressed non-umlauted vowel. If a vowel is umlauted, it is generally stressed. However, there are exceptions to this tendency, a few of which are under (ii).

(ii)	Möbel/möblieren	'furniture/to furnish'
	Typ/typisch/typológisch	'type/typical/typological'
	Land/Ausländer	'country/foreigner'

Now for schwallables in OT. The first full-fledged account can be found in Cohn & McCarthy (1994), who observe that Indonesian schwa is unstressable (as it is in German). This is accounted for by the constraint NON-HEAD(ə) given in (34).

(34) NON-HEAD(ə)
Stressed [ə] is prohibited.

Schwa has an additional property in this language: it is metrically invisible. They account for this property with another constraint: NON-FOOT(ə) in (35).

(35) NON-FOOT(ə)
Schwa-headed syllables have no metrical projection.

In contrast to NON-HEAD(ə), this last constraint is violable. Indonesian minimal words are disyllabic (except for a handful of lexical exceptions, borrowings, which are monosyllabic) and many words are disyllabic by virtue of combining a schwa syllable with one non-schwa vowel, as illustrated in (36). Notice that the schwa-syllable is not allowed to be final: there is no word like **bírə* or **bátirəm*.

(36)	(ərú)	'Australian pine'	ənám	'six'
	bərí	'give'	kərá	'monkey'
	kəcíl	'small'	kərjá	'work'
	sətəláh	'after'	əmpəlás	'sandpaper'

Indonesian has a high-ranking constraint FT-BIN, requiring syllabic or moraic foot binarity (see Chapters 1 and 3). The word *bicára* 'speak' is footed as *bi(cára)*, where parentheses indicate footing, because *(bi)(cára)* would violate FT-BIN. The same holds for the third syllable in *(kònti)nu(ási)* 'continuation' and *(àme)ri(kàni)(sási)* 'americanization'. FT-BIN is formulated in such terms that syllabicity or moraicity counts for binarity, but the discussion makes clear that only syllabification counts. The word *tik* 'type' for instance is

However, it is apparent in those words that they are all derivations from stems in which the generalization that umlauted vowels appear only in stressed syllables holds(see Chapter 4).

augmented to disyllabicity by the addition of a schwa, becoming *ətik*. Thus [k] is not moraic. Furthermore, true monosyllabic words are never found (apart from a few lexical exceptions). This implies that minimal words, containing a full vowel syllable and a schwallable must be footed, as illustrated in (38a). These words differ from polysyllabic words containing schwa, as in (37), which have enough syllables with a full vowel that can form feet. One example of footing of these words is shown in (38b), in which word schwallables do not need to be footed. In (38b), the first two syllables do not participate in the metrical structure of the word; only the last two do. The schwallable in (38b) fulfills (35), whereas the one in (38a) does not. What is not clear to us is how other polysyllabic words including schwa syllables, like the ones given in (37), are footed, since Cohn & McCarthy are not explicit about this.

(37) kopərási 'cooperation' gámələn 'Indonesian orchestra'
apártəmen 'apartment' cərítəra 'story'

(38) a. (ərú)
b. kopə(rási)

In German, as in Indonesian, schwa is unstressable, but it is generally metrifiable, though in some rare cases there is evidence that it is not footed.[17] But contrary to Cohn & McCarthy, we propose that its non-stressability is accounted for by the fact that schwa is nonmoraic. It projects a syllable, but no mora. Nonmoraicity is accounted for by a constraint, called NOMOSCH, formulated in (39). It ensures that a schwallable is always nonmoraic and, as a consequence, always unstressed, because nonmoraic syllables are too light to attract stress.

(39) NOMOSCH (Nonmoraic Schwallable)
A schwa syllable is nonmoraic.

[17] See Chapter 4 for examples with umlaut-inducing *-chen*. It is shown there that productive umlaut, only induced by the diminutive affixes *-chen* and *-lein*, applies in a foot. Thus, *Rädchen* 'little wheel', *Skandälchen* 'little scandal' but **Äutochen/*Äutöchen* 'little car', **Mönatchen/*Mónätchen* 'little month'. In words like *Dotterchen* 'little yolk' and *Ankerchen* 'little anchor' (without umlaut) the schwallable must be metrically visible. However, in *Brüderchen* 'little brother', *Bäuerchen* 'little peasant', *Nädelchen* 'little needle' and *Kügelchen* 'little ball' (with umlaut) the reverse seems to be true.

This constraint is undominated and crucially ranked above BIMOR. There are no examples of syllables containing schwa or a syllabic sonorant and having some weight. Schwallables can have up to three segments in their coda (all coronals or [ʁ] and exceptionally [m]) and still be nonmoraic. All other consonants occuring in the same syllable are also nonmoraic. As they usually are coronals, it could be a consequence of their being appendices (see 2.1.6 for more about these cases).

The following tableau for Hubert (name) shows that NOMOSCH cancels the effect of BIMOR.

/hubɐ t/ *Hubert*	NOMOSCH	BIMOR
σ / |\ ☞ (hu). b ɐ t		*
σ /\ μ μ | | (hu). b ɐ t	*!	

Tableau 7

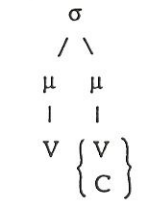
We assume that NOMOSCH can replace NON-HEAD(ə) in Indonesian, too. Cohn & McCarthy (1994:24, footnote 14) say without further comments that they do not consider the further formal development of NON-HEAD(ə), and we think that nonmoraicity of schwa can account for the fact that it is never stressed, as in German.

In section 2.2 it will be shown that syllabic inflections, which always consist of schwallables, have the same properties as stem schwallables.

2.1.4 Bimoraicity: the consequences of BIMOR

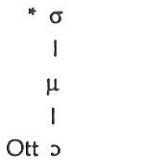
Having shown that schwallables require a special constraint that gives them absolute nonmoraicity, we will now return to syllables with a full vowel. As shown in section 2.1.2, these syllables have the minimal structure (40); see also Kager (1989:185) for the same constraint in Dutch.

(40) Bimoraic syllable



Monomoraicity is excluded for syllables with a full vowel in their nucleus. Hence, a syllable structure like (41) is impossible.

(41) No monomoraicity for syllables with a full vowel



The fact that lax vowels can only appear in closed syllables has consequences for a word-internal lax vowel followed by a single consonant and a vowel, as in the examples given in (42). The list is adapted from Ramers[18] (1992:247); in all these examples the main stress is on the first syllable. Remember that a dot under a consonant signalizes ambisyllabicity.

(42) Words with an ambisyllabic consonant

Kippe	[kɪp̣ə]	'cigarette-end'
Robbe	[ʀɔb̥ə]	'seal'
Mitte	[mɪt̥ə]	'middle'
Widder	[vɪd̥ə]	'ram'

[18] Ramers offers a detailed account of ambisyllabicity in German and proposes correlating underlying ambisyllabicity with orthography (see also Giegerich 1985, Prinz & Wiese 1990 and Butt & Eisenberg 1990, who defend the thesis that orthography has an influence on phonology). All doubly written consonants, like those in (42), as well as the final ones in *Ballett* 'ballett', *Prozeß* 'process' and *Duell* 'duel', signalize ambisyllabicity. As Ramers himself observes, this approach implies absolute neutralization, which is undesirable since it is unmotivated by the phonetic facts. The singly written consonant in *Balance* 'balance' (ambisyllabic by an extra rule) and the doubly written one in *Ballade* 'ballad' are not distinguished phonetically.

Backe	[bak̥ə]	'cheek'
Roggen	[ʀɔgn̥]	'rye'
offen	[ɔf̥n̥]	'open'
Masse	[mas̥ə]	'mass'
lache	[lax̥ə]	'laugh, 1st pers sg'
Komma	[kɔm̥a]	'comma'
trenne	[tʀɛn̥ə]	'separate, 1st pers sg'
Hölle	[hœl̥ə]	'hell'
irren	[ɪʀ̥n̥]	'to be mistaken'

Ambisyllabicity of the medial consonant in words like those in (42) is generally recognized by the phonologists of German. It has some phonetic reality and corresponds to a phonological need.

Phonetically a single consonant after a stressed lax vowel and before an unstressed vowel does not have the phonetic correlates of a syllable-initial consonant, like aspiration for instance. Word-initial /t/s and /d/s are realized with clearly defined closures and releases: /t/s are aspirated, as are the voiceless stops of other places of articulation. In contrast, word-medial consonants are not realized as clearly. In English, alveolars before an unstressed vowel are realized as flaps (very short prevoiced alveolars with little or no sign of a release burst). Turk (1994) discusses the distribution of bilabial stops in English. She compares two theories of syllable affiliations, both of which involve resyllabification of the medial consonant. Kahn (1976) proposes that the /p/ of *leper* is underlyingly the onset of the second syllable and becomes ambisyllabic on the surface structure. In Selkirk's (1982b) account, the consonants in the flapping environments are syllable-final in the surface representation: *leper* is syllabified as *lep.er*. Turk finds that bilabial stops following a stressed vowel and preceding an unstressed one pattern with syllable-final stops, and not with syllable-initial ones. However, as she observes, her results are not incompatible with Kiparsky (1979), who claims that the relevant environment for syllabification is the foot, a comment with which we completely agree. Turk's experiments (as well as similar ones by Krakow 1989 and Treiman & Danis 1988[19]) consider only English data, but it is very probable that the same results apply to German as well.

[19] Treiman & Danis find that the consonant type has an effect on its syllabification: sonorants are more often interpreted as ambisyllabic than obstruents.

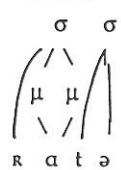
Phonologically, ambisyllabicity closes a syllable whose peak is a lax vowel. A stressed syllable is at least bimoraic, and the second mora comes from the ambisyllabic consonant. Two constraints are involved in the syllabification of the medial consonant: ONSET and BIMOR. The consonant in question has to be the onset of the second syllable in order to fulfill ONSET, but it also must close the first syllable in order to satisfy BIMOR, since this consonant is the only segment that can give the first syllable its missing second mora. (See Kager 1989 for the same point in Dutch.)

Ambisyllabicity of the medial consonant satisfies both requirements. The word *Ratte* 'rat' with an ambisyllabic medial [t] is syllabified as in (43): [t] is moraic in its function as the coda of the first syllable and nonmoraic in its function as the onset of the second syllable.

(43) *Ratte* [ʀaṭə]

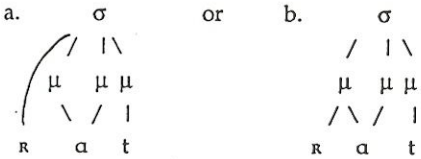
The syllabification of *Ratte* contrasts with that of *rate* 'guess', in which the long tense vowel is already bimoraic. In *rate*, the only function of [t] is to be the onset of the second syllable (44).

(44) *rate* [ʀɑ:tə]



Onsets do not enter the moraic count, which reflects the fact that onsets do not play any role in the syllable weight. The onset is simply adjoined to the syllable node (45a), as proposed by Hayes (1989), McCarthy & Prince (1993a), etc., or it can be adjoined to the first mora (45b), as in Hyman (1985).

(45) Onset



In this work, the representation (45a) will be used, because it better reflects the weightlessness of the onset. However, nothing hinges on the one or the other representation.

The conflict between the requirement of bimoraicity imposed on syllables with full vowels and the fact that a medial consonant is also the onset of the second syllable is thus solved by ambisyllabicity. Such cases are exactly the kind of conflicts the Optimality Theory addresses. Tableau 8, illustrating the evaluation of *Mitte* [mɪṭə] 'middle', shows the effect of BIMOR and ONSET on ambisyllabic consonants. Since the lax vowel of the first syllable is monomoraic, it needs the following [t] to add a second mora in order to fulfill BIMOR. The first syllable of candidate b. is monomoraic and does not fulfill BIMOR; it is thus eliminated. Notice that in a word with a schwallable, BIMOR is systematically violated in order to fulfill NOMOSCH. But NOMOSCH has no effect on syllables with a full vowel: it only checks the nonmoraicity of schwallables. What matters is the violation of BIMOR by a syllable with a full vowel. Candidates a. and c. both violate BIMOR once, but candidate c. also violates ONSET, which candidate a. does not. So candidate a. wins. Nothing forces the ranking of BIMOR and ONSET, sowe assume that they are not ranked.

μ | /m ɪ tə/ *Mitte*	NOMOSCH	BIMOR	ONSET
a. σ σ \/ \ μ μ | | ☞ m ɪ t̬ ə		*	
b. σ σ | / μ | m ɪ . t ə		**!	
c. σ σ \/ \ | μ μ | | m ɪ t . ə		*	*!

Tableau 8

At this point a problem arises. According to the constraints of Tableau 8, medial [t] of *rate* [ʀɑ:tə] 'guess' can be ambisyllabic like the [t] of *Ratte* [ʀat̬ə] or *Mitte* [mɪt̬ə].

✳ μ μ \/ /ʀ ɑ tə/ *rate*	TRIMAX	NOMOSCH	BIMOR	ONSET
a. σ σ \/ \ \ μ μμ \/ | ☞ ʀ ɑ t ə			*	
b. σ σ \/ \ μ μ \/ | ☞ ʀ ɑ t ə			* *	

Tableau 9

If [t] is ambisyllabic, the first syllable is trimoraic, which is not prohibited by the constraints discussed so far, including TRIMAX (introduced in section 2.1.2 and discussed in the next section), which restricts the number of moras in German syllables to maximally three: consider Tableau 9 and remember that the big asterisk in the upper left corner of the Tableau indicates that it has a flaw of some sort.

Trimoraicity in word-final syllables is widespread, but word-internal syllables are generally bimoraic (though there are exceptions; see the next section). Compare the data in (46) and (47). In (46), all words are trimoraic (see the next section for a systematic presentation of trimoraicity), and in (47), the first syllable of each word has two moras.

(46) Trimoraic syllables

Lob	[lo:p]	'praise'
Krug	[kʀu:k]	'jug'
Korb .	[kɔe̯p]	'basket'
brüsk	[brysk]	'brusque'

(47) Bimoraic syllables

Robe	[ʀo:.bə]	'robe'
Höhle	[hø:lə]	'cave'

Ambisyllabicity is restricted to syllables which would otherwise be monomoraic. Trimoraicity of nonfinal syllables is avoided as far as possible. To avoid ambisyllabicity in words like *rate* or in the words in (47), NOCODA is active.

This constraint posits that, other things being equal, the onset of a syllable is affiliated to one syllable only. Tableau 10 is an extension of Tableau 9. It shows the effect of NOCODA on the syllabification of *rate*. Both candidates fulfill NOMOSCH and ONSET, and both violate BIMOR by their schwallable. But candidate b. crucially violates NOCODA. For this reason, candidate a. wins. NOCODA has no effect on truly ambisyllabic consonants, since BIMOR and ONSET are ranked higher than NOCODA.

μ μ \/ /ʀ ɑ tə/ *rate*	TRIMAX	NOMOSCH	BIMOR	ONSET	NOCODA
a. σ σ /\ μ μ \/ ☞ ʀ ɑ . t ə			*		
b. σ σ /\ \ μ μ μ \/ | ʀ ɑ t̩ ə			*		*!

Tableau 10

In this section, the implications of BIMOR have been examined. This constraint guarantees that the lax vowels are checked by a consonant. In case there is only one medial consonant, it is ambisyllabic. Ambisyllabicity is restricted to syllables with a lax vowel. NOCODA blocks ambisyllabicity in syllables with a tense vowel, as well as on syllables closed by two consonants. This step is necessary since in principle trimoraic syllables are allowed in German, as will be demonstrated in the next section.

A remarkable fact is that although BIMOR is a violable constraint, it is never violated by final open syllables, but only by schwallables, which are nonmoraic by decree. Only schwas are nonmoraic; all other vowels are bimoraic.

2.1.5 Trimoraicity

After having looked at the conditions under which bimoraicity is forced, this section examines trimoraic syllables. It will be shown in the next chapter that only trimoraic syllables are heavy in German.

Some examples of morpheme-final trimoraic syllables are given in (46), which is repeated in (48) along with some additional instances. The three moras are made up of a tense vowel followed by one consonant (48a),

or of a lax vowel followed by two consonants (48b), or of a diphthong followed by one consonant (48c).

(48) Trimoraic syllables

a.	Lob	[lo:p]	'praise'
	Krug	[kʀu:k]	'jug'
	lahm	[l ɑ:m]	'lame'
	Atom	[aṭó:m]	'atom'
	Pirat	[pi.ʀɑ:t]	'pirate'
	Prinzip	[pʀɪn.tsí:p]	'principle'
b.	Korb	[kɔɐ̯p]	'basket'
	brüsk	[bʀʏsk]	'brusque'
	Instinkt	[ɪns.tɪŋkt]	'instinct
	autark	[au̯.táɐ̯k]	'self-sufficient'
	Elefant	[e.le.fánt]	'elephant'
c.	Baum	[bau̯m]	'tree'
	Pfeil	[pfai̯l]	'arrow'
	allein	[al̩ái̯n]	'alone'
	Astronaut	[as.tʀo.náu̯t]	'astronaut'

These trimoraic syllables contrast not only with bimoraic ones (see the preceding section), but also with longer syllables in word-final position. The words in (49) are trimoraic, like those in (48), but they have additional, nonmoraic segments in their codas called *appendices*. Syllables with appendices are the subject of the next section; they are not considered here.

(49) Longer syllables

Herbst	[hɛɐ̯pst]	'autumn'
Obst	[o:pst]	'fruit'
eins	[ai̯ns]	'one'

The third mora is always consonantal and can be a sonorant (only word-finally), as in (50), or an obstruent, as in (51) to (53). Trimoraic syllables are also found in word-medial position, as shown by the following examples.

(50) Sonorants as the third mora

Bahn	[bɑ:n]	'railway'
Lehm	[le:m]	'clay'
Aal	[ɑ:l]	'eel'
Helm	[hɛlm]	'helmet'
Symptom	[zʏmp.to:m]	'symptom'
Daimler	[daɪ̯m.lɐ]	car brand

The obstruent can occur after a tense vowel or a diphthong, as in (51) and (52).

(51) Obstruents in the third position after a tense vowel or a diphthong

Tense vowel + fricative

Muesli	[my:s.li]	'muesli'
Wüste	[vy:s.tə]	'desert'
Kloster	[klo:s.tɐ]	'monastery'
Australien	[aʊ̯s.tʁɑ:.li.ən]	'Australia'

(52) Obstruents in the third position after a tense vowel or a diphthong

Tense vowel + stop

Adler	[ɑ:t.lɐ][20]	'eagle'
Redner	[ʁe:t.nɐ]	'speaker'

It can also appear after a lax vowel and another consonant, as in (53).

(53) Obstruents in the third position after a lax vowel plus a consonant

a. Liquid + stop/affricate

Arktis	[aʁ̯k.tɪs]	'Arctic'
Arznei	[aʁ̯ts.naɪ̯]	'medicine'
Partner	[paʁ̯t.nɐ]	'partner'

b. Nasal+stop

Symptom	[zʏmp.to:m]	'symptom'
Klempner	[klɛmp.nɐ]	'plumber'

[20] *Adler* and *Redner* have an alternative syllabification in which the medial consonant cluster is the onset of the second syllable (Giegerich 1992).

Palimpsest	[pa.lɪmp.sɛst]	'palimpsest'
Plankton	[plaŋ̯k.to:n]	'plankton'

c. Stop + fricative

abstrakt	[aps.trakt]	'abstract'
Obstruent	[ɔps.tʁu. ɛnt]	'obstruent'
extra	[ɛks.tʁɑ]	'extra'

As can be seen from the data, the third mora is not a marginal phenomenon in German and should be allowed in the phonology of the language. In this aspect, German differs from Dutch for which Kager (1989) assumes a maximal bimoraicity. Kager formulates a constraint against tripositional syllables followed by non-dentals.

Consider how some of the constraints introduced so far interact to choose the optimal syllabification of the word *Symptom*. Since both syllables in this word are trimoraic, the candidates in Tableau 11 display parallel violations or fulfillments of constraints in both syllables simultaneously. The constraint PARSE (Chapter 1), which has not been considered for German until now, but which has been assumed implicitly, since all input material appears in the optimal output candidates, is made explicit in Tableau 11. Remember that the faithfulness constraints PARSE and FILL are assumed to be undominated in German. Remember also that PARSE is parameterized: here only PARSE-seg is relevant, which requires that segments have a syllabic affiliation (see also Scobbie 1991:133 for a similar requirement in the Declarative Phonology framework). The first candidate, the optimal one, does not violate any constraint. It fulfills PARSE, since all segments belong to some syllable. It also fulfills TRIMAX and BIMOR, in being maximally trimoraic and minimally bimoraic, with no superfluous structure. Candidate b. violates PARSE, because [p] and [m] are phonetically deleted. Apart from that it does not violate any constraints shown in the tableau. PARSE and TRIMAX are not ranked since they are both undominated.

/zʏmptom/ *Symptom*	PARSE	TRIMAX	BIMOR
a. ☞ zʏ mp. t o m			
b. z ʏm<p>.t o<m>	*!*		

Tableau 11

In sum, trimoraic syllables are not totally exceptional in German, though morpheme-internal ones are not as frequent as morpheme-final ones. Trimoraicity is maximal in German: there is no syllable with four moras.

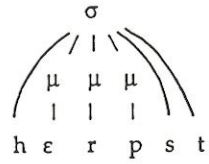
2.1.6 The Appendix

Final syllables can contain more segments than medial ones. As Borowsky (1986:165) comments:

> "It has been recognized that the possible sequences of consonants found in word-initial and word-final positions are not an altogether true reflection of the possible sequences found in syllable initial and syllable final positions in the syllable. For example, languages often allow various violations of syllable structure at word-edges - appendices. An appendix may contain a series of consonants not normally allowed in medial position, or it may contain violations of sonority restrictions, or it may contain violations on other phonotactic constraints on syllable structure." Borowsky (1986:165)

In German, appendix consonants are always coronal and nonmoraic. They are simply attached to the syllable node and are usually analyzed as extraprosodic (or extrametrical). They do not contribute to the syllable weight and do not always respect the sonority hierarchy.[21] *Herbst* 'autumn' has the structure shown in (54).

(54) Appendices



'Herbst'

It is often difficult to decide whether coronal segments in the coda of a final syllable are appendices or truly moraic. In the case of *Herbst, Papst, Obst, eins,* ... the final coronals are appendices, because they come on top of the three moras. In other cases, the segments preceding the coronals do not suffice to fill the three moraic positions. On the one hand, in a word like *Elefant* 'elephant' , the final syllable must have three moras, because it is stressed and should therefore be heavy. In a word like *Kobold* 'goblin', on the other hand, which also has two coronals in the coda of its last syllable (or at least one that can be analyzed as an appendix, since /l/ is not an appendical segment), the situation is different. The final syllable is not stressed, and it thus seems better to assume nonmoraic final coronals, i.e. appendices. Nevertheless, in the remainder of this work, two final coronals that follow a lax vowel will always be analyzed as moraic, no matter what the stress pattern is. Hence both the two final coronals of *Elefánt* and those of *Kóbold* are equally moraic.

(55)

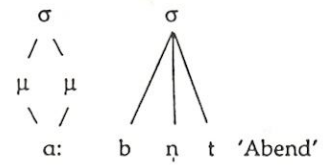
'Kobold'

[21] But see the remarks in section 2.1.1.

However, *Elefant* has a regular stress, whereas that of *Kobold* is lexically marked.

Similarly, coronals closing a schwallable can be moraic or not. It has already been proposed that they are not. A word like *Abend* [ɑ:.bn̩t] 'evening' has the structure shown in (56):

(56)



The following generalizations arise: in a syllable whose nucleus is moraic, the following segments are also moraic, up to a maximum of three, due to the limitation imposed by TRIMAX. In contrast, in a syllable whose nucleus is nonmoraic, no segment is moraic. The first generalization can be expressed by MORAICITY, which can be understood as an iterative weight-by-position phenomenon.

(57) MORAICITY
Segments in the coda of a moraic nucleus are moraic.

The second generalization expresses the fact that schwallables are totally devoid of weight. They simply do not count in the metrical structure of words. Appendical segments and codas of schwallables have the same status: they never add weight to the syllable they are attached to. It will be shown in section 2.2.1.1 that the majority of appendical segments, both in syllables with a full vowel and in schwallables, arise through inflection. In fact, all inflection is either appendical and nonsyllabic or syllabic with an added schwallable.

The existence of appendical segments has an important implication for the ranking of the constraints. TRIMAX, which limits the number of moras in a syllable to three, conflicts with MORAICITY, which forces each segment from the nucleus on to be moraic. In words like *Herbst* or *Papst*, MORAICITY says that all five segments from the nucleus on should be moraic, but TRIMAX limits the number of moras to three. It has been repeatedly shown that the

trimoraicity constraint is unviolable, thus MORAICITY must be the one that is violated. Compare the candidates in Tableau 12. Remember that PARSE-seg simply requires that segments have a syllabic or moraic affiliation, in other words, that they are phonetically realized. Candidate c. violates this constraint because the last segment [t] is not realized phonetically. All other candidates fulfill it. Candidate b. violates TRIMAX. Candidate a. wins because it only violates MORAICITY, which is lower ranked than PARSE-seg and TRIMAX.

μ | /hɛɐ̯pst/ *Herbst*	PARSE-seg	TRIMAX	MORAICITY
a. σ μ μ μ ☞ hɛʀpst			**
b. σ μ μ μμ μ hɛʀp st		*!*	
c. σ μ μ μ hɛʀps<t>	*!		

Tableau 12

A word with a schwallable is illustrated in Tableau 13. Since the nucleus of the second syllable of *Abend* is nonmoraic, all other tautosyllabic segments are nonmoraic as well. Candidate b. shows a violation of NOMOSCH. In candidate c., the last segment, being unparsed, violates PARSE. Candidate a., on the other hand, violates no constraint.

	NOMOSCH	PARSE	TRIMAX	MORAICITY
μ μ \/ / abn̩t / *Abend*				
a. σ σ /\ μ μ \/ ☞ a. b n̩ t				
b. σ σ /\ /\ μ μ μ μ \/ | | a b n̩ t	*!			
c. σ σ /\ μ μ \/ a b n̩ <t>		*!		

Tableau 13

2.1.7 Special consonant clusters

Finally, to close the discussion on the syllabification of German monomorphemes, consider the following words.

(58)

Adler	'eagle'	[(ɑ:.dlɐ)$_{Ft}$]$_{PW}$ or	[(ɑ:t/d.lɐ)$_{Ft}$]$_{PW}$
Ordner	'file'	[(ɔ̯ɐ̯.dnɐ)$_{Ft}$]$_{PW}$ or	[(ɔ̯ɐ̯t/d.nɐ)$_{Ft}$]$_{PW}$
Kadmium	'cadmium'	[(ká.dmium)$_{Ft}$]$_{PW}$ or	[(kát/d.mium)$_{Ft}$]$_{PW}$
Magma	'magma'	[(má.gma)$_{Ft}$]$_{PW}$ or	[(mák/g.ma)$_{Ft}$]$_{PW}$
Leibniz, Wagner		[(vɑ:.gnɐ)$_{Ft}$]$_{PW}$ or	[(vɑ:k/g.nɐ)$_{Ft}$]$_{PW}$
Handlung	'action'	[(hán.dluŋ)$_{Ft}$]$_{PW}$ or	[(hánt/d.luŋ)$_{Ft}$]$_{PW}$

Only the last of these words is a complex one; all others are monomorphemic. In these words, an obstruent precedes a sonorant. In the reverse case, if a sonorant precedes an obstruent as in the words in (59), the sonorant is the coda of the first syllable, and the obstruent the onset of the

second syllable, as predicted both by the sonority hierarchy and the Contact Law of Vennemann (1988:40).[22]

(59)

Partei	[paɐ̯.táj]	'party'
Alto	[ál.to·]	'alto'

The interesting words are those listed in (58). The medial consonant clusters are the subject of a paper by Giegerich (1992) in which he makes a distinction between Standard German, with the consonant cluster as the onset of the second syllable (first option in (58)), and Colloquial German, in which the syllable boundary lies in the middle of the consonant cluster (second option in (58)). However, as Vater (1992:105) also comments, the individual intuitions and realizations of these words vary considerably.

Regardless of the correctness of the distinction between Standard and Colloquial German, the variable syllabification of these words shows that inside a foot, syllables are not as clear-cut (or 'crisp' to use a term coined by Itô & Mester 1994) as at the foot boundaries (see also section 2.2.2, and Chapter 4 for various phonological alternations taking the foot as their domains).

The following section considers the syllabification in complex words.

2.2 Syllable structure of complex words

In this section, the constraints responsible for the syllabification of complex words are reviewed. Since at least two morphemes are involved, two cases must be distinguished: either syllabification takes place across morpheme boundaries or it does not. In the following cases it does:

- inflectional suffixation
- vowel-initial derivational suffixation

[22] 'A syllable contact A$B is the more preferred, the less the Consonantal Strength of the offset A and the greater the Consonantal Strength of the onset B; more precisely – the greater the characteristic difference CS(B) – CS(A) between the Consonantal Strength of B and that of A.'

And in the following cases it is blocked:

- consonant-initial derivational suffixation
- compounding
- prefixation

Prefixation and compounding will be inspected in sections 2.2.2 and 2.2.3, respectively. They are relatively straightforward, though it will be shown that some cases involve optional syllabification across morpheme boundaries. Suffixation, however, which is examined in section 2.2.1, requires more attention.

2.2.1. Suffixation

Suffixation can be inflectional or derivational. Inflection is considered first.

2.2.1.1 Inflection

Inflection can be syllabic or non-syllabic. It is the only morphological operation that can be non-syllabic, in the sense that it does not necessarily add a syllable but only segments to the stem it adjoins to. There are two conflicting trends in the German syllable (as in other languages): the first one is to keep the syllables as small as possible. Algorithms that build syllables from the segment string, like those proposed by Kahn (1976), Steriade (1982), Clements & Keyser (1983), Borowsky (1986), Kager (1989) and Sloan (1992) for English and Dutch and Giegerich (1985), Wiese (1988), Hall (1992a) and Yu (1992) for German, often distinguish two levels of syllabification. At a first stage, the 'core' syllable is formed (corresponding in earlier models to the nucleus), which consists of two positions, the most sonorous one (the syllable peak) and the immediately following one, thus restricting this first syllable to two positions, skeletal or moraic. The second trend consists in realizing all input segments from the stem or inflectional suffixes in order to satisfy FILL. Thus, it is often proposed that at a later stage, level-2 syllabification, the remaining segments are adjoined. Non-syllabic inflectional suffixes are appendices, i.e. peripheral segments added at the right edge of the final syllable. Since the appendical segments do not count

for the weight of the syllable, they are also extrametrical. Thus, in German, appendicality and extrametricality amount to the same thing. They apply to coronal segments which come from the stem or from a suffix, which are not part of the core syllable and which are, consequently, nonmoraic. It will be shown shortly how Optimality Theory accounts for inflectional suffixes, but let us first take a look at the data.

The list (60) shows some inflectional suffixes which consist of appendical coronal segments.

(60) Non-syllabic inflectional suffixes

a. Genitive singular

Tor-s	'gate'
Stuhl-s	'chair'
Ara-s	'parrot'

b. Plural inflection

Auto-s	'cars'
Film-s	'movies'

c. 3rd pers. sg. of the present tense

lach-t	'laughs'
schwimm-t	'swims'

d. 2nd pers. sg. of the present tense

lach-st	'laugh'
schwimm-st	'swim'

e. superlative

schön-st	'most beautiful'
klar-st	'clearest'

With the exception of plural inflection, which is largely lexicalized anyway, all these suffixes have syllabic allomorphs, though the conditions for their allomorphy vary. For instance, the nominal genitive singular suffix *-s* is obligatorily replaced by *-es* if the stem itself ends in [s], as illustrated in (61a). In fact, even when the stem ends with some other consonant, the genitive singular suffix is optionally *-es*, except when the stem's final syllable is unstressed. This restriction can be explained by the fact that German prefers trochaic feet to any others and avoids creating a dactylus whenever possible (Eisenberg 1991, Féry 1991). (61b) illustrates the 3rd person of the present

tense. There is no optionality here: the suffix *-t* is replaced by *-et* when the stem ends with a coronal stop ([t] or [d]). As for the superlative, the suffix *-st* becomes *-est* when the stem ends with a coronal obstruent ([t, d, s, z, ʃ]) (see Wurzel 1970:172-176 for a detailed account of these alternations).

(61) Syllabic allomorphs of nonsyllabic inflectional suffixes

a. Genitive singular

Mumpitz-es	'nonsense'
Ereigniss-es	'event'
Hut-(e)s	'hat'
Tor-(e)s	'gate'
König (*e)s	'king'
Atem (*e)s	'breath'

b. 3rd pers. sg. of the present tense

red-et	'talks'
bad-et	'bathes'

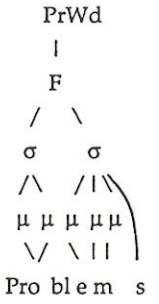
c. superlative

röt-est	'reddest'
heiß-est	'hottest'

Even though the last syllable of inflected words like *des Ara-s* 'of the parrot' (*des Auto-s* 'of the car', *des Album-s* 'of the album'...) looks as if it were trimoraic, it is in fact bimoraic, as shown in (62a). All nonsyllabic inflectional suffixes consist of coronal segments and they are added to syllables which can be trimoraic, as shown in (62b). Stress is not affected by the addition of inflections.

(62) a.

b.



Next consider the syllabic inflections: they are either allomorphs of nonsyllabic inflections (as in (61)) or intrinsically syllabic. In both cases, they add a syllable to the stem they attach to. Syllables added through inflection are always schwallables and thus unstressed. They are syllabified with the stem. Some examples of syllabic inflection are given in (63).

(63) Syllabic inflection

a. Dative plural

Tisch-en [n̩]	'tables'
Hund-en [n̩]	'dogs'
Motor-en [n̩]	'motors'

b. Infinitive, also 1st pers. pl. and 3rd per. pl.

lach-en [n̩]	'to laugh'
segel-n [l̩n]	'to sail'
mäh-en [n̩]	'to mow'

c. Nom. sg. fem, also acc., weak neuter, masc, fem nom., acc. sg.

schön-e [ə]	'beautiful'
blau-e [ə]	'blue'
grob-e [ə]	'gross'

d. Nom sg. masc, strong, also gen., dat, fem, comparative

schön-er [ɐ]	'beautiful'
blau-er [ɐ]	'blue'
grob-er [ɐ]	'rough'

e. Dative neuter or masc.

bös-em [m̩]	'naughty'
schön-em [m̩]	'beautiful'

Obviously, many inflectional suffixes add a syllabic [n], [ɐ], [m] or [s].[23] Some others just add a schwa, like the adjectival feminine nominative singular (63c), the first person singular of the present tense, and other adjectival and nominal forms (including plural inflection). The syllabification of these inflectional suffixes does not differ from that of the stem schwallables discussed in section 2.1.3. They obey the constraint NOMOSCH that forces them to be nonmoraic.

Two inflectional affixes can occur in a row: if they are both syllabic, as illustrated in (64), the result is two nonmoraic syllables at the end of the form. Hence, three schwallables can be concatenated if the stem itself ends in a schwallable, as in the second example in (64a). Again, the syllabification of these forms does not differ from the stem's syllabification. All schwallables fulfill NOMOSCH.

(64) Sequence of syllabic inflections

a. Comparative + inflection, e.g. nom. fem.

schön-er-e	'more beautiful'
trocken-er-e	'drier'

b. Syllabic perfect inflectional suffix + 1st or 3rd pers pl.

red-et-en	'spoke'
kost-et-en	'cost'

In Optimality Theory, some constraint must be made responsible for the nonmoraicity of all inflectional suffixes. In nonsyllabic inflection, the morpheme boundary – indicated by | in (65) – is located in the middle of a syllable and is often a moraic boundary:

(65) Tor|s
schön|st

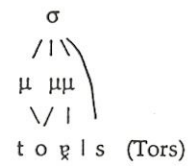
Nonmoraicity can simply be imposed on inflectional suffixes by a special constraint:

[23] See Chapter 4 for an account of the syllabic sonorant in verbs like *segeln* 'to sail', *wandern* 'to hike', etc.

(66) NOMOINFL (Nonmoraic inflection)
Inflectional suffixes are nonmoraic.

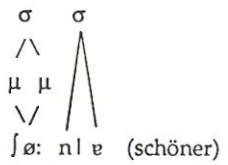
The consequence of this undominated constraint is that all inflectional suffixes, whether syllabic or non-syllabic, are nonmoraic. The difference between the two types of inflection is that some inflectional suffixes are appendices, whereas others form a syllable, as shown in (67) and (68).

(67)



(Tors)

(68)



(schöner)

Another constraint, ALIGN-R is responsible for the syllabification across stems and suffixes; it is always violated in inflection, which will be illustrated in the next subsection.

2.2.1.2 Derivation

Derivation is always syllabic. It is slightly more complex than inflection, because derivational suffixes can begin with a vowel or a consonant, and they can be stressed or not. In this chapter, only syllabification is considered. Stress in complex words is examined in Chapter 4.

As in McCarthy & Prince's (1993a) account of Axininca Campa, the following cases can be distinguished according to the nature of the segments at the edge of the morphemes involved: either the stem ends with a vowel and the suffix begins with a vowel (69a) or a consonant (69b); or the stem ends with a consonant and the suffix begins with a vowel (69c) or a consonant (69d).

(69) a. V + V: Böe/bö-ig 'gust (of wind)/squally'
Ruhe/ruh-ig 'peace/peaceful'
sto-isch 'stoic'
Prosa/prosa-isch 'prose, prosaic'
b. V + C: froh/fröh-lich 'gay/gaily'
roh/Roh-heit 'raw/rawness'
c. C + V: Kind/kind-isch 'child/childisch'
Tat/tät-ig 'act/active'
polar/Polar-ität 'polar/polarity'
d. C + C: faul/Faul-heit 'lazy/lazyness'
Geld/geld-los 'money/moneyless'

When two vowels come together, as in (69a), each one is the nucleus of a different syllable (compare these words with *Fleisch* [flaiʃ] 'meat' and *keusch* [kɔɣʃ] 'chaste', in which the same sequences of segments constitute diphthongs).[24] As in Axininca Campa, diphthongization of two heteromorphemic vowels is not a possible option. In German, as in other languages, there is a violable constraint ALIGN-R (Prince & Smolensky 1993, McCarthy & Prince 1993a) which says that the right edge of a stem, a morphological constituent, must coincide with the right edge of a syllable, a prosodic constituent.

(70) ALIGN-R
Align (Stem, Right, Syllable, Right)
The right edge of every stem coincides with the right edge of some syllable.

The effect of this constraint is visible in the words under (69a), like *ruhig* [ʀu:.ɪç] and *böig* [bø:.ɪç], in which the two vowels belong to different syllables.

In V + C (69b) and C + C (69d), syllabification also satisfies ALIGN-R. The morpheme boundary is at the same time a syllable boundary.

In the C + V cases (69c), however, morpheme boundary and syllable boundary do not coincide: 'resyllabification' applies. This is easily captured by the constraints ALIGN-R and ONSET if the dominance relation of these two

[24] We owe these examples to Hubert Truckenbrodt.

constraints is as in Tableau 14: ONSET dominates ALIGN-R and forces syllables to have onsets.

/tät-ig/'act-ive'	ONSET	ALIGN-R
☞ tä.t l ig		*
tät l .ig	*!	

Tableau 14

The same constraint ranking is responsible for the syllabic inflection of the preceding section in which syllabification across a morpheme boundary is involved, too; compare the following tableau:

/schön-n̩/ 'beautiful-infl'	ONSET	ALIGN-R
☞ schö.n l n̩		*
schön l .n̩	*!	

Tableau 15

When the inflectional suffix consists of consonants only, ONSET has no effect, and ALIGN-R is violated anyway. The only conceivable candidate that does not violate ALIGN-R is one involving a violation of PARSE. But this constraint dominates ONSET, as shown in Tableau 16, and its violation is always fatal.

/schön-st/ 'beautiful-infl'	PARSE	ONSET	ALIGN-R
☞ .schön l st.			*
.schön l .<st>	*!		

Tableau 16

In all other cases of suffixation, ONSET has no effect: either there is no segment which can serve as an onset to the second syllable (69a), or there is already one in the suffix (69b,d).

As far as syllabification is concerned, suffixation in German has the same properties as it has in Axininca Campa. ALIGN-R is only violated in case the suffix begins with a vowel and the stem has a final C; otherwise, syllabification across morpheme boundary is avoided. In some cases, as in

the much described constrast between *Handlung* 'act' and *handlich* 'handy'(Rubach 1989, Giegerich 1992, Yu 1992), the effect of ALIGN-R can be made audible in clear speech. In this case [d] in *handlich* will be more readily devoiced than in *Handlung*, since the stem boundary in the former is before the [l], whereas it is after the [l] in the latter word. However, it is questionable whether the distinction is ever made in connected speech.

In sum, syllabification across morphemes applies if either the suffix consists of consonants only (nonsyllabic inflection) or the stem ends in a consonant and the suffix begins with a vowel or a syllabic sonorant (derivation or syllabic inflection). In all other cases, no syllabification across morphemes applies.

2.2.2 Prefixation

Prefixation always introduces a 'crisp' syllable boundary between the right edge of the prefix and the left edge of the stem. No syllabification across morpheme boundaries is possible in this context. A constraint, ALIGN-L, controls the syllabification of prefixation. It forces the left edge of a foot to coincide with the left edge of a syllable boundary.

(71) ALIGN-L
Align (Foot, Left, Syllable, Left)
The left edge of every foot coincides with the left edge of some syllable.

This constraint is stronger than the one that aligns the right edge of a stem with a syllable boundary. It is undominated, in particular by ONSET, so that even in a sequence consisting of a prefix's final C and a stem's initial V, there is a syllable boundary between the two morphemes. A 'crisp' syllable edge before a vowel is signalized by a glottal stop (Moulton 1962:142 describes it as an allophonic variant of a vowel before an open juncture). Thus, the word *beantworten* 'to answer' is realized as in (72a). Possible configurations are listed and illustrated in (72).

(72)	a. V + V:	be-ántworten	[bə.ʔant.vɔɐ̯.tn̩]	'to answer'
		ge-ángelt	[gəʔ.aŋlt]	'fished',

		ver-öden	[fɐ.ʔø:.dn̩]	'to become deserted'
	b. V + C:	be-téiligen		'to take part'
		ge-tánzt		'danced'
		ver-tílgen		'to devour'
	c. C + V:	ún-echt	[ʊn.ʔɛçt]	'unreal'
		wég-erklären	[vɛk.ʔɛɐ̯.kle:.ʁn̩]	'to explain away'
		Án-ordnung	[ʔan.ʔɔɐ̯dnʊŋ]	'order'
	d. C + C:	ún-treu		'unfaithful'
		ín-tolerant		'intolerant'
		éin-treten		'to go in'

It remains to be explained why the foot is involved in ALIGN-L, and not the stem or the the Prosodic Word. Prosodic Words have crisp edges, as illustrated by the examples from McCarthy & Prince (1993b:47) in (73).

(73)	bergab	'downhill'	[(.bɛʁk.)$_{Ft}$]$_{PW}$ [(ʔáp.)$_{Ft}$]$_{PW}$
	aufessen	'to eat up'	[(.ʔáʊ̯f.)$_{Ft}$]$_{PW}$ [(ʔɛ̀sn̩.)$_{Ft}$]$_{PW}$
	verirren	'to lose one's way'	[(.fɐ.)$_{Ft}$]$_{PW}$ [(ʔɪʁn̩.)$_{Ft}$]$_{PW}$
	Zollamt	'customs office'	[(.tsɔ́l.)$_{Ft}$]$_{PW}$ [(ʔàmt.)$_{Ft}$]$_{PW}$

In these examples, a glottal stop is inserted before the second morpheme's initial vowel, indicating at least the left edge of a new Prosodic Word word-internally. But, as shown in (74), not only the left Prosodic Word boundary triggers Glottal Stop Insertion, but also the left foot boundary, since the words in (74) are monomorphemic and consist of one Prosodic Word. *Chaot* 'anarchist' and *Ruin* 'ruin' have a glottal stop before their stressed vowel, whereas the hiatus in *Fluor* 'fluorine' and *Museum* 'museum' takes place inside a foot and is not released by a glottal stop.

(74)	a.	Ruin	'ruin'	[(ʁu:.)$_{Ft}$ (ʔí:n)$_{Ft}$]$_{PW}$
		Chaot	'anarchist'	[(kɑ:.)$_{Ft}$ (ʔó:t)$_{Ft}$]$_{PW}$
		Theater	'theater'	[(te:.)$_{Ft}$ (ʔá:.tɐ)$_{Ft}$]$_{PW}$
	b.	Fluor	'fluorine'	[(flú:.ɔʁ)$_{Ft}$]$_{PW}$
		Museum	'museum'	[(mu:.)$_{Ft}$ (zé:.ʊm)$_{Ft}$]$_{PW}$

The clear syllable, foot and Prosodic Word boundaries of (73) and (74a) contrast with blurred syllable edges within a foot, as in (74b) and (58), repeated here for convenience.

(58)	Adler	'eagle'	[(ɑ:.dlɐ)$_{Ft}$]$_{PW}$	or	[(ɑ:t/d.lɐ)$_{Ft}$]$_{PW}$
	Ordner	'file'	[(ɔ$_{\underline{ɐ}}$.dnɐ)$_{Ft}$]$_{PW}$	or	[(ɔ$_{\underline{ɐ}}$t/d.nɐ)$_{Ft}$]$_{PW}$
	Kadmium	'cadmium'	[(ká.dmiʊm)$_{Ft}$]$_{PW}$	or	[(kát/d.miʊm)$_{Ft}$]$_{PW}$
	Magma	'magma'	[(má.gma)$_{Ft}$]$_{PW}$	or	[(mák/g.ma)$_{Ft}$]$_{PW}$
	Leibniz, Wagner		[(vɑ:.gnɐ)$_{Ft}$]$_{PW}$	or	[(vɑ:k/g.nɐ)$_{Ft}$]$_{PW}$
	Handlung	'action'	[(hán.dlʊŋ)$_{Ft}$]$_{PW}$	or	[(hánt/d.lʊŋ)$_{Ft}$]$_{PW}$

Native speakers do not agree on the syllabification of these words: according to some phonologists (Vennemann 1992:404, for example), the medial syllable boundary is located before the consonant cluster, in which case the onset of the second syllable is exceptional, because it does not correspond to a permitted PW-initial onset; for other authors (e.g., Kloecke 1982, Giegerich 1992, Yu 1992), the syllable boundary is located either before or in the middle of the consonant cluster, in the latter case the voicing of the stop would be an exception to Final Devoicing, which, according to most German phonologists (following Vennemann 1972), takes place before a syllable boundary.[25] As a matter of fact, Final Devoicing applies in the speech of some, but not all, speakers, and is subject to variation even in the speech of one and the same speaker. Aspiration of the stop, which optionally goes with Final Devoicing, never takes place foot-internally.

Thus, syllable boundaries at the foot boundary are always well defined and crisp, but inside a foot the syllabification varies. Crisp syllable boundaries are the domain of Glottal Stop Insertion and Final Devoicing, whereas at blurred syllable boundaries Glottal Stop Insertion is blocked and Final Devoicing applies only optionally.

For these reasons, it must be the foot edge, not the Prosodic Word or the stem, which is responsible for the crisp syllable edge. Since prefixes and

[25] Giegerich (1992) distinguishes between Colloquial German, in which the syllable boundary lies in the middle of the consonant cluster (*A[t].ler, Wei[t].ner*), and Standard German, with the consonant cluster as the onset of the second syllable (*A.[d]ler Wei.[d]ner*).

stems define at least different feet, prefixation in German always involves a syllable boundary between the prefix and stem.

Some prefixed forms have two possible pronunciations, one corresponding to the description given above, the other involving resyllabification across prefix and stem. An example is given in (75). However, this behavior is limited to highly lexicalized words.

(75) un. ?abhängig/u.nabhängig 'independent'

In the second pronunciation of *unabhängig*, the prefix forms a foot with the first syllable of the stem. Thus, it is not a true exception to (69) because German speakers do not always interpret this word as complex.

2.2.3 Compounding

Compounds require crisp syllable boundaries, too. Each member of a compound forms its own feet and Prosodic Word, which are domains for syllabification. No syllabification across morpheme boundaries is possible here, even in highly lexicalized words. Some examples of compounds are given in (76).

(76)	a. V + V:	Roh-öl	[ʀó:.øl]	'crude oil'
		Nah-Ost	[ná:.ɔst]	'Middle East'
	b. V + C:	Stroh-mann	[ʃtʀó:.man]	'front man'
	c. C + V:	Leer-element	[lé:$_{\underline{ɐ}}$.elemɛnt]	'empty element'
	d. C + C:	Blick-feld	[blɪ̈k.fɛlt]	'field of vision'
		Ozon-loch	[o.tsó:n.lɔx]	'hole in the ozone layer'

The unviolable constraint ALIGN-L (71) accounts for the syllabification of compounds, too.

We have thus seen that, as far as syllabification is concerned, prefixation and compounding behave in the same way: both introduce crisp syllable boundaries. Suffixation, on the other hand, sometimes implies resyllabification and sometimes not. Inflection always does, whereas

derivation involves resyllabification only when the stem ends with a consonant and the suffix begins with a vowel.

2.3 Conclusion

In this chapter, the foundations for the following chapters have been laid. The syllable structure has been examined from different points of view: the sonority hierarchy, the number of moras and syllabification. The most important aspect of syllable theory for the rest of this work is the number of moras, since it determines syllable weight. German syllables can be non-, bi- or trimoraic. Syllables with a schwa or a syllabic sonorant as nucleus are nonmoraic; their nonmoraicity makes them unstressable. Open syllables and those consisting of a lax vowel plus a consonant are bimoraic; they make up the default case, the unmarked syllable. However, as will be shown in the next chapter, they differ as far as their weight is concerned: true closed syllables are heavier than open syllables or those closed by an ambisyllabic consonant. Finally, syllables consisting of a tense vowel followed by a consonant, or of a lax vowel followed by two consonants are trimoraic; these syllables are heavy since they attract stress and they are generally, although not exclusively, found in word-final position. Moreover, word-final coronals, called appendices, can be added to all kinds of syllables; they are extrametrical and do not play any role in the syllable's weight.

Another aspect of syllable theory which is of relevance for the later chapters is syllabification across morpheme boundaries. 'Resyllabification' is restricted to some well-defined cases: inflectional and vowel-initial derivational suffixation. In all other cases (prefixation, consonant-initial derivational suffixation and compounding) separate syllabification domains are defined for each morpheme.

The OT framework accounts for all the aspects of syllable structure just mentioned in an elegant way. For instance, the bimoraicity generalization expressed by the violable BIMOR is a powerful constraint in German. Maximal trimoraicity is rendered by an unviolable constraint TRIMAX. Ambisyllabicity is a natural consequence of the interaction of three independently needed constraints, BIMOR, NOCODA and ONSET. More

specifically, we have introduced several constraints that play a role in the syllabification of German words. They are listed in (77).

(77) a. Undominated constraints
FILL, PARSE, NUC, VOCNUC, TRIMAX, NOMOSCH, ALIGN-L, NOMOINFL
b. Dominated constraints
ONSET, NOCODA, BIMOR, SON, HNUC, ALIGN-R, MORAICITY

Four different components have been examined, which require their own ranking. First the sonority properties. The undominated constraints require that each syllable has a syllabic nucleus (NUC), and that each vowel is the nucleus of some syllable (VOCNUC). It has been shown that HNUC, a constraint to the effect that the most sonorous segment is the syllabic nucleus, is violable in German: it is crucially violated by a word like *Polen*, whose second nucleus /n/ is less sonorous than its onset. Finally, SON is also violable, although the details of the sonority hierarchy violations have not been examined.

(78) Sonority
NUC, VOCNUC >> ONSET >> HNUC, SON

Second, the number of moras in each syllable. We have found that German syllables are maximally trimoraic (TRIMAX), though the unmarked number of moras found in a syllable is two (BIMOR). Schwallables are nonmoraic (NOMOSCH). Ambisyllabicity is forced in syllables whose rhyme would otherwise consist of an unchecked lax vowel. This is ensured by the ranking of ONSET and BIMOR above NOCODA.

(79) Moraic composition
TRIMAX, NOMOSCH >> ONSET, BIMOR >> NOCODA

Third, the moraicity or nonmoraicity of individual segments. Each segment is phonetically realized: there is no deletion of segments. This is guaranteed by undominated PARSE. There is no epenthesis, neither: FILL is undominated,

too.[26] However, the trimoraic maximum (TRIMAX) can force appendical segments to be nonmoraic. This is caused by the domination of TRIMAX over MORAICITY, the constraint requiring that the stem's codaic segments are moraic. Moreover, NOMOINFL, the constraint forcing the nonmoraicity of inflectional segments, is undominated.

(80) Moraicity of the segments

FILL, PARSE, NOMOINFL, TRIMAX >> MORAICITY

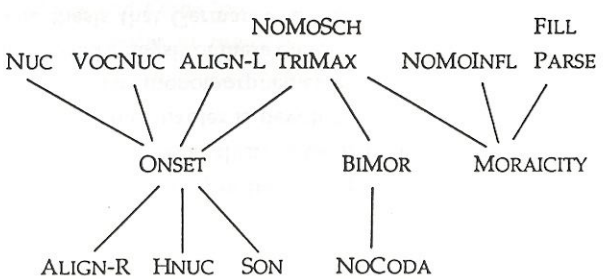
Fourth, the syllabification across morpheme boundaries. This is expressed by only two Align constraints. Affixation is always peripheral in German. The left edge of a stem always coincides with the left edge of a syllable, which means that there is no resyllabification between prefixes and stems or between two members of a compound (undominated ALIGN-L). Suffixation, on the other hand, can trigger resyllabification between a stem and a suffix if the stem ends with a consonant and the suffix begins with a vowel (ONSET >>ALIGN-R).

(81) Syllabification across morphemes

ALIGN-L >> ONSET>> ALIGN-R

The following partial ranking is thus active in German.

(82)



[26] The status of the foot-initial nonphonemic glottal stop in German is unclear. We do not consider it as a true epenthetic segment, but it deserves more study. See Chapter 4 for a context of its emergence.

The next chapter is devoted to stress assignment in monomorphemic words. The results of this chapter are largely confirmed by the stress pattern.

Chapter 3
Foot formation and stress pattern in monomorphemes

This chapter gives a survey of the stress patterns in monomorphemic words. After a short rule-based analysis of German lexical stress in the first section (3.1), the rest of the chapter is devoted partly to an overview of the stress pattern of German monomorphemes and partly to the development of a constraint-based analysis of these data.

The thesis that German is a quantity-sensitive language is largely confirmed (sections 3.2.1, 3.3.1, 3.4.1), and so are Vennemann's (1992) German stress rules, if we slightly modify his Penult Rule (section 3.3.2.1). It was demonstrated in Chapter 2 that syllables with a full vowel are either bimoraic or trimoraic. All kinds of bimoraic syllables are expected to have the same weight. However, as far as stress is concerned, bimoraic syllables with their own closing consonant (i.e., true CVCs) are heavier than open syllables or syllables that are closed by an ambisyllabic consonant. Trisyllabic words with a true CVC penult are stressed on the penult (or on the final syllable if it is trimoraic), whereas words with an open or ambisyllabic penult can have stress on the first syllable. The same difference exists in Dutch, various accounts of which have been offered in the literature (f.i. by Lahiri & Koreman 1988 and Kager 1989). In section 3.3.2.1 a new solution is proposed for German that retains the bimoraicity generalization: moraic segments can 'lose' a mora, as long as this does not imply a segmental loss. Thus, moraic segments that still have a moraic or syllabic affiliation can lose a mora in an unstressed syllable. A vowel, bimoraic from the point of view of syllable structure, is then monomoraic for stress, and an ambisyllabic consonant, moraic from the syllabic point of view, becomes nonmoraic. This approach combines proposals of Lahiri & Koreman, Kager and Hayes (1995).

For the most part, the optimality-theoretic account of German stress to be developed in sections 3.2.2, 3.3.2.2 and 3.4.2 uses well-known constraints like FOOT-BINARITY, FOOT-FORM (TROCHAIC), ALIGN-HEAD, etc. The advantage of Optimality Theory over a rule-based analysis of lexical stress lies in the fact that the foot structure is derived at once, in one step, and its well-formedness is evaluated by a series of universal constraints, instead of

being constructed by an iteration of directional foot formation rules. Furthermore, in the Optimality Theory framework, there is no need for repair devices, like defooting, refooting, stress deletion and the like, which tend to make traditional metrical analyses less attractive. However the main advantages of the OT approach over former ones is that no distinction between native and non-native vocabulary is needed for the German stress pattern, and that monomorphemes and complex words are accounted for by the same constraints.

3.1 A rule-based analysis of German word stress

In terms of traditional metrical theory and a combination of proposals by Liberman & Prince (1977), Kiparsky (1979), Selkirk (1980, 1984), Hayes (1980, 1982, 1995), Prince (1983), Halle & Vergnaud (1987), Trommelen & Zonneveld (1993) and others, German metrical structure has the following properties:

(1) a. Each syllable projects an asterisk on line 0.
b. Final syllables are extrametrical (lexically marked).
c. Some syllables have lexical stress. They project an asterisk on line 2.
d. A trimoraic syllable projects an asterisk on line 1 (quantity-sensitivity).
e. Line 0 parameter setting: bound left-headed feet, right-to-left. Heads are located on line 1.
f. Line 1 parameter setting: unbound, right-headed, and heads are located on line 2.

Each content word has a metrical structure with one prominent syllable (culminativity) and rule (1a) posits that each syllable participates in the metrical structure. German is a quantity-sensitive language; this is expressed by (1d). But only trimoraic syllables are intrinsically heavy and get a mark on line 1 (stress-by-weight). Otherwise, stress is determined by rules. First, (1e) says that feet are constructed on the syllable string: a trochaic foot is erected

on two consecutive syllables (stress-by-position).[1] This property of forming trochees is crucial for German (and for English, Dutch, etc.; see, e.g., Dresher & Lahiri 1991, Hayes 1995, and Vennemann 1992). Second, if two or more syllables in a word have a stress by (1d) or (1e), the rightmost one gets an additional beat, and thus the main word stress: this is the so-called Right-End Rule (Prince 1983) expressed in (1f).

The following examples illustrate these rules.

(2)

```
    * * *
a. Albino

b. _
c. _
d. _

   * *
  (*) (* *)
e. Al bino

     *
   (*  *)
  (*) (* *)
f. Al bino
```

(3)

```
    * *          Line 0
a. Kürbis

b. _
c. _
d. _

     *           Line 1
  ( *  *)        Line 0
e. Kürbis

     *           Line 2
  ( *)           Line 1
  ( *  *)        Line 0
f. Kürbis
```

Albino 'albino' and *Kürbis* 'pumpkin' have no extrametricality and no lexical stress. They consist of bimoraic syllables only. Regular rules of foot formation (1e and f) and head location determine their stress patterns.

(4)

```
    * *
a. Tarif

b. _

c. _
```

(5)

```
    * * *        Line 0
a. Elefant

b. _

c. _
```

[1] But two nonmoraic syllables cannot form a trochee.


```
     *           Line 1
   * * *         Line 0
d. Elefant
   * *           Line 1
  (* *) (*  )    Line 0
e. Ele fant

     *           Line 2
   (*  *)        Line 1
  (* *) (*)      Line 0
f. Ele fant
```

In *Tarif* 'charge' and *Elefant* 'elephant' the last syllable is trimoraic and, following (1d), this syllable projects an asterisk on line 1 before the foot formation rules apply, which must then respect this asterisk.

(6)

```
    * * *        Line 0
a. Firlefanz

   * * <* >      Line 0
b. Firlefanz

c. _
d. _

     *           Line 1
  (* *) < *>     Line 0
e. Firle fanz

     *           Line 2
   (* )          Line 1
  (* *) < *>     Line 0
f. Firle fanz
```

The last syllable of *Firlefanz* 'frippery' is trimoraic and should project a grid position on line 1. But it does not. This is explained by lexically driven last

syllable extrametricality, as formulated in (1b). If the last syllable is extrametrical, it is ignored by the stress rules (Hayes 1982:227). The first two syllables form a left-headed foot, as required by (1e) and (1f).

(7)		(8)	
	* * *		* * Line 0
	a. Ameise		a. Partei
	b. _		b. _
	*		* Line 2
	*		* Line 1
	* * *		* * Line 0
	c. Ameise		c. Partei
	d. _		d. _
	*		* Line 2
	*		* * Line 1
	(* *) *		(*) (*) Line 0
	e. Amei se		e. Par tei
	*		* Line 2
	(*)		(* *) Line 1
	(* *) *		(*) (*) Line 0
	f. Amei se		f. Par tei

Some stresses are unpredictable and must be lexically prespecified ('top-to-bottom stress': Hayes 1995), as in *Ameise* 'ant' and *Partei* 'party'. Since schwallables are nonmoraic (Chapter 2), they are too light to be the head of a foot. In *Ameise* (7) the last syllable is not metrified. Words with final stress on a bimoraic syllable, like *Partei* in (8), are exceptional. According to a proposal first made by Hayes (1982:239) for English, such words have a lexically driven foot structure.

A further property of German monomorphemic stress has not been listed in (1) because it can be derived from other properties: apart from a handful of exceptions, the stress in words with a final schwa goes to the

penultimate syllable. Schwa syllables nearly always form a syllabic trochee with the preceding syllable, and, since this is the last foot, it automatically gets the main stress (see also Vennemann 1986, 1992 and Jessen 1994).

The foot formation rule (1e) creates a secondary stress on the first syllable. This is a welcome consequence, because the secondary stress is phonetically realized.

The goal of this chapter is twofold. First of all, the predictions made by (1) must be verified. For this purpose, a large database of German words called CELEX was searched. CELEX was developed at the Max-Plank-Institute for Psycholinguistics in Nijmegen. The September 1993 version of CELEX, which is used here, contains about 52,000 monomorphemic, derived and composed words. The information used consists of the orthographic list, the phonetic transcription and the accent pattern. In taking CELEX as the source of our investigation we do not aim at exhaustivity; but we do have a large coverage.

The list was purged of proper names (the stress pattern of which is often deviant from other words: see Möller 1986), derivations, compounds, occasional mistakes and redundancies. Whenever there was doubt as to whether a given word was really monomorphemic or a German word at all, it was rejected – except in finally-stressed words containing three or more syllables, because in these cases the uncertainty of their status as monomorphemic or complex words is systematic. Some examples are *Allergíe* 'allergy', *Dokumént* 'document', *Frikassée* 'fricassee', *Gouvernéur* 'governor', *Kompromíß* 'compromise', *Manifést* 'manifesto', etc., the last syllable of which can be analyzed as a suffix, although the stem is not a free morpheme (Marchand 1969, Selkirk 1982, Inkelas 1989, Fleischer & Barz 1992). The final list may still contain too many words of French origin, as well as obsolete or very rare words; but although the correction of the initial list took a long time, it was rewarding since the resulting list is relatively reliable. Of course, all exact numbers given here are to be taken with a grain of salt, though we are confident that the proportions conform to reality (if such a thing exists).

It must also be pointed out that common nouns are over-represented in the final list. Verbs usually come with one or more inflectional affixes and have thus had to be discarded. As for adjectives, they are simply less numerous than nouns. Furthermore they are often monosyllabic or disyllabic

with a final schwa syllable. These words have a predictable stress and have thus not been taken into consideration. Prepositions, determiners, conjunctions and the like are usually monosyllabic, or occasionally disyllabic with a final schwa syllable, and the same remark applies to them.

The second task undertaken in this chapter is to replace the rules in (1) with an optimality-theoretic account of the German lexical stress pattern.

The following sections investigate di-, tri- and quadrisyllabic words in turn. Each section first gives an overview of the data and then an OT account of the stress pattern.

3.2 Disyllabic words

3.2.1 Survey of data

In CELEX the list of disyllabic German words consists of 11,900 items: 10,260 have their main stress on the first syllable and 1,640 have it on the second syllable. Having eliminated all compounds, proper names, derived words (most of which have an unstressed suffix), and some redundancies (like words listed with two orthographies), there remain around 2,500 monomorphemic disyllabic words with main stress on the first syllable and 918 with main stress on the second syllable. Of the former 2,500 words, there are approximately 1,930 monomorphemic words with a schwa in their second syllable, which are not considered here, since their stress pattern is predictable. The remaining 577 words stressed on the first syllable and 918 words with stress on the second syllable are the objects of this section. (9) gives an overview of how disyllabic words are divided into initially- and finally-stressed.

(9) Disyllabic monomorphemes

	full vowel in 2nd syllable	schwa in 2nd syllable
stress on the 1st syllable (σ́σ)	577	approx. 1,930
stress on the 2nd syllable (σσ́)	918	0

3.2.1.1 Stress pattern σ́σ (stress on the first syllable)

In this section, we will take a look at the 577 words with initial stress and a full vowel in the second syllable.

Let us first consider the first syllables. In what follows, onsets are always represented as C, which should actually be C_0 (which means that there can be zero or more consonants), because the onset may be empty or contain more than one consonant. However, since it does not count for the syllable weight, we hope that this notation is not too misleading.

(10) First syllable in disyllabic words with stress on the first syllable (to be revised)

CV:	266
CV	84
CVC	205
CVCC	15
CV:C	7

Only 84 words seem to have a short vowel in the first stressed syllable, but then they all have an ambisyllabic consonant closing the first syllable (CVC), so that (10) is to be corrected to (11). Thus, all first syllables have at least two moras in their rhyme:

(11) First syllable in disyllabic words with stress on the first syllable

CV:	266		2 μ
CVC	289	(84 ambisyllabic C, 205 CVC)	2 μ
CVCC	15		3 μ
CV:C	7		3 μ

(12) Moraic count of the first syllable (stress pattern σ́σ)

2 μ	555
3 μ	22

The following two tables give the structures of the *second* syllable in the same words:

(13) Second syllable in disyllabic words with stress on the first syllable

CV:	210	2 μ
CVC	279	2 μ
CVCC	48	3 μ
CV:C_0 (VVC_0)	40	3 μ

(14) Moraic count of the second syllable (stress pattern σσ)

2 μ	489
3 μ	88

The majority of syllables, both initial and final, are bimoraic. Only 22 of the 577 stressed syllables are really heavy (trimoraic), and the second unstressed syllable is trimoraic in 88 cases.

The following table shows the distribution of moras across the two syllables.

(15) Moraic count in disyllabic words with stress on the first syllable

2μ 2μ	2μ 3μ	3μ 2μ	3μ 3μ
472	83	17	5

We will now go through the data, starting with a sample of the 472 words with two bimoraic syllables. The first syllables of the words in (16) and (17) have a rhyme consisting of a short lax vowel and a medial ambisyllabic consonant. In (16) the second syllable is open, and thus half-long (see Chapter 2)[2]; there are 41 words of this sort. The words in (17) have a second rhyme consisting of a lax vowel closed by a consonant, and thus a second closed syllable (33 words).

(16)	Essay	'essay'	Echo	'echo'
	Uni	'university'	Sherry	'sherry'

[2] In most words of this kind with a final CV: syllable, the final vowel is [a]; [o] and [i] are frequent, too, but [u] or [e] are rare. Apart from these, no other vowels appear in the last syllable of such words.

	Ami	'Yank'	Anno	'year'
	brutto	'gross'	Fasching	'carnival'
	Gecko	'gecko'	Villa	'villa'
	Ghetto	'ghetto'	Gummi	'rubber'
	groggy	'groggy'	Hobby	'hobby'
	Komma	'comma'	Kaffee	'coffee'
	mini	'mini'		
(17)	Pudding	'blancmange'	Phallus	'phallus'
	Mammut	'mammoth'	Messing	'brass'
	Sheriff	'sheriff'	Wallach	'gelding'
	Schilling	'schilling'		

In (18) and (19), the first syllable has a long open vowel as its rhyme. 90 words have a second open syllable, too, as illustrated in (18).

(18)	Ära	'parrot	Drama	'drama'
	Oma	'granny'	bravo	'bravo'
	Photo	'photo'	Judo	'judo'
	Kino	'movie'	Kanu	'canoe'

In 134 words the first syllable is a long open vowel and the second one is closed.

(19)	Graphik	'graphic'	Logik	'logic'
	Krokus	'crocus'	Bison	'bison'
	Efeu	'ivy'	Datum	'date'
	Ethik	'ethics'	Ethos	'ethos'
	Fazit	'result'	Globus	'globe'

In (20) and (21) the first syllable is a lax vowel closed by only one consonant. In 106 words the second is an open syllable, as illustrated in (20).

(20)	Whisky	'whisky'	Ultra	'extremist'
	Auto	'car'	blanco	'blank'
	Firma	'company'	Sauna	'sauna'

	Konto	'account'	Mensa	'refectory'
	zirka	'approximately'	Trauma	'trauma'

Finally, in 68 words the second syllable contains a short lax vowel closed by a single consonant.

(21)	Scharlach	'scarlet fever'	Kürbis	'pumpkin'
	Hektar	'hectar'	Spektrum	'spectrum'
	Nektar	'nectar'	Sultan	'sultan'
	Türkis	'turquoise'	Vampir	'vampire'

Now for the words with trimoraic syllables. In 88 words, the second syllable is trimoraic, but only in the following 5 words is the first syllable trimoraic, too[3]:

(22)	Antlitz	'countenance'	Antwort	'answer'
	Leutnant	'lieutenant'	Labskaus	'lobscouse'
	Sandwich	'sandwich'		

In 83 words the first syllable is bimoraic and the second one trimoraic. (23) and (24) contain words with an open first syllable (long tense vowel). In (23) the second syllable is closed by two consonants, and in (24) it has a long tense vowel and a consonant (32 words).

(23)	Schlehdorn	'blackthorn'	Agens	'agent'
	Ahorn	'maple'	Borax	'borax'
	Phönix	'phoenix'	Phalanx	'phalanx'
	Pharynx	'pharynx'	Habicht	'hawk'
	Predigt	'sermon'	Wisent	'aurochs'
	Lulatsch	'lanky fellow'	Gepard	'cheetah'
(24)	Demut	'humility'	Bisam	'musk'
	Raglan	'raglan sleeve'	Zierat	'ornament'

[3] In Chapter 2, words like *Wüste, Priester, Daimler,* etc. with a first trimoraic syllable and a second schwallable were introduced. These words are not considered in this chapter, since their initial stress is predictable. However, they raise the number of the existing disyllabic words with a first trimoraic syllable in a considerable extent.

	Dativ	'dative'	Fakir	'fakir'
	Tapir	'tapir'	Sisal	'sisal'
	Platin	'platinum'		

38 words with a trimoraic final syllable and a bimoraic first one have a closed first syllable, as shown in (25) and (26). In (25) the final syllable is closed with at least two consonants; in (26), the second syllable has a long tense vowel and is closed by one consonant.

(25)	Index	'index'	Standard	'standard'
	Dolmetsch	'interpreter'	Bastard	'bastard'
	Mangold	'swiss chard'		
(26)	Schicksal	'destiny'	Scheusal	'monster'
	Hangar	'hangar'	Turban	'turban'
	Autor	'author'	Tambur	'drummer'
	Bistum	'diocese'	Beispiel	'example'
	Heimat	'native country'	Balsam	'balsam'
	Heirat	'marriage'	Lorbeer	'laurel'
	Kleinod	'piece of jewelry'		

In 13 words, some of which are listed in (27), the first syllable has an ambisyllabic closing consonant and the second syllable is closed by two consonants or, as in the case of *Safran* and *passiv* , the second syllable has a long tense vowel and a consonant.

(27)	Billard	'billard'	Borretsch	'borage'
	Bussard	'buzzard'	Napalm	'napalm'
	Safran	'saffron'	passiv	'passive'

The first syllable is trimoraic in 22 words. Apart from the five words in (22), in which both syllables are trimoraic, there remain 17 words, some of which are shown in (28).

(28)	extra	'extra'	Arktis	'Arctic'
	Output	'output'	Kaustik	'caustic'

Müesli	'muesli'	Punktum	'final'
Plankton	'plankton'	Service	'service'

3.2.1.2 Stress pattern σσ́ (stress on the second syllable)

Let us now consider the 918 words with main stress on the second syllable.

329 of them have an open long first syllable (CV:). In 293 words, the first syllable is closed by an ambisyllabic consonant (CVC ambisyllabic) and in 296 words it is closed by a consonant which is not ambisyllabic: 279 with a lax vowel and one consonant, 17 with two consonants. (29) and (30) summarize these data.

(29) First syllable in disyllabic words with stress on the second syllable

CV:	329	2μ
CVC	572 (293 ambisyllabic, 279 CVC)	2μ
CVCC	17	3μ

(30) Moraic count of the first syllable (stress pattern σσ́)

2 μ	901
3 μ	17

Now for the final syllable. Only 195 words have a final bimoraic syllable: 87 words, many of which have a French origin or touch, have an open syllable (CV: syllable), and in 108 words the final syllable is closed by only one consonant. In contrast, 723 words have a final trimoraic syllable: in 237 words, it is closed by a lax vowel and two consonants (VCC); and in 486 words it has a long tense vowel closed by one consonant (V:C).

(31) Second syllable in disyllabic words with stress on the second syllable

CV:	87	2μ
CVC	108	2μ
CVCC	237	3μ
CV:C	486	3μ

(32) Moraic count of the second syllable (stress pattern σσ́)

2 μ	195
3 μ	723

Table (33) shows the distribution of moras in both syllables.

(33) Moraic count in disyllabic words with stress on the second syllable

2μ 2μ	2μ 3μ	3μ 3μ
195	706	17

Whereas in the case of initially-stressed words there were more bimoraic (489) than trimoraic (88) final syllables, this proportion is inverted in finally-stressed words: there are many more trimoraic (723) than bimoraic (195) final syllables.

As in the case of the initially-stressed words, we will now give a systematic presentation of some examples. Words with a bimoraic finally-stressed syllable, all of which also have a bimoraic first syllable, are listed in (34) to (36); (37) to (41) contain words with a final trimoraic syllable.

(34) gives a list of words whose final syllable is open. The vowels of these syllables are [e:] in 29 words, [i:] in 14, [o:] in 13, [õ:] in 12, [y:] in 5, [ɛ̃:] in 4, [u:] in 4, [a:] in 3, [ã:] in 2 and [œ̃:] in 1 word. These words have the pattern (2μ 2μ).

(34) a. [e:]

Ade	'bye'	Allee	'avenue'
Frottee	'terry cloth'	Filet	'fillet'
Idee	'idea'	Moschee	'mosque'

b. [i:]

Kopie	'copy'	Genie	'genius'
Jury	'jury'	Phobie	'phobia'

c. [o:]

Assaut	'assault'	Büro	'office'
Depot	'warehouse'	hallo	'hello'

d.	[õ]			
	Bonbon	'candy'	Bouillon	'bouillon'
	Ballon	'balloon'		
e.	[y:]			
	Menü	'menu'	Fondue	'fondue'
f.	[u:]			
	Ragout	'ragout'	tabu	'taboo'
g.	[a:]			
	Etat	'budget'	hurra	'hurray'
h.	[ø:]			
	Milieu	'milieu'	Adieu	'farewell'

Although the 67 words with an open final syllable illustrated in (34) have a first syllable closed by an ambisyllabic consonant, there are 20 more words whose first syllable is closed by its own consonant, some of which are shown in (35). In my opinion, the composition of the first syllable does not matter much because final stress on a bimoraic syllable is analyzed as lexical (idiosyncratic), regardless of the first syllable.

(35) a.	[õ:] Pardon	'sorry'	Lorgnon	'lorgnon'
b.	[e:] Gourmet	'gourmet'	Armee	'army'
c.	[œ̃:] Parfum	'perfume'		
d.	[i:] Partie	'part'		

Now consider the 108 words with a second CVC syllable (among them many with the final syllables *-ett* or *-ell*), some of which are listed in (36). Here, too, stress is lexical and the weight of the first syllable does not matter much.

(36) a.	Schafott	'scaffold'	Galopp	'gallop'
	Hotel	'hotel'	Metall	'metal'
	Spinett	'spinet'	Jackett	'jacket'
	ahoi	'ahoi'	Appell	'appeal'
	April	'April'		
b.	Bordell	'brothel'	Quartett	'quartet'
	Partei	'party'	Exzeß	'excess'

Finally, consider the words with a final trimoraic syllable, as in (37) to (41). Among these are 17 with a trimoraic first syllable. All of them have a lax vowel closed by two consonants and they also all have a trimoraic final syllable, as in (37). Orthographically, many of these words end with an *x*, which is phonetically bisegmental [ks].

(37)	Exkurs	'digression'	Export	'export'
	extern	'external	extrem	'extreme'
	Transport	'transport'	Dompteur	'tamer'
	Mixtur	'mixture'	Symptom	'symptom'
	Skulptur	'sculpture'	Textil	'textile'
	transfer	'transfer'		

Some examples of the 706 words with a final trimoraic syllable and an initial bimoraic one are listed in (38) to (41). In (38) and (39) the first syllable is open or the medial consonant is ambisyllabic; in (40) and (41) there is a medial consonant cluster, so that the first syllable is closed by its own consonant. In (38), the final trimoraic syllable consists of a long tense vowel closed by a consonant, and in (39) it consists of a lax vowel closed by two consonants.

(38)	Figur	'figure'	Fasan	'pheasant
	Krakeel	'row'	Kredit	'loan'
	immun	'immune'	Pilot	'pilot'
	Tarif	'charge'	Profil	'profile'
	Musik	'music'	Idol	'idol'
	Kanal	'canal'	Problem	'problem'
	Kamel	'camel'	Atom	'atom'
	Juwel	'jewel'	Patron	'patron'
	Papier	'paper'		

(39)	Student	'student'	Alaun	'alum'
	Hydrant	'hydrant'	Damast	'damask'
	Smaragd	'emerald'	Lizenz	'license'
	Triumph	'triumph'	Alarm	'alarm'
	Tumult	'tumult'	Gigant	'giant'

	Klient	'client'	Talent	'talent'
	Protest	'protest'	Reflex	'reflex'

In (40), the final trimoraic syllable has a long tense vowel closed by a consonant, and in (41) a lax vowel is followed by two consonants.

(40)	Menthol	'menthol'	mondän	'smart'
	Kanton	'canton'	Organ	'organ'
	Phosphat	'phosphate'	Merkur	'Mercury'
	Reptil	'reptile'	Kostüm	'costume'
	Oktav	'octave'	Archiv	'archive'
	Emblem	'emblem'	Vulkan	'volcano'
	Struktur	'structure'	Balkon	'balcony'
	Orkan	'hurricane'	Altar	'altar'
	Person	'person'	Scharnier	'hinge'
	Kultur	'culture'	Soldat	'soldier'
	Bandit	'bandit'	Karton	'carton'
(41)	markant	'striking'	Komfort	'comfort'
	konvex	'convex'	kompakt	'compact'
	Diskurs	'discourse'	Infarkt	'infarct'
	Konzert	'concert'	Instinkt	'instinct'
	charmant	'charming'	Akzent	'accent'
	Diphtong	'diphthong'		

Let us sum up the most important results of this section. The default stress location in disyllabic words is the initial syllable, which is bimoraic in the overwhelming majority of cases, especially if words with a final schwallable are taken into consideration. In all words, whether initially or finally stressed, the first syllable predominantly consists of a CV: or a CVC syllable, in which the second consonant may be ambisyllabic. However, many (918) words have final stress. In 723 of these words, the final stressed syllable is trimoraic. The obvious generalization is that trimoraic final syllables are stressed. There are 811 disyllabic words with a final trimoraic syllable, of which 723 are finally stressed; only 88 words with a final trimoraic syllable have stress on the initial syllable.

3.2.2 Optimality account

The data discussed in the preceding section largely confirm the principles listed at the beginning of this chapter, in section 3.1: German is a quantity-sensitive language that forms trochaic feet and it has a Right End Rule. Furthermore, there are lexical exceptions. In the next section we will see that these properties are also confirmed by the polysyllabic words.

In the OT framework, constraints first proposed by Prince & Smolensky (1993) for Hindi and Latin have been successfully applied to other languages by different authors, for example McCarthy & Prince (1993a, b), Hung (1993), Buckley (1994), Hammond (1994, 1995), Kager (1994) and Kenstowicz (1994a, b). Before showing how OT accounts for the German disyllabic words, we will review the different stress patterns these words can have. (42) to (44) show the "regular", predictable stress patterns and (45) and (46) the "irregular", idiosyncratic ones.

1. Words with two bimoraic syllables and stress on the first syllable (including the numerous words not considered in the preceding section with an initial bimoraic syllable and final schwa):

(42) a. Farbe [f a ɐ̯ . bə] 'color'

b. Mammut [m á m̩ ʊ t] 'mammoth'

2. Finally-stressed words with an initial bimoraic syllable and a final trimoraic one:

(43) Kamel [k a m̩ é l] 'camel'

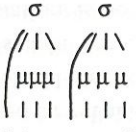
3. Words with two trimoraic syllables and stress on the final syllable:

(44) Symptom [z ʏ m p. t ó m] 'symptom'

4. Words with two bimoraic syllables and stress on the second syllable:

(45) Spinett [ʃp ɪ n̩ é t] 'spinet'

5. Words with two trimoraic syllables and stress on the initial syllable:



(46) Leutnant [l ɔ̈ʏ t. n a n t] 'lieutenant'

The following constraints, introduced by Prince & Smolensky (1993) and McCarthy & Prince (1993a,b), are active in German[4]:

[4] The following discussion presupposes that stress is generated by Gen.

(47) FOOT-BINARITY
Feet must be binary under syllabic or moraic analysis.

(48) FOOT-FORM (TROCHAIC)
(Ft –> σ_S σ_W)

(49) ALIGN- TROCHEE-RIGHT
Align (Prosodic Word, Right, Trochee, Right)
Every Prosodic Word ends with a trochee.

(50) ALIGN- FOOT-LEFT
Align (Prosodic Word, Left, Foot, Left)
Every Prosodic Word begins with a foot.

Some authors (Liberman & Prince 1977, Giegerich 1985, Kager 1993, Hayes 1995) take the first one, FOOT-BINARITY, to be universal. FOOT-BINARITY disallows unary ('degenerate') feet by requiring that feet are minimally binary as well as ternary or unbounded feet by requiring that they are maximally binary: feet are either disyllabic $[\sigma\sigma]_F$ or bimoraic $[\sigma_{\mu\ \mu}]_F$. In German, bimoraic syllables with full vowels are heavy enough to form their own foot.

German corresponds to the generalized trochee pattern of Hayes (1995), since it maximizes feet. Bimoraic feet are formed only if syllabic trochees are impossible. In OT, this is expressed by FOOT-FORM (TROCHAIC) which posits that a syllabic trochee is formed whenever possible and is preferred to a bimoraic or iambic foot. [5]

[5] In Kager's (1994) account, FOOT-FORM(TROCHAIC) is replaced by TROCH-FT, which considers both the syllabic and the moraic trochees as equally well formed. Taking Estonian as his example, Kager (1994) proposes that, in some languages, the preference for maximal foot construction is accounted for by *CLASH, a constraint that avoids stress clash. In Estonian, a pedification like (pí.mes).(tàt.tu).te 'the dazzled, gen.pl.' is better than *(pí.mes).(tàt).(tù.te), though the second form does better both on PARSE-SYL and on ALL-FEET-LEFT, the mirror image of ALL-FEET-RIGHT (see 3.3.2.2). The second pedification contains an illicit stress clash. Thus, binary syllabic rhythm in Estonian is due to strict avoidance of clash. However, in German, there is no need for *CLASH to express that syllabic trochees are preferred to moraic ones because trimoraic syllables are largely confined to final position. Thus, the fact that a word like Manifest 'manifesto' is pedified as (Mà.ni).(fést) and not as *(Mà).(nì).(fést) is due to FOOT-FORM(TROCHAIC) and ALIGN-FOOT-LEFT, which ensure the formation of a syllabic trochee at the left edge of a Prosodic Word.

German has no iterative foot formation and thus no exhaustive footing. It has a final main stress and an initial secondary stress. Syllables in-between are unstressed. This is expressed by ALIGN-TROCHEE-RIGHT, which posits that a trochee is formed at the end of a Prosodic Word, and by ALIGN-FOOT-LEFT, which guarantees the presence of a foot word initially. The trochee allowed by ALIGN-TROCHEE-RIGHT is either di- or monosyllabic. If it is monosyllabic, it is trimoraic. In fact, the final trochee is defined by the grid positions which are projected by syllables, or, in case of trimoraic syllables, by moras (see constraint (51) and the discussion on p. 108). PARSE-SYLLABLE, a constraint that forces all syllables to enter the pedification, counting each unparsed syllable as a violation, is not active in German. The asymmetry between the requirements of a syllabic trochee word finally and just a foot word initially is motivated by the data, not only by the monomorphemes, but also by the complex words, especially by those prefixed by a schwa prefix (see Chapter 4). Examples of words violating ALIGN-TROCHEE-RIGHT are those with a final stressed bimoraic syllable, like *Spinett* and *Karusell*.

Let us now see how the constraints just introduced account for the disyllabic words. We will first consider words with a final schwa; these words form a single syllabic trochee. As before, round parentheses indicate feet.

(Farbe)	'color'	(Fenster)	'window'
(Robe)	'dress'	(Segel)	'sail'
(Zelle)	'cell'	(Atem)	'breath'
(Seide)	'silk'		

The most relevant candidates for the word *Farbe* are shown in Tableau 1. The optimal candidate a. consists of one trochaic foot and fulfills all four constraints: the first because the foot is binary, the second because there is a syllabic trochee at the right edge of the foot, the third because there is an initial foot and the fourth because the foot is trochaic. Candidate b. shows that the two feet option is eliminated by FOOT-BINARITY, since the nonmoraic schwa syllable cannot form a foot on its own.[6] Such a candidate is neither

[6] Since there are no German monomorphemes whose first syllable is a schwallable, no independent constraint requiring that schwallables are unstressed (as proposed for Indonesian by Cohn & McCarthy 1994) is necessary. A schwallable is always the weak member of a trochee.

moraically nor syllabically binary and thus does not fulfill the bimoraicity requirement of FOOT-BINARITY. Candidate b. also violates FOOT-FORM (TROCHAIC), since no syllabic trochee is formed in this candidate. Candidate c. violates FOOT-FORM (TROCHAIC), too, by forming an iambic foot, but it fulfills the other three constraints: the foot is binary and there is a foot that is both initial and final. Finally, candidate d. violates ALIGN-TROCHEE-RIGHT and FOOT-FORM (TROCHAIC). FOOT-BINARITY is satisfied since the first syllable is bimoraic. Of course, violation of a constraint is not a problem *per se*, but since there is a candidate that fulfills all constraints, candidates violating one or more constraints are suboptimal.

All tableaux in this chapter adopt a bracketed grid as proposed by Halle & Vergnaud (1987). Line 1 is always shown, line 2 only if necessary, and line 0 is ignored.

The inputs of all tableaux in this chapter are unsyllabified stems since there is no reason to assume that syllabification and stress assignment take place on different levels. Thus, the constraints responsible for syllabification, introduced in Chapter 2, and the metrical constraints of this chapter apply simultaneously. In section 3.3.2.2, some interactions between the two sets of constraints are discussed. The correct syllabifications are shown in (42) to (46).

μ | faʁbə	FOOT-BINARITY	ALIGN-TROCHEE-RIGHT	ALIGN-FOOT-LEFT	FOOT-FORM (TROCHAIC)
a. (x .) ☞ Farbe				
b. (x) (x) Far be	*!	*		**
c. (. x) Farbe		*!		*
d. (x) Far be		*!		*

Tableau 1

Tableau 2 gives an example of a disyllabic word with stress on the first syllable and a full vowel in the last one (*Komma, Judo, Mammut, Efeu*, etc.). Such words have two bimoraic syllables. Syllabic binarity and trochaicity are ensured by ALIGN-TROCHEE -RIGHT, which is fulfilled only by candidate a. The tableau resembles Tableau 1, except for the fact that the last syllable of *Mammut* contains a full moraic vowel, which implies that it can form a foot on its own since it fulfills FOOT-BINARITY. This is relevant only for the second foot of candidate b. This candidate violates FOOT-FORM (TROCHAIC) because it does not form a trochee. Candidates c. and d. are like in Tableau 1 and the same comments as above apply to them.

μ μ | | /mamʊ t/	FOOT-BINARITY	ALIGN-TROCHEE - RIGHT	ALIGN-FOOT-LEFT	FOOT-FORM (TROCHAIC)
a. (x .) ☞ Mammut				
b. (x) (x) Mam mut		*!		*
c. (. x) Mammut		*!		*
d. (x) Mam mut		*!		*

Tableau 2

A different ranking of the constraints like, for example, the one illustrated in Tableau 3, would eliminate the same candidates as in Tableaux 1 and 2, because the optimal candidate is the only one which fulfills all the constraints. However, the ranking chosen for Tableaux 1 and 2 will be supported by later examples.

* μ μ | | /mamʊ t/	ALIGN-FOOT-LEFT	FOOT-FORM (TROCHAIC)	ALIGN-TROCHEE - RIGHT	FOOT-BINARITY
a. (x .) ☞ Mammut				
b. (x) (x) Mam mut		*!*	*	
c. (. x) Mammut		*!	*	
d. (x) Mam mut		*!	*	

Tableau 3

In order to account for the words with a final trimoraic syllable, for example *Kamel* and *Symptom* in (43) and (44), two additional constraints are needed.

(51) THREEMORAS =TWOGRIDPOSITIONS

Trimoraic syllables project two grid positions. (Or: A grid position is projected from maximally two moras.)

(52) ALIGN-HEAD

Align (PrWd, Right, Head(PrWd), Right)

The right edge of every PrWd coincides with its head.

A trimoraic syllable cannot be the weak member of a foot.[7] Since the foot-binarity requirement is absolute (FOOT-BINARITY is an undominated constraint), trimoraic syllables are too heavy to form their own feet. We are confronted with a paradoxical situation: trimoraic syllables have too many moras to form their own feet, but as syllables they are allowed to be only part of a foot, albeit the strong one. To avoid this situation, we adopt Prince's (1983:62) analysis of Estonian, which has also been used by Hayes (1995) and Kager (1994). In their respective treatments of Estonian, all three authors consider overlong syllables (as exemplified by the first syllables of

[7] Prince & Smolensky (1993:53) formulate a constraint WTS (Weight-to-Stress) which prohibits heavy syllables in weak positions. This is equivalent to Hayes's (1980) and others' constraint 'w-nodes do not branch.'

(káu:).(kè.le) 'far away', and *(trúu:).(tù.se).(lèki)* no gloss) as projecting two grid positions. Prince and Hayes analyze overlong syllables as trimoraic and alternatively mono- and disyllabic. Kager, on the other hand, does not take any position on the nature of the overlength ('an extra element of length'). Prince's original proposal accounts for the fact that, in Estonian, a syllable adjacent to an overlong one can be stressed, so that there is a clash between an overlong syllable and a following syllable. But if an overlong syllable projects two grid positions, there is no clash on the grid. In German, trimoraic syllables are generally final, so that it cannot be verified whether trimoraic syllables can be followed by stressed syllables. Only the few disyllabic words with initial trimoraic syllables in (22) and (28) can be used as a test, but they do not deliver clear results. The trisyllabic words have nearly no nonfinal trimoraic syllables and are of no help either. In sum, the assumption that trimoraic syllables in German project two grid positions is simply a formal *ad hoc* device that is not corroborated by the data. However, it does no harm and allows us to keep FOOT-BINARITY in its original formulation. Formally, a grid position is projected from maximally two moras. Trimoraic syllables are decomposed into two plus one moras: the first two moras project one grid position, and the third projects another one.

ALIGN-HEAD (McCarthy & Prince 1993b:17) replaces the Right-End Rule of Prince (1983) for determining foot prominence. It is active whenever more than one foot is involved and says that the rightmost foot is the most prominent one, the head of the Prosodic Word.

Tableau 4 illustrates the effect the constraints introduced so far have on the word *Kamél*. Disyllabic words with an initial bimoraic and a second trimoraic syllable have an iambic stress pattern: the first syllable is weak, the second is strong. Candidate a. illustrates the optimal case, in which two feet, a bimoraic one and a second trimoraic, trochaic one, are formed. The foot on the second syllable is required by THREEMORAS=TWOGRIDPOSITIONS, which is undominated and prohibits a trimoraic syllable as the weak member of a trochee, forcing it to form a foot. This candidate satisfies all constraints, except for one violation of FOOT-FORM (TROCHAIC). Candidate a. consists of two feet and, in such a case, ALIGN-HEAD guarantees that the final foot has main stress. Candidate b. violates ALIGN-FOOT-LEFT and is therefore eliminated. Candidate c. is like candidate a., except for the location of the main stress, which is on the first syllable: ALIGN-HEAD is thus violated.

Candidate d. is eliminated by one of the highest constraints, THREEMORAS =TWOGRIDPOSITIONS, since a trimoraic syllable does not project two grid positions. Candidate e., the final one, has a ternary foot, thus violating FOOT-BINARITY.

μ μ μ | \/ /kamel/ *Kamel*	3μ = 2**	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x) (x.) ☞ Ka mel						*
b. x (x .) Ka mel				*!		
c. x (x) (x .) Ka mel					*!	*
d. x (x .) Kamel	*!					
e. x (. x.) Kamel		*!	*			*

Tableau 4

Some of the constraint rankings are justified in Tableau 4. First, THREEMORAS =TWOGRIDPOSITIONS must dominate FOOT-FORM (TROCHAIC) to prevent the formation of a single trochee in words like *Kamel*. If the dominance relation between these constraints were reversed (FOOT-FORM (TROCHAIC) >> THREEMORAS =TWOGRIDPOSITIONS), the formation of trochees would prevail over the prohibition of trimoraic syllables in the weak position of a trochee, and the stress pattern *Kámel* would be optimal.

FOOT-BINARITY and THREEMORAS =TWOGRIDPOSITIONS are not ranked: they are both undominated. A violation of either of these constraints is always fatal.

ALIGN-TROCHEE -RIGHT and ALIGN-FOOT-LEFT must be ranked above FOOT-FORM (TROCHAIC) to allow the formation of feet other than syllabic trochees at the beginning of the word. This will be demonstrated in section 3.3.2.2 with words like *Pyjama,* which have a syllabic trochee on the right edge of the word rather than on the left edge.

ALIGN- TROCHEE -RIGHT is ranked before ALIGN-FOOT-LEFT. ALIGN-FOOT-LEFT is always fulfilled in monomorphemes. And yet, it is not undominated to account for the fact that prefixes consisting of a schwa syllable can appear at the beginning of the word. In this case, the nonmoraic prefix is not footed, and ALIGN-FOOT-LEFT is violated.

In Tableau 4, ALIGN-HEAD is ranked on a par with ALIGN-FOOT-LEFT. It will be shown below that prespecified stresses can override the effect of ALIGN-HEAD, and that the formation of final feet is not blocked by ALIGN-HEAD (see Tableau 7).

Now for the last regular pattern, illustrated by *Symptóm*, with two trimoraic syllables and final stress. This word consists of two feet, one on the first and one on the second syllable, as shown in the winning candidate a. of Tableau 5. This form fulfills all constraints, including FOOT-FORM (TROCHAIC), because the last syllable is heavy and trochaic. ALIGN-HEAD ensures that the rightmost foot's head is also the head of the Prosodic Word. Candidate a. wins against candidate b., which violates ALIGN-HEAD. Candidate c. is also eliminated. Since the first syllable is trimoraic, it is too heavy to be the weak member of a foot and this option is eliminated by THREEMORAS =TWOGRIDPOSITIONS. The same candidate also violates FOOT-BINARITY and FOOT-FORM (TROCHAIC). The last candidate also violates THREEMORAS =TWOGRIDPOSITIONS.

μ μ μ \ / /zymptom/*Symptom*	3μ = 2**	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) (x.) ☞ Symp tom						
b. x (x .) (x .) Symp tom					*!	
c. x (. x .) Symptom		*!	*			*
d. x (x .) Symptom	*!					

Tableau 5

The last series of disyllabic words that must be accounted for are the two irregular stress patterns: words with a lexical stress on the last syllable and those with a lexical stress on the first syllable. The former are illustrated by *Spinétt* or *Menü*, with two bimoraic syllables but stress on the last syllable. The latter have a final unstressed trimoraic syllable. Some of them also have a trimoraic first syllable, like *Leutnant*, and some others, like *Heimat* or *Autor* , have an initial bimoraic syllable.

Let us first consider the words with final stress. According to the constraints discussed so far, a trochaic foot should be erected on them, and initial stress should be the consequence. However, this is not the case. On the contrary, these words have an exceptional stress pattern. In general, there are two ways of accounting for this exceptionality: either different metrical grammars are assumed to coexist in a given language and words are classified according to the grammar they belong to, or there is only one system and some words are exceptions; in this case, exceptional stress location is prespecified. If cogrammars can coexist, then there must be a different grammar for each deviant stress pattern. On the other hand, if only one grammar is used, then exceptional stress patterns are more or less deviant. A proposal made by Giegerich (1985: 24-25), and also defended by

Ramers (1992:265), illustrates what would be a cogrammar for words like *Spinétt* or *Hotél*. Giegerich assumes that the final consonants in the words in (36) like *Schafótt, Galópp, Hotél, Metáll, Spinétt, Bordéll* and *Exzéß* are abstract long consonants and thus attract stress by being heavy, in the same way as words like *Magazín* or *Konzért*. In his review of Giegerich (1985), Hayes (1986:233) pinpoints the problem with this approach in the following terms:

> A number of difficulties are apparent here. First, in order to get a stress-attracting heavy syllable in words like *Met[á]ll, Pro[é]ß*, Giegerich must assume abstract geminates in the underlying representation. These contrast underlyingly with the single consonant in *Kónsul, Átlas*, but surface identically. This is just the kind of abstract representation that Kiparsky (1973) has provided compelling arguments against: it isn't supported elsewhere in the phonology, but merely encodes exceptions to a single rule.

The solution Hayes advocates, and with which we agree, is that those words have lexically listed stress. The same holds for the words in (34) and (35) with an open syllable, as well as for the words in (36) with a final diphthong (*Partei, ahoi*): they, too, have idiosyncratic stress.[8]

Stress on a final bimoraic syllable is prespecified in the following way: the last syllable has an asterisk on line 2.

(53)
x
x
Spinett

Following Prince & Smolensky (1993), McCarthy & Prince (1993), and Itô, Mester and Padgett (1994), a family of faithfulness constraints guarantees that prespecification is preserved. We will follow the formulation of Itô, Mester and Padgett (1994):

[8] See also Inkelas, Orgun and Zoll (1994) who argue against the principled existence of cophonologies for lexical exceptions and nonproductive regularities.

(54) FAITH (Feature Faithfulness)

PARSEFEAT: All input features are parsed
FILLFEAT: All features are part of the input
PARSELINK: All input association relations are kept
FILLLINK: All association relations are part of the input

The following constraint which takes care of prespecified stress can be added to the list.

(55) FAITH (Grid position Faithfulness)

PARSEASTERISK: All input asterisks are kept.

Having FAITH rank high prevents a prespecified asterisk from being removed from the candidates. Tableau 6 illustrates the metrical structure of the word *Spinett*, which has a prespecified asterisk on line 2 (and on line 1, because of the Continuous Column Constraint (Prince 1983, Halle & Vergnaud 1987, Hayes 1995), which says that an asterisk on a line n implies asterisks on all lines below n). Candidate a. forms an iambic foot, and candidate b. forms two feet. The constraints choose candidate a. as optimal, since candidate b. violates FOOT-FORM (TROCHAIC) twice. Candidate a. is better than all others, even those involving only a syllabic trochee like candidate c., which violates the undominated constraint FAITH. Candidate d. violates ALIGN-FOOT-LEFT.

μ μ x | | x /ʃpɪ nɛt/ Spinett	FAITH	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	FOOT-FORM (TROCH)
a. x (. x) ☞ Spinett			*		*
b. x (x) (x) Spi nett			*		**!
c. x (x .) Spinett	*!				*
d. x (x) Spi nett			*	*!	*

Tableau 6

Finally, let us see how the constraints and principles seen so far account for the last irregular stress pattern, the initial stress on *Leutnant*. Remember that there are only five words of this kind, with two trimoraic syllables and initial stress. Two of them have a foreign origin: *Leutnant* and *Sandwich*, and three are lexicalized derivations or compounds: *Antwort*, *Antlitz* and *Labskaus*. The exceptionality of this stress is different from the *Spinett* kind because in this case two feet are erected, and the first syllable is the more prominent. In *Leutnant*, ALIGN-HEAD does not hold any longer. The exceptional stress can be captured by a lexical grid mark on line 2, as in the case of *Spinett*.

x
x
(56) Leut.nant

In a sense, this pattern impresses one as being more exceptional than the preceding one, and the fact that there are only five words with this pattern can be interpreted as a confirmation of this analysis.

The second syllable is trimoraic and thus consists of its own trochaic foot. Now, as illustrated in (57a), ALIGN-HEAD should promote the second

syllable. FAITH cannot block this promotion. It only ensures that prespecified asterisks are preserved in the surface form.

x x	x
(x) (x)	(x) (x)
(57) a. *Leutnant	b. Leutnant

We propose a new constraint, ONEHEAD, formulated in (58), in order to prevent the formation of two asterisks on line 2 in monomorphemes. This constraint must be ranked before ALIGN-HEAD in order to annihilate its effect. In fact, it is undominated.

(58) ONEHEAD
A constituent has at most one head.

Let us now examine the last tableau of this section, Tableau 7, which displays the constraints responsible for the stress pattern of *Léutnant*. Since FOOT-BINARITY is fulfilled by all the candidates of Tableau 7, it has had to make room for the other, more important constraints. Candidate a. fulfills all constraints, with the exception of ALIGN-HEAD. Candidate b. violates ONEHEAD, candidate c. violates THREEMORAS =TWOGRIDPOSITIONS and candidate d. violates FAITH. Candidate e. shows that the formation of two feet is better than only one. Even if the last candidate does not violate ALIGN-HEAD, it does violate ALIGN-TROCHEE-RIGHT and is therefore eliminated. This form motivates the ranking of ALIGN-HEAD below ALIGN-TROCHEE-RIGHT. On the other hand, nothing motivates a ranking between ALIGN-HEAD and ALIGN-FOOT-LEFT or FOOT-FORM (TROCHAIC). For this reason, we have ranked ALIGN-HEAD on a par with ALIGN-FOOT-LEFT.

μμ μ | | | l ɔɣ t n a n t	3 μ =2**	AITH	ONE HEAD	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCHAIC)
a. x (x.)(x.) ☞ Leut nant						*	
b. x x (x.)(x.) Leut nant			*!				
c. x (x .) Leutnant	*!						
d. x (x.) (x.) Leut nant		*!					
e. x (x.) Leut nant				*!			

Tableau 7

This tableau concludes the optimality-theoretic approach to the disyllabic stress patterns. The following section is devoted to the trisyllabic words.

3.3 Trisyllabic words

3.3.1 Survey of data

There are 19,227 trisyllabic words listed in CELEX which can be divided into the following eight metrical classes:

1) σσσ: main stress on the first syllable, no secondary stress: 11,440 items.
2) σσσ: main stress on the second syllable, no secondary stress: 4,927 items.
3) σσσ: main stress on the final syllable, no secondary stress: 1823 items.
4) σσσ: main stress on the first and on the last syllable: 125 items.
5) σσσ: main stress on the first and on the second syllable: 20 items.

6) σσσ: main stress on the second, secondary stress on the last syllable: 7 items.[9]
7) σσσ: main stress on the first, secondary stress on the last syllable: 5 items.[10]
8) σσσ: main stress on the first, secondary stress on the second syllable: 880 items.

The last five patterns contain only compounds and are irrelevant for this section. But the remaining three patterns contain monomorphemes with only one main stress; they are the subject of our investigation. Unlike in the case of disyllabic words, trisyllabic words containing schwas have to be taken into consideration now, since the presence of a schwa in one syllable does not necessarily imply stress on another syllable, as is the case in disyllabic words. However, we will see that the following generalization holds for a large majority of the cases: schwa is final and attracts main stress on the penult. Of course, this generalization has to be accounted for.

Having eliminated all complex words, proper names, etc., there remain 1,312 trisyllabic monomorphemes, the stress pattern of which are distributed as indicated in (59).

(59) Trisyllabic monomorphemes

stress on the first syllable (σσσ)	255	(38 with final schwa, 217 others)
stress on the second syllable (σσσ)	664	(528 with final schwa, 136 others)
stress on the third syllable (σσσ)	393	

In the following subsections, each stress pattern will be examined in turn.

[9] All of these are verbs with a detachable particle: *dabeisein* 'to be present', *genugtun* 'to satisfy', *heraussein* 'to be out', *hervortun* 'to distinguish oneself', *hinaussein* 'to be out', *zuvortun* 'to do first', *zurücktun* 'to put back'.

[10] These, too, are verbs with detachable particles: *innesein* 'to be aware of something', *heimlichtun* 'to behave secretively', *wiedertun* 'to do again', *übeltun* 'to do something wicked', *übertun* 'to exaggerate'.

3.3.1.1 Stress pattern óσσ (stress on the first syllable)

The vast majority of the 11,440 CELEX-listed words with their main stress on the first syllable are compounds and derived words with a stressless derivational suffix. Only 255 monomorphemic words remain, of which 38 have a final schwa. At first sight, this seems to contradict the already mentioned fact that nearly all the trisyllabic words with final schwa are stressed on the penult. However, 20 of these 38 words with a final schwa and initial stress contain a hiatus between the second and the third syllables, as shown in (60). The unstressed [i] is usually pronounced as a glide, which makes the word disyllabic.

(60)	Orgie	'orgy'	Arie	'aria'
	Prämie	'bonus'	Bestie	'beast'
	Bronchie	'bronchial tube'	Aktie	'share'
	Dahlie	'dahlia'	Folie	'foil'
	Hostie	'host'	Linie	'line'
	Mumie	'mummy'		

In (61) and (62) more initially-stressed words with a hiatus between the second and third syllables are listed. In these words, as in (60), the second syllable's nucleus is an unstressed [i], but the third syllable has a full vowel (plus a consonant in nearly all cases). Though the words in (61) behave similarly to those in (60) as far as syllabification is concerned (they are often pronounced as disyllabic words as a consequence of the *i*-glide formation), those under (62) are clearly trisyllabic.[11] The onset consonants are important for the realization of the second syllable as a full syllable. If the onset of the second syllable has two consonants, the [i] is realized as a full syllable. In contrast, all [i] syllables in (60) and (61) have an onset consisting of a single consonant.[12]

[11] Two more words, *Triangel* 'triangle' and *Biathlon* 'biathlon', have a stressed [i] in the first syllable instead of an unstressed one in the second syllable.

[12] Notice that the word *Spezies* has an affricate in the onset of the relevant syllable. Still [i] is realized as a glide. This can be used as an additional argument for the monosegmental status of [ts] in German (see the literature on affricates Wurzel 1980a, Kloeke 1982, Dogil & Jessen 1989, Ramers & Vater 1992, among others).

(61)	Stadion	'stadium'	Studium	'studies'
	Barium	'barium'	Gremium	
	'committee'			
	Kaviar	'caviar'	Morphium	'morphine'
	Orient	'Middle East'	Thymian	'thyme'
	Spezies	'species'		
(62)	Schlendrian	'slackness'	Atrium	'atrium'
	Baldrian	'valerian'	Ganglion	'ganglion'
	Requiem	'requiem'	Embryo	'embryo'

Before we return to the stress properties of trisyllabic words with stress on the first syllable, let us finish this digression on hiatus. Sixteen more initially stressed words have a hiatus involving a vowel other than [i] in the second syllable (the first member of the hiatus). Of these, only [u] can become a glide, as in the words in (63) – although it cannot as easily in those under (64):

(63)	Jaguar	'jaguar'	Linguist	'linguist'
	Pinguin	'penguin'	Tenuis	'tenuis'
(64)	Januar	'January'	Februar	'February'
	Vakuum	'vacuum'		

In (63), [u] behaves like [i] in (60) and (61). There is only one consonant in the onset of the second syllable and the words are usually pronounced as disyllabics. The words in (64) are truly trisyllabic: [u] cannot be realized as a glide so easily, and this is surprising. Of the three words, only *Februar* has two consonants in the relevant onset. We assume that the word *Januar* behaves in analogy to *Februar*. The last item, *Vakuum*, has a hiatus consisting of two identical vowels. According to Barkey (1994), who follows Hall (1992:137), this kind of hiatus is always broken up by a glottal stop.[13]

[13] Hall analyzes words like *Kontinuum* 'continuum' and *Alliierten* 'allies' as complex words in which the morpheme boundary coincides with the hiatus joint. According to him, "adjacent, identical feature matrices can occur on the surface [only CF] when these sequences are heteromorphemic." However, there are (admittedly rare) counterexamples,

Other initially-stressed words with a hiatus involve non-high vowels and are always realized as trisyllabic words. The list in (65a) contains words with a hiatus between the second and third syllables, and (65b) is a word with a hiatus between its first and second syllables.[14]

(65) a.	Statue	'statue'	Stereo	'stereo'
	Aloe	'aloe'	Pharao	'Pharaoh'
	Nukleus	'nucleus'	Ozean	'ocean'
	Pankreas	'pancreas'	Boreas	'north wind'
b.	Koitus	'coitus'		

Now consider the remaining words with final schwa and stress on the first syllable. Interestingly, the number of words with initial stress, final schwa and no hiatus is rather small: all in all 18 words, which are listed in (66). [15] This number is particularly small if compared to the 528 trisyllabic words with stress on the penult and schwa in the last syllable to be discussed in the next section.

(66)	Berserker	'berserker'	Roboter	'robot'
	Manager	'manager'	Araber	'Arab'
	Presbyter	'presbyter'	Teenager	'teenager'
	Management	'management'	Bulldozer	'bulldozer'
	Eidechse	'lizard'	Hebamme	'midwife'
	Einöde	'barren waste'	Herberge	'inn'
	Brosame	'crumb'	Alkoven	'alcove'
	Almosen	'alms'	Mobile	'mobile'
	Systole	'systole'	Ameise	'ant'

Seven of the words in (66) have *-er* in their final syllable, which may be interpreted as a suffix, or at least in analogy to a suffix. *Management* is a loan

like *Vakuum, Kontinuum* (which, in our opinion, should be analyzed as monomorphemic), and proper names like *Schiit* (cited by Hall), *Kanaan, Coop*, etc.

[14] All vowels forming a hiatus with the following syllable are tense and fulfill the bimoraicity minimum for syllables.

[15] Giegerich (1985) and Jessen (1994) cite three more words of this kind which are not listed in CELEX: *Elritze* 'minnow', *Maßholder* 'maple' and *Urkunde* 'certificate'.

word taken over with its original stress pattern (the same is true for *Teenager* and *Manager*). *Einöde, Brosame* and *Hebamme*, as well as *Maßholder, Urkunde* and maybe even *Herberge* and *Eidechse* can be interpreted as compounds. *Alkoven, Almosen, Systole* and *Elritze* have an alternative stress pattern in which the second syllable gets main stress. *Mobile* is often pronounced with a final [e].

Now compare the weight of the first syllable in the remaining words. Not surprisingly, this syllable is mostly bimoraic. It is trimoraic in only one word, *Rosmarin* 'rosemary', and this word has a strong flavor of compounding.

The following tables give an overview of the syllabic and moraic composition of the three syllables.

(67) First syllable in trisyllabic words with stress on the first syllable

CV:	128	
CVC	126	(32 ambisyllabic, 94 CVC)
CV:C	1	

(68) Moraic count of the first syllable (stress pattern ́σσ)

2 μ	254
3 μ	1

(69) Moraic count of the second syllable (stress pattern ́σσ)

0 μ	16
2 μ	237
3 μ	2

(70) Moraic count of the third syllable (stress pattern ́σσ)

0 μ	38
2 μ	173
3 μ	44

As one can see from the tables, the first and the second syllables are nearly always bimoraic. Only the third syllable can be trimoraic, which happens in 44 words.

Examples of words with a bimoraic first syllable are given in (71) to (73). (71) lists words with three bimoraic syllables (open or closed with one C). In the overwhelming majority of such words, and there are 161 words of this pattern, the second syllable is either open or else closed by an ambisyllabic consonant (see also the words in (60) to (64) with a hiatus, and (87) to (94) in the next section which point to the same generalization). In only one word is the second syllable closed by its own consonant[16]: *Elektron* 'electron'. This word has an alternative stress pattern with main stress on the second syllable. This is an amazing regularity which has never been accounted for successfully, though some attempts have been made (see section 3.3.2.1).

(71a) contains words with a final closed syllable, and (71b) words with a final open syllable.

(71) a.	Bräutigam	'bridegroom'	Exodus	'exodus'
	Spekulum	'speculum'	Spezimen	'specimen'
	Ypsilon	'y'	Albatros	'albatros'
	Festival	'festival'	Estragon	'tarragon'
	Lexikon	'encyclopedia'	Kumulus	'cumulus'
	Minimum	'minimum'	Publikum	'audience'
	Tetanus	'tetanus'	Ananas	'pineapple'
b.	Gigolo	'gigolo'	Amphora	'amphora'
	Indigo	'indigo'	Cholera	'cholera'
	Kolibri	'humming bird'	Kanapee	'sofa'
	Marabu	'marabou'	Mobile	'mobile'
	Cembalo	'harpsichord'	Paprika	'pepper'

In (72) the last syllable is trimoraic (tense vowel plus a consonant, or lax vowel plus 2 consonants). There are 42 words with a final trimoraic syllable, ten of which have a hiatus between the second and third syllables and ten of

[16] There are, however, 15 more words with a closed second syllable, but this syllable either is in a word with a final trimoraic syllable (*Gabardin, Adjektiv*) or it is a schwa syllable (*Kabeljau, Schmetterling*).

which are linguistic terms. In only two words, *Konjunktiv* and *Subjunktiv*, is the second syllable also trimoraic. In all other cases it is bimoraic.

(72)	Indolenz	'indolence'	Korridor	'corridor'
	Harlekin	'harlequin'	Bariton	'baritone'
	Pelikan	'pelican'	Telefon	'telephone'
	transitiv	'transitive'	Substantiv	'noun'
	Singular	'singular'	Ablativ	'ablative'
	Firlefanz	'frippery'	Elfenbein	'ivory'

Finally, in (73) the medial syllable is a schwallable (16 words). The first and third syllables are generally bimoraic, though in two cases, *Firlefanz* and *Elfenbein*, the last syllable is trimoraic. (*Elfenbein* is a lexicalized compound.)

(73)	Bumerang	'boomerang'	Schmetterling	'butterfly'
	Kabeljau	'cod'	Limerick	'limerick'
	Pfifferling	'chanterelle'	Sellerie	'celery'
	Kakerlak	'cockroach'	Firlefanz	'frippery'
	Elfenbein	'ivory'		

In sum, all trisyllabic words with stress on the first syllable fall into one of three classes. First, a certain number of words have a hiatus between the second and third syllables whose first member is often a high vowel; some of these words have a tendency to be pronounced as disyllabics. Second, many words have three bimoraic syllables; in nearly all these words, the second syllable is open or closed by an ambisyllabic consonant. Third, there are some exceptional stress patterns: some words have final schwa syllables, and some have a trimoraic final syllable.

3.3.1.2 Stress pattern σσσ (stress on the second syllable)

Of the 4,927 trisyllabic CELEX words with main stress on the penult, most have an unstressed suffix. Only 664 monomorphemic trisyllabic words of this stress pattern can be isolated; they fall into two distinct groups:

- 528 words have a schwa in their final syllable.
- 136 words have a final full vowel in this position.

Compare the following tables. There is only one word with a trimoraic stressed syllable (*Apartment*), all other words have a bimoraic stressed penult.

(74) Second syllable in trisyllabic words with stress on the second syllable

CV:	390	2μ
CVC	273 (131 ambisyllabic, 142 CVC)	2μ
CVCC	1	3μ

(75) Moraic count of the second syllable (stress pattern σόσ)

2 μ	663
3 μ	1

The unstressed syllables are bimoraic, too. There is only one word with an initial schwallable: *Renonce* 'renounce (in playing cards)'. The only initial trimoraic syllable is found in the word *Abszisse* 'abscissa'.

(76) Moraic count of the first syllable (stress pattern σόσ)

0 μ	1
2 μ	662
3 μ	1

The last syllable is either schwa or bimoraic.

(77) Moraic count of the third syllable (stress pattern σόσ)

0 μ	528
2 μ	136

Some examples of words with a final schwa are given in (78). Since these words have a regular stress pattern, we have not attempted to divide them according to their first and second syllables.

(78)

Eskorte	'escort'	Oktober	'October'
Schimpanse	'chimpanzee'	Strapaze	'strain'
Antenne	'antenna'	Banane	'banana'
Forelle	'trout'	Kaliber	'calibre'
Charakter	'character'	Kaninchen	'rabbit'
Lavendel	'lavender'		

Next consider the 136 words with a final full vowel. All of them have a final bimoraic syllable. 74 words have a final open syllable and 62 have a closed syllable in this position. The final syllables are as follows (this is an exhaustive list): there are 34 words with a final [o:] (79), 34 words with a final [a:] (80) and 6 words with a final [i:] (81). As for the final closed syllables, they are divided as follows: 11 words have final [ʊs] (82), 8 words have final [ʊm] (83), 20 have final [ɔʁ] (84), 11 words have final [ɪk] (85) and 12 have final [ɪs] (86). In the words under (a.) the second syllable is closed by its own consonant, and in (b.) it is always open. This classification will be relevant in section 3.3.2.1, where Vennemann's rules are reviewed.

(79)

a. Inferno	'inferno'	Memento	'memento'
Fiasko	'fiasco'	Flamingo	'flamingo'
Kommando	'command'		
b. Albino	'albino'	Bajazzo	'clown'
Guano	'guano'	Moskito	'mosquito'
Kasino	'casino'	Kimono	'kimono'
Lumbago	'lumbago'	Libido	'libido'
Neutrino	'neutrino'	Piano	'piano'
Risotto	'risotto'		

(80)

a. Aorta	'aorta'	Mazurka	'mazurka'
Miasma	'miasma'	Veranda	'veranda'
b. Angina	'angina'	Arena	'arena'
Dilemma	'dilemma'	Fortuna	'fortune'
Guerilla	'guerilla'	Gorilla	'gorilla'
Lametta	'lametta'	Piranha	'piranha'
Pyjama	'pyjamas'	Alpaka	'alpaca'

(81) a.	Dementi	'denial'		
b.	Alkali	'alkali'	Bikini	'bikini'
	Konfetti	'confetti'	Salami	'salami'
	Safari	'safari'		
(82) a.	Orgasmus	'orgasm'	Akanthus	'acanthus'
	Alumnus	'alumnus'	Hibiskus	'hibiscus'
	Marasmus	'marasmus'	Meniskus	'meniscus'
b.	Bazillus	'bacillus'	Hiatus	'hiatus'
	Papyrus	'papyrus'	Trochäus	'trochee'
(83) a.	Addendum	'addendum'		
b.	Adjutum	'grant'	Faktotum	'factotum'
	Futurum	'future'	Museum	'museum'
(84) a.	Inspektor	'inspector'	Instruktor	'instructor'
	Projektor	'projector'	Redaktor	'editor'
	Transistor	'transistor'		
b.	Konditor	'confectioner'	Senator	'senator'
	Kurator	'curator'	Professor	'professor'
(85) a.	Scholastik	'scholasticism'	Elektrik	'electricity'
	Semantik	'semantics'		
b.	Kosmetik	'beauty culture'	Bionik	'bionics'
	Botanik	'botany'	Keramik	'ceramics'
	Kinetik	'kinetics'	Poetik	'poetics'
	Polemik	'polemics'		
(86) a.	Galaxis	'galaxy'		
b.	Arthritis	'arthritis'	Anschovis	'anchovy'
	Bronchitis	'bronchitis'	Rachitis	'rickets'

Some of the final syllables seem to have an intrinsic (lexical) tendency to be unstressed. Compare the lists (79) - (86) with the following ones, which have the same endings in words with initial stress: There are 17 words with a final [o:] and main stress on the first syllable (87), 21 words with [a:] in their final

syllable (88), 4 words with final [i:] (89), 36 words with final [ʊm] (90), 25 words with [ʊs] (91), 4 words with [ɔʀ] (92), 7 words with [ɪs] (93) and one word with [ɪk] (94), thus corroborating the hypothesis that these syllables are lexically unstressed (some authors analyze them as suffixes). As already pointed out, all second syllables of initially-stressed vowels are open or closed by an ambisyllabic consonant.

(87)	Embryo	'embryo'	Indigo	'indigo'
	Stereo	'stereo'	Studio	'studio'
	Ultimo	'ultimo'	Gigolo	'gigolo'
(88)	Algebra	'algebra'	Gloria	'gloria'
	Kabbala	'cabbala'	Kamera	'camera'
	Cholera	'cholera'	Mafia	'Mafia'
	Media	'media'	Paprika	'pepper'
(89)	Kolibri	'humming bird'	Alibi	'alibi'
	Potpourri	'potpourri'	Sellerie	'celery'
(90)	Optimum	'optimum'	Stadium	'stage'
	Atrium	'atrium'	Barium	'barium'
	Unikum	'unique thing'	Helium	'helium'
	Gremium	'committee'	Kalzium	'calcium'
	Klinikum	'clinical training'	Morphium	'morphine'
	Publikum	'audience'	Praktikum	'training'
	Physikum	'name of the preclinical examination'		
(91)	Impetus	'impetus'	Omnibus	'omnibus'
	Abakus	'abacus'	Sozius	'partner'
	Koitus	'coitus'	Kosinus	'cosine'
	Kumulus	'cumulus'	Nuntius	'nuncio'
	Nukleus	'nucleus'	Radius	'radius'
	Terminus	'term'	Tetanus	'tetanus'
	Celsius	'centigrade'		

(92)	Editor	'editor'	Junior	'junior'
	Korridor	'corridor'	Monitor	'monitor'
(93)	Genesis	'genesis'	Klematis	'clematis'
	Klitoris	'clitoris'	Mimesis	'mimesis'
	Tenuis	'tenuis'	Syphilis	'syphilis'
	Synesis	'synesis'		
(94)	Limerick	'limerick'		

Additional support for the hypothesis that these syllables are lexically unstressed comes from the observation that there are no trisyllabic words with final stress that end in [o:] or [a:] (as compared to 30 words ending in [i:] and 18 in [e:], 12 with a nasal vowel, 3 in [y:] and 2 in [ø:]), and no words ending in [ʊm] and [ʊs]. The only counterexamples are *Republik*[17] and *Mosaik*, ending in -[i:k], *Meteor*, ending in [o:ʁ], and *Paradies*, ending in [i:s]. The final vowel in these words is stressed and long.

There is a clear trend for final [a] and [o] to be unstressed and for [e], umlauted and nasal vowels to be stressed, though the number of words ending in such vowels is too small to allow true generalizations. [i] occurs in both stressed and unstressed positions. Compare the following tables, which count all appearing vowels in the final syllables of di- and trisyllabic words, both in stressed and in unstressed syllables.

(95) Vowels in final open syllables (detail)

		a	o	i	e	u	y	ø	nasal vowels
disyllabic	stressed	3	14	14	29	4	5	0	19
	unstressed	103	50	44	6	7	0	0	1
trisyllabic	stressed	0	0	30	10	0	3	2	11
	unstressed	55	51	10	2	2	0	0	0

[17] Also realized as [ʁepublɪk].

(96) Vowels in final open syllables

Total	a	o	i	e	u	y	ø	nasal vowels
stressed	3	14	44	39	4	8	2	30
unstressed	158	101	54	8	9	0	0	1

Summing up the results of this subsection, we may say that words with a final schwa syllable are usually stressed on the penult. In medially stressed words with a final full vowel, all three syllables are bimoraic. They have a final open or closed syllable. However, the final syllables which occur seem to be restricted to a small group which has been exhaustively listed above.

3.3.1.3 Stress pattern σσσ́ (stress on the last syllable)

Of the 1,823 items with main stress on the last syllable in CELEX, there remain 393 words after the elimination of complex words, proper names, etc. Many finally-stressed words do not allow an unambiguous classification as monomorphemic or polymorphemic, because many endings look like derivational suffixes, although there is no free morpheme which can serve as a basis. It may be the case that the cut made here is too radical, and the number of 393 is too small; but the reverse may equally well be true. Some ambiguous cases are listed in (97).

(97)	Polizei	'police'	Allergie	'allergy'
	Allianz	'alliance'	Audienz	'audience'
	Dokument	'document'	arbiträr	'arbitrary'
	feminin	'feminine'	Amateur	'amateur'
	Kapital	'capital'	Katholik	'Catholic'
	Majestät	'Majesty'	Manifest	'manifesto'
	redundant	'redundant'	Sektion	'section'
	Kompromiß	'compromise'	Version	'version'
	Antiquar	'antiquarian bookseller'		

It has been observed in the preceding section that some final syllables, like *-us, -um, -ik, -is, -or, -a,* or *-o*, have a tendency to be unstressed. But the

opposite seems to be true, too: some final syllables have a tendency to be stressed. Most of these syllables are trimoraic and have a long vowel and one consonant ([a:r], [e:t], [i:l], [i:r], [i:n], [o:m], [o:n], [o:p]) or a short vowel and two (or more) consonants ([ant], [ants], [ɛnt], [ɛnts]), but some are bimoraic and have only a short vowel and a consonant or a glide ([ɛt], [aɪ̯]). Recall the discussion of these syllables in section 3.2.2.

Compare the following tables, which review the syllabic and moraic composition of the third syllable.

(98) Last syllable in trisyllabic words with stress on the last syllable

CV:	66	2μ
CVC	28 (all true CVC)	2μ
CV:C	225	3μ
CVCC	74	3μ

(99) Moraic count of the third syllable (stress pattern σσό)

2 μ	94
3 μ	299

As in disyllabic words, a final stress occurs predominantly on trimoraic syllables, which suggests quantity-sensitivity.

The first two syllables are generally bimoraic, though there are some exceptions in the first syllable. It is trimoraic in a few rare words like *Transvestit* 'transvestite'. The second syllable is always bimoraic.

Examples of words with a final bimoraic syllable are given in (100). They are followed by words with a final trimoraic syllable, first with a long tense vowel and one consonant in (101), and then with a short lax vowel and two consonants in (102).

(100)				
	Omelett	'omelette'	Avenue	'avenue'
	Jalousie	'venetian blind'	Assemblee	'assembly'
	Kompromiß	'compromise'	Etikett	'label'
	Karusell	'merry-go-round'	Kotelett	'chop'
	Kabarett	'cabaret'	Négligé	'négligé'
	Rhapsodie	'rhapsody'	Theorie	'theory'

(101)				
	Apparat	'apparatus'	Appetit	'appetite'
	Domizil	'domicile'	Heroin	'heroin'
	Kormoran	'cormorant'	Katalog	'catalogue'
	Meteor	'meteor'	Perspektiv	'telescope'
	Paradies	'paradise'	Vitamin	'vitamin'
	Syndikat	'syndicate'		

(102)				
	Artefakt	'artefact'	Architekt	'architect'
	Katafalk	'catafalque'	Diamant	'diamond'
	Fundament	'foundations'	Testament	'will'
	Manuskript	'manuscript'	Obelisk	'obelisk'
	Redundanz	'redundancy'	Vagabund	'vagabond'

The final two consonants are usually coronals, or at least one of them is. In finally-stressed words, too, there are no words with a medial trimoraic syllable.

Thus, in trisyllabic words with final stress, the final syllable is often, indeed in three quarters of the cases, trimoraic. However, it looks as if the final stressed syllables are somehow lexicalized. The preceding syllables are bimoraic.

3.3.1.4 Summary

The weights of stressed syllables in trisyllabic words are compared in the following tables:

(103) Weight of stressed syllables in trisyllabic words

	CVC(amb)	CVC	CV:	CV:C	CVCC
Stress on 1st syllable	32	94	128	1	0
Stress on 2nd syllable	131	142	390	0	1
Stress on 3rd syllable	0	28	66	225	74
Total	163	264	584	226	75

(104) Moraic count of stressed syllables in trisyllabic words

	2μ	3μ
Stress on 1st syllable	254	1
Stress on 2nd syllable	663	1
Stress on 3rd syllable	94	299
Total	1011	301

The following generalizations about the stress patterns of trisyllabic words arise from this overview:
1) The stressed syllable is bimoraic when nonfinal, and mostly trimoraic when final.
2) Trimoraic syllables are found almost exclusively in final position.
3) When the last syllable is a schwallable, stress is on the penult.
4) If the penult is closed by its own consonant, stress is on the penult or on the final syllable, not on the antepenult.
5) In words with penultimate stress, the final syllable is often lexically unstressed.
6) In words with final stress, the final syllable is often lexically stressed.

3.3.2 Theoretical account

3.3.2.1 Vennemann's (1986, 1992) rules

Before an optimality-theoretic account of trisyllabic words is given in section 3.3.2.2, this section will review Vennemann's (1986, 1992) approach to word stress. His generalizations about German stress rules are entirely confirmed by the data. However, we propose a slight reformulation of the Penult Rule which reflects the data more adequately than Vennemann's original formulation. Vennemann (1986:30) formulates two German word stress rules, both of which are relevant for trisyllabics with initial main stress.

(105) Vennemann's (1986) first German Word Stress Rule
If the penultima of a monomorpheme is unreduced and closed, antepenultimate accent is impossible.[18]

(106) Vennemann's (1986) second German Word Stress Rule
If the penultimate of a monomorpheme is unreduced and the ultima is reduced, [ante CF]penultimate accent is impossible.[19]

In Vennemann (1992: 406) there appear four word stress rules,[20] two of which, the 'Reduced Syllable Rule' formulated in (107) and the 'Penult Rule' in (108), replace his first and second German Word Stress Rules.

(107) Vennemann's (1992) PENULT RULE
The accent does not retract beyond a heavy penult.

(108) Vennemann's (1992) REDUCED SYLLABLE RULE
A covered reduced ultima arrests the accent on the last full syllable.

Let us first examine the significance of the second rule, expressed in (106) and (108). Both in its 1986 and in its 1992 formulation, the rule says something about words with a final schwa syllable and a penult with a full vowel. It claims that in such words, the penult is stressed and antepenultimate stress is impossible. The 1992 formulation adds 'covered', which means that the rule does not concern words with a naked final syllable and a hiatus like *Bestie* and *Requiem*. As already extensively shown, this rule has considerable predictive power. The 18 words listed in (66) and repeated here are the only trisyllabic exceptions. On the other hand, 528 words conform to the rule in having penultimate stress and a final schwallable.

[18] The German original reads: 'Ist die Pänultima eines Simplex unreduziert und geschlossen, so ist Präpänultimaakzent unmöglich.'
[19] In the original: 'Ist die Pänultima eines Simplex unreduziert und die Ultima reduziert, so ist Pänultimaakzent unmöglich.' There is an obvious typo in this formulation. It should read: 'Ist die Pänultima eines Simplex unreduziert und die Ultima reduziert, so ist PRÄpänultimaakzent unmöglich.'
[20] The two other rules are the Full Syllable Rule ('Only full syllables can be accented.'), which does not require much comment, and the Three Syllable Rule, discussed in section 3.4.

(66)	Berserker	'berserker'	Roboter	'robot'
	Manager	'manager'	Araber	'Arab'
	Presbyter	'presbyter'	Teenager	'teenager'
	Management	'management'	Bulldozer	'bulldozer'
	Eidechse	'lizard'	Hebamme	'midwife'
	Einöde	'barren waste'	Herberge	'inn'
	Brosame	'crumb'	Alkoven	'alcove'
	Almosen	'alms'	Mobile	'mobile'
	Systole	'systole'	Ameise	'ant'

The following twelve quadrisyllabic words are counterexamples, too. But 209 quadrisyllabic words conform to the Reduced Syllable Rule.

(109)a.	Kuddelmuddel	'muddle'
	Abenteuer	'adventure'
	Knickerbocker	'knickerbockers'
	Pampelmuse	'grapefruit'
	Pumpernickel	'pumpernickel'
	Tingeltangel	'night-club'
	Konterbande	'contraband'
	hanebüchen	'outrageous'
b.	Apokope	'apocope'
	Apostrophe	'apostrophe'
	Kantabile	'cantabile'
	simpliciter	'absolutely'

The examples in (66) and (109) show that penultimate stress in these words is not impossible (Vennemann (1992:406) says: 'I know of no exceptions'), but just exceptional. Since the exceptions are so few, it can be concluded that the Reduced Syllable Rule makes the right predictions for German.[21]

[21] Kager (1989), who observes the same generalization in Dutch, proposes a derivative account for syllabification. In a first step, the syllable preceding schwa is systematically heavy in having the onset of the schwallable as part of its coda. At this stage, schwa is not syllabified. In a second step, after stress assignment has taken place, resyllabification applies: schwa is syllabified and the segment(s) preceding it form the onset of this last syllable.

Now for the Penult Rule, formulated in (105) and (107). This rule predicts that an initial stress in trisyllabic monomorphemes (or more generally antepenultimate stress in polysyllabic words) is not possible if the medial or penultimate syllable is heavy (or closed in Vennemann's 1986 analysis). In this case, the main stress is on the final syllable, if heavy, or otherwise on the penultimate. So it should not be possible to find words with a closed penult and antepenultimate stress.

There are two kinds of counterexamples to the Penult Rule. First, in (110), the second syllable is closed by its own consonant and should therefore attract stress. But in fact, the stress is on the first syllable.

(110)	Máßholder	'maple'	Élektron	'electron'
	Ámeise	'ant'	Bérserker	'berserker'
	Élritze	'minnow'	Hérberge	'inn'
	Gábardin	'gabardine'	Tríangel	'triangle'
	Áttentat	'assassination'	Kábeljau	'cod'
	Mánagement	'management'		
	Kónterbande	'contraband'		
	Parádoxon	'paradox'		
	Súbjunktiv	'subjunctive'	Ádjektiv	'adjective'
	Kónjunktiv	'subjunctive'		

The words listed in (110) are irreducible and would probably count as exceptional in every analysis, because the penultimate syllable is closed by its own consonant, and such syllables almost always attract stress. The last three examples are taken from a paradigm: grammatical words have stress on the first syllable (Vennemann 1992 and Jessen 1994 among others). Six words have a final schwa syllable, and are thus also exceptions to the Reduced Syllable Rule just discussed. *Konterbande* is quadrisyllabic and is explained away as a compound by some authors.

The need for a reformulation of the rule becomes apparent with the second kind of exception. Vennemann considers lax vowels ('abruptly cut' in his terminology, see Chapter 2) to be the nuclei of heavy syllables, because at the phonetic level such syllables are automatically closed by a consonant (and a closed syllable is always heavy). On the other hand, tense vowels

project open and thus light syllables. This implies that, according to the Penult Rule, words with a penultimate tense vowel can be stressed on the antepenultimate syllable, but words with a penultimate lax vowel can not be. However, in unstressed positions, it is extremely dificult to determine if a vowel is lax or tense. In our list of 255 trisyllabic monomorphemes with initial stress, 136 words have a short medial vowel and the other 96 words have a light penult (with a medial schwa, as in *Kámera, Séllerie, Fírlefanz,* in 14 words) or an open second syllable, partly glided, as in *Fébruar, Pínguin* and *Médía* (in 82 words). Compare the following words.

(111)	Ókzident	'Occident'	Ómnibus	'omnibus'
	Optimum	'optimum'	Spekulum	'speculum'
	Stimulus	'stimulus'	Ypsilon	'y'
	Gigolo	'gigolo'	Ablativ	'ablative'
	Ananas	'pineapple'	Abakus	'abacus'
	Festival	'festival'	Handicap	'handicap'
	Positron	'positron'	Roboter	'robot'
	Champignon	'mushroom'		
	Bräutigam	'bridegroom'		
	Nachtigall	'nightingale'		
	Pumpernickel	'pumpernickel'		

In Duden (Drosdowski 1981) most of these words are transcribed with a tense vowel and are thus no exceptions to the Penult Rule. *Nachtigall, Bräutigam* and *Pumpernickel* are transcribed with a lax vowel (also *Paradoxon,* which has been classified with the words with a closed penult), and should be considered as exceptions.

In the terminology introduced in this study, open syllables and syllables closed with an ambisyllabic consonant have the same weight. We propose replacing the notion of heaviness in the original formulation of the Penult Rule by the notion of 'closed by its own consonant' or true CVCs. True CVC penults arrest the accent. The Penult Rule is replaced with the following rule:

(112) Closed Penult Rule

Stress does not retract beyond a true CVC penult.

This reformulation accounts for the fact that open syllables and syllables consisting of a lax vowel and an ambisyllabic consonant behave in the same way. They do not arrest stress. In contrast, syllables closed by their own consonant do arrest stress (except for the exceptions listed in (110)).

In Dutch, the same asymmetry between open and closed penults has been observed (Kager 1989, Lahiri & Koreman 1988, Nouveau 1994, Trommelen & Zonneveld 1994, Van der Hulst 1983 among others).[22] Kager's first major generalization about Dutch primary stress[23] says: "Primary stress cannot be on the antepenult, if the penult is closed and contains a full vowel, or if the penult contains a diphthong." Moreover, if the penult is open, two cases must be distinguished, for which Kager (1989: 227) formulates two minor generalizations:

- Words with final closed short vowel syllables have antepenultimate stress.

- Words with open final syllables have penultimate primary stress.

These generalizations predict the patterns in (113) and (114) respectively:

(113) .... ó σ σ
CV: CVC

(114) ... σ ó σ
CV: CV:

In sum, two asymmetries are claimed to exist in Dutch: first, the contrast between open and closed syllables in penultimate position: closed syllables arrest stress, whereas open syllables allow stress to retract to the initial syllable. This contrast exists in German, too. Second, the asymmetry shown

[22] Trommelen & Zonneveld (1994:2-3) write: "The principal generalization indicative of quantity-sensitivity is that main stress is allowed to reach the antepenultimate syllable only if the prefinal syllable is open, not if it is closed. Compare *ál.co:hol* and *Cá:na:da* with *rododéndron* and *esperánto* (never **ródódendron* or **espéranto*)." If we try to apply this distinction to German, the predictions made by this characterization turn out to be exactly the same as those made by Vennemann, since Trommelen & Zonneveld consider syllables with a final ambisyllabic consonant as closed; as a consequence, the same exceptions as before are exceptions to this generalization.

[23] The two others are: 1. Primary stress is within a three-syllable window at the righthand word edge. 2. Primary stress is directly before a schwallable – if the schwa is preceded by a consonant.

in (113) and (114): antepenultimate stress is possible only if the final syllable is closed and the penult is open, but if both final syllables are open, the stress tends to be on the penult. This contrast is also found in German, but to a considerably smaller extent. The words in (111) conform to pattern (113) and those in (79b), (80b) and (81b) (*Albino, Angina, Alkali*) to pattern (114). However, in many cases the closedness vs. openness of the last syllable does not play any role in the stress placement in trisyllabic words. Two types of counterexamples illustrate this. First, (82b) to (86b), reproduced here, list words with final closed syllables, penult open, but stress on the penult, which are hence counterexamples to (113).[24] Second, (71b) lists words with open last and penultimate syllables, but stress on the initial syllable, which are thus counterexamples to (114). This list is also reproduced here. In German, there is only a tendency for words of the syllabic pattern of (113) to be stressed on the initial syllable; we do not think that this is in need of an explanation.

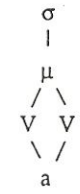
(82) b.	Bazíllus	'bacillus'	Hiátus	'hiatus'
	Papyrus	'papyrus'	Trochäus	'trochee'
(83) b.	Adjútum	'grant'	Faktótum	'factotum'
	Futurum	'future'		
(84) b.	Kondítor	'confectioner'	Senátor	'senator'
	Kurátor	'curator'	Professor	'professor'
(85) b.	Kosmétik	'beauty culture'	Biónik	'bionics'
	Botanik	'botany'	Keramik	'ceramics'
	Kinetik	'kinetics'	Poetik	'poetics'
	Polemik	'polemics'		
(86) b.	Arthrítis	'arthritis'	Anschóvis	'anchovy'
	Bronchitis	'bronchitis'	Rachitis	'rickets'

[24] If the final syllable of these words are analyzed as suffixes (like for instance by Vennemann 1992), they do do not count as counterexamples, since (113) only holds for monomorphemes. However we do not analyze these syllables as suffixes.

(71) b.	Gígolo	'gigolo'	Ámphora	'amphora'
	Índigo	'indigo'	Chólera	'cholera'
	Kolibri	'humming bird'	Kanapee	'sofa'
	Marabu	'marabou'	Mobile	'mobile'
	Cembalo	'harpsichord'	Paprika	'pepper'

The asymmetry between closed and open penults expressed by the Penult Rule is more intriguing and remains to be explained. It has been proposed that Dutch VC-syllables are heavy, whereas V:-syllables are light, as in Vennemann's proposal for German. The problem is how to express this difference. Lahiri & Koreman (1988) argue that the moraic distinction does not extend to open syllables, since vowels are never short in this environment, and they propose that vowel length contrast is made by skeletal positions, not by mora count. Thus vocalic length and vocalic weight are properties of two different levels (or 'tiers'): length is represented by the skeleton, and weight by the moras. A long vowel is monomoraic, but it is associated with two skeletal positions. On the other hand, closed syllables are bimoraic and are also associated with two skeletal positions.

(115) i.



ii.

However, contrary to the predictions made by the analysis, the contrast between V:C and VC does lead to weight differences in final positions. For this reason, Kager (1989) rejects Lahiri & Koreman's proposal and instead proposes anchoring the distinction between open and closed syllables' weights in the melodic complexity of the syllable. (116i) is light since both moras are linked to the same root node, and (116ii) is heavy because the two moras are associated with different segments. Diphthongs are predicted to be heavy, because they are melodically complex (Kager analyzes them as a sequence of two vowels). Thus, according to Kager's proposal, it is no longer moras that define the syllable's weight, but rather skeletal positions.

(116) i.

ii.

The solution advanced here is a mixture of Lahiri & Koreman's, Kager's and Hayes's (1995) proposals. In accordance with Kager, syllables with full vowels are always bimoraic with respect to their syllable's structure. But we think that Lahiri & Koreman are right in expressing the weight difference in moras: unstressed syllables can be monomoraic. This looks like an irreducible paradox: open syllables can be both bimoraic and monomoraic. To resolve this paradox, we propose that the moraic structures for syllable formation and for stress can be different. In unstressed position, a bimoraic tense vowel and a syllable closed by an ambisyllabic consonant can 'lose' a mora as far as the stress pattern is concerned. On the other hand, a syllable closed by its own consonant is always bimoraic, with respect to both the syllable structure and the stress pattern. Let us illustrate this proposal.

Paprika is transcribed in Duden with a tense [i], which, according to the analysis so far, is bimoraic and stands in an open syllable. But one of the moras is 'lost' for stress. Syllable node and metrical grid are on two different levels of the representation. However, both are sensitive to the number of moras associated with the segments. Since syllables consist of at least two moras, both moras of [i] are associated with the syllable node. A metrical grid position, on the other hand, can be projected from only one mora, as long as it is not the strongest of its foot (see below). A medial unstressed open syllable or one that is closed by an ambisyllabic consonant projects only one mora to the grid position. (117) and (118) illustrate this. Both moras associate with the syllable node, but only one projects a metrical grid.

(117)

Papri ka [i]

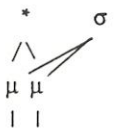
Bräutigam has a medial lax [ɪ], which is monomoraic and cannot stand in an open syllable. The ambisyllabic consonant closing this syllable is attached to the syllable node, but not to the grid position, as in *Paprika*.

(118)

Bräuti g am [ɪ]

In a syllable closed by its own consonant, this option is not possible. Both the vowel's and the consonant's moras must be associated to the syllabic node. This is illustrated by the second syllable of *Veranda* in (119).

(119) i.



Vera n da

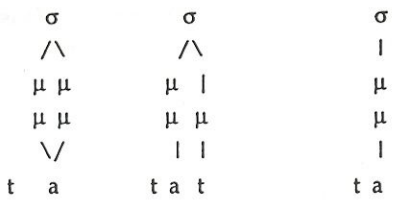
* ii.

Vera n d a

Though the metrical grid is at play here and not the syllable structure, loss or non-attachment of a mora is only possible if the segment it is associated with is parsed in some other way: the vowel of the medial syllable in *Paprika* still has a mora, and the ambisyllabic consonant [g] of *Bräutigam* is the onset of the following syllable. In contrast, if [n] in *Veranda* loses its mora, no other affiliation for this segment remains. It must be concluded that the metrical grid is sensitive to the segmental composition of the syllables it is projected from, and not only to the number of moras in each syllable. Some facts mentioned in the literature find a natural explanation in this analysis. The medial unstressed vowel of words like *Gígolo, Páprika, Léxikon, Ánanas* etc. is neutralized in its tenseness. It can even become a schwa as in the examples mentioned by Vennemann (1992:401): *Mol[ə]kül, App[ə]rat, Asp[ə]rin, Lok[ə]motive, Käng[ə]ruh, Aph[ə]rese, Di[ə]zese, am[ə]sieren.*

In accounting for these two criteria of weight, as attested by different languages, like Ancient Greek (Steriade 1990), Tübatulabal (Crowhurst 1990), etc., Hayes (1995), proposes that some languages have two layers of moras:

(120) a. CV: b. CVC c. CV



The interesting case is (120b), in which CVC can be heavy or light. According to Hayes, some processes refer to the lower layer of moras, in which the syllable is heavy, whereas some other processes refer to the higher layer, where the syllable behaves as if it were light. A similar duality is at work in German. CVC (ambisyllabic) and CV: syllables are bimoraic ('heavy') for syllable structure, as has been demonstrated in Chapter 2. But, in unstressed position, they are monomoraic. However, whereas Hayes needs two layers of moras, only one is necessary in our proposal. It is the same moras that represent both syllable composition and weight.

A question that arises in relation to the stressability of closed vs. open syllables is why the distinction is confined to medial penultimate syllables. If closed syllables are heavy and open syllables are light as assumed by many phonologists, shouldn't we be able to find a difference in the stressability of these syllables in more than just one context? In particular, a difference of weight should be felt in disyllabic words, too. However, at least in German, this is not the case. 266 initially-stressed words have an open first syllable and 289 have a closed one (22 have a trimoraic syllable). The second syllable is open in 210 words and closed in 279. In finally stressed words, the first syllable is open in 329 and closed in 572 cases. And, crucially, the second syllable is open in 87 words and closed in 108 ones (there are 723 overlong syllables in this context). Thus, the data do not allow us to assume a weight difference between open and closed syllables in disyllabics, since the number of closed vs. open syllables both in stressed and unstressed positions does not differ significantly. Only the trimoraic (overlong) syllables attract stress and are thus regarded as heavier. Moreover, neither the initial nor the final position of trisyllabics allows us to distinguish between open 'light' syllables

and closed 'heavy' syllables (compare words like *Jalousie, Theorie* , on the one hand, to *Omelett, Kompromiß* on the other).

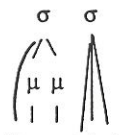
The confinement of the distinction to medial penults must therefore derive from the fact that peripheral syllables (both initial and final) have a certain amount of stress. For example, final open unstressed syllables have half-long vowels (instead of short ones). Only medial syllables are able to be completely unstressed in German, and be metrically monomoraic.

The following section gives an optimality-theoretic account of the stress pattern of trisyllabics.

3.3.2.2 Optimality account

The trisyllabic words confirm the properties of German word stress presented in sections 1 and 3.2.2 of this chapter. Let us first review the different stress patterns, starting with the regular ones.

1. Words with initial stress and a hiatus between the second and third syllables which are usually pronounced as disyllabics.[25]



(121) a. x Bestie [bɛ s. tʲiːə] 'beast'
(x .)

b. x Studium [ʃ t u . dʲʊ m] 'studies'
(x .)

[25] These words can also be pronounced as trisyllabics. We assume that both the syllabic and the nonsyllabic versions of the high vowel can serve as inputs.

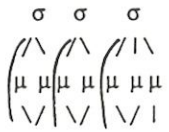
2. Stress on the medial syllable. In this case, stress is always regular: the last syllable is a schwa (122a) or a bimoraic syllable (122b), but never a trimoraic syllable.

(122) a. Sekunde — x / (x) (x .) — [z e . k ʊ n . d ə] — 'second'

b. Pyjama — x / (x)(x .) — [p y . ʤ ɑ . m ɑ] — 'pyjamas'

3. Stress on the last syllable. This stress pattern is regular when the last syllable is trimoraic and forms its own foot. There is a secondary stress on the first syllable.

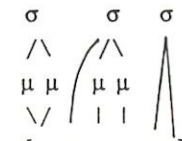
(123) Vitamin — x / (x .) (x) — [f i . t a . m i n] — 'vitamin'



Now for the irregular patterns:

4. Initial stress in 'real' trisyllabics (without hiatus, or with hiatus when the first involved vowel is not glided). The second syllable is open or closed by an ambisyllabic consonant in the vast majority of the cases. Two different footings are possible. First, the last syllable is extrametrical and a foot is erected on the first two syllables (124). Second, the initial stress is prespecified. In this case, the first and second syllables form a foot together, and the last syllable is footed on its own (125a). Or, if the last syllable has a schwa, the second and third syllables are footed together (125b). In this case, the first syllable forms its own foot.

(124) a. Papri<ka> — x / (x .) — [p a p ʁ i . k a] — 'pepper'



b. Amei<se> — x / (x .) — [ɑ . m a ɻ . z ə] — 'ant'

x
(x .)(x)

(125) a. Paprika

x
(x)(x .)

b. Ameise

5. Final stress on a bimoraic syllable. In this case, stress is lexically prespecified.

(126) Karusell — x / (x .) (x) — [k a ʁ̩ ʊ ʂ ɛ l] — 'merry-go-round'

The same constraints that were used for *Farbe* and *Mammut* (Tableaux 1 and 2 in section 3.2.2) account for the first regular pattern in the disyllabic realization of *Bestie* and *Studium*. The optimal candidates fulfill all relevant constraints. The only difference between Tableau 8 and Tableau 9 comes from the fact that the last syllable's nucleus in *Bestie* is a schwa, whereas it is a full vowel in *Studium*. In Tableau 8 candidate b. violates FOOT-BINARITY

because the last syllable is nonmoraic, whereas in Tableau 9 it does not. In both tableaux, candidates b., c. and d. violate ALIGN-TROCHEE-RIGHT.

μ | /bɛstʲə/ *Bestie*	FOOT-BINARITY	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	FOOT-FORM (TROCHAIC)
a. (x .) ☞ Bes.tie				
b. (x) (x) Bes tie	*!	*		**
c. (. x) Bestie		*!		*
d. (x) Bes tie		*!		*

Tableau 8

μ μ μ \/ | /ʃtudjʊm / *Studium*	FOOT-BINARITY	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	FOOT-FORM (TROCHAIC)
a. (x .) ☞ Studium				
b. (x) (x) Stu dium		*!		**
c. (. x) Stu dium		*!		*
d. (x) Stu dium		*!		*

Tableau 9

The second regular pattern, exemplified by the words *Sekunde* and *Pyjama* in (122), is the most regular. It consists of two feet, one disyllabic and one monosyllabic.

In the case of *Pyjama*, ALIGN-TROCHEE-RIGHT is active in forcing the unique syllabic trochee at the right edge of the word rather than at the left

edge. Compare the candidates in Tableau 10. Candidate b., which has the syllabic trochee at the left edge of the word, is eliminated by ALIGN-TROCHEE-RIGHT. Candidate c. has no trochee word finally and is also eliminated by ALIGN-TROCHEE-RIGHT. Candidate d. violates FOOT-BINARITY in having a ternary foot.

μ μ μ μμ μ \/ \/ \/ /pydʒamɑ/ *Pyjama*	FOOT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCHAIC)
a. x (x) (x .) ☞ Py jama					*
b. x (x .) (x) Pyja ma		*!			*
c. x (x)(x) (x) Py ja ma		*!			***
d. x (. x .) Pyjama	*!	*			*

Tableau 10

Consider next Tableau 11 for *Sekunde*. Candidate a. violates none of the constraints, except for one violation of FOOT-FORM (TROCHAIC) and is thus optimal. Candidate b. has no foot on the first syllable and thus violates ALIGN-FOOT-LEFT. Candidates c. and d. both violate FOOT-BINARITY and ALIGN-TROCHEE-RIGHT. Candidate c. also violates ALIGN-HEAD.The option of forming a syllabic trochee at the beginning of the word, shown in candidate e., is already eliminated by ALIGN-TROCHEE-RIGHT.

μ μ μ \/ | /zekʊndə/ *Sekunde*	FOOT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCHAIC)
a. x (x) (x .) ☞ Se kunde					*
b. x (x .) Se kunde			*!		*
c. x (x) (x) (x) Se kun de	*!	*		*	*<*
d. x (. x .) Sekunde	*!	*			*
e. x (x .) Sekunde		*!			

Tableau 11

We now turn to the third regular pattern: stress on the final trimoraic syllable. In *Vitamin*, too, two feet are erected. Since the last syllable is trimoraic, it forms its own foot by projecting two grid positions.

Tableau 12 illustrates the word *Vitamin*. Candidate a. fulfills all constraints. All other candidates violate one or more constraints.

μ μμ μμ μ \/\/ \/ /fi tamin/ *Vitamin*	3 μ =2**	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCHAIC)
a. x (x .)(x.) ☞ Vita min						
b. x (x .) (x) Vita min	*!		*			*
c. x (. x) (x.) Vita min						*!
d. x (x)(x .) Vi tamin	*!					*
e. x (x) (. x .) Vi tamin		*!	*			**

Tableau 13

Consider next the irregular stress patterns. As in the disyllabic words, there are two irregular patterns: initial stress as illustrated by words like *Paprika* and *Ameise* and *Studium* and *Bestie* in their trisyllabic pronunciations, and final stress on a bimoraic syllable.

We will examine initial stress first. There are two possible accounts for these words and each is reviewed in turn. First, the final syllable of *Paprika* can be analyzed as extrametrical. Extrametricality is hotly debated in OT. Prince & Smolensky (1993:52) propose replacing it with a constraint NONFINALITY, which puts the emphasis on the non-stressability of the final syllable (as in Latin, for example) and not on its prosodic status.

(128) NONFINALITY

No head of PrWd is final in PrWd.

Hung (1993) proposes explaining extrametricality (final stresslessness in her terminology) by the interaction of two constraints, RHYTHM and PARSE.

(129) RHYTHM

A stressed element must be followed by an unstressed element.

(130) PARSE

A prosodic constituent is dominated by a prosodic constituent of the immediately superordinate type.

RHYTHM has basically the same effect as NONFINALITY for explaining extrametricality. PARSE is strongly parameterized: in the tableau below the unparsed Foot is not part of the PrWd (the immediately higher constituent in the prosodic hierarchy) and therefore cannot have a head (but it is phonetically realized). If RHYTHM is higher-ranked than PARSE, then extrametricality (non-parsing) is the result.

	RHYTHM	PARSE (FOOT)
... (σσ) #	*	
... < (σ σ) > #		*

Tableau 14

However, this proposal, as well as that of Prince & Smolensky for Latin, presupposes that the stress pattern is consistent across all words in the language under investigation. This is not the case for German. In German, some words with three bimoraic syllables have stress on the first syllable (*Páprika, Álbatros*) while others have penultimate stress (*Gorílla, Arthrítis*) or final stress (*Assemblée, Garantíe*). In our first explanation, exceptionality of two of these patterns is assumed, in the form of prespecified 'templates'. A new parameterization of FAITH, formulated in (131) accounts for the preservation of prespecified extrametricality, as shown in (124), and it is called FAITHEX to distinguish it from the former FAITH which preserves prespecified grid positions (55)..

(131) FAITH (Extrametricality)

PARSEEXTRAMETRICALITY: All input extrametricality is preserved.

Tableau 15 illustrates different candidates for the metrical structure of *Paprika*. In order to fulfill high-ranking FAITHEX, the optimal candidate violates ALIGN-TROCHEE-RIGHT. Since there is only one syllabic trochee, and since it is initial in the Prosodic Word, ALIGN-FOOT-LEFT is fulfilled.

μ μ μμ μ | \/\/ /paʁi k ɑ /Papri<ka>	FAITH EX	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) ☞ Papri<ka>			*			
b. x (x) (x) Pa pri<ka>			*			*!*
c. x (. x) Papri<ka>			*			*!
d. x (x) (x .) Pa prika >	*!					*

Tableau 15

The second explanation for 'irregular' initial stress in the trisyllabics is based on the observation that it is the medial syllable rather than the last one that does not count for the metrification. This is particularly evident in words with a hiatus like *Bestie* and *Studium* in which the second syllable can entirely disappear. But also in words like *Paprika, Braütigam, Lexikon,* etc. it is the medial syllable that reduces and can be pronounced as a schwa (Kohler 1977, Vennemann 1992). In the preceding section, it was shown that these syllables are bimoraic for the syllable structure but monomoraic for metrification. To account for this fact, we propose that the initial syllable has a prespecified main stress like the prespecified stress of *Leutnant,* an asterisk on line two, and that the final syllable forms its own foot. The medial syllable is the weak member of the initial foot. The foot structure of *Paprika* is shown in (132): the

second syllable forms a foot with the first one, and the last syllable forms a foot alone.

(132) x
(x .) (x)
Papri ka

However, the constraints introduced so far are not sufficient to choose the footing in (132) as optimal. To see this, consider the following tableau. FAITH ensures that the prespecified stress is preserved. Candidate b. fulfills ALIGN-TROCHEE-RIGHT, which is higher ranked than ALIGN- FOOT-LEFT, and should thus be optimal.

※ μ μ μμ μ x | \/\/ x /papʀi kɑ / Paprika	FAITH	ONE HEAD	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) (x) Papri ka				*!		*	*
b. x (x) (x .) ☞ Pa prika						*	*

Tableau 15'

Before a new constraint is introduced to account for the metrification of *Paprika*, consider a word with lexical stress on the first syllable and final schwa like *Ameise* which conforms to the constraints used so far. This is because the final schwa syllable is not heavy enough to form its own foot and is grouped together with the second syllable.

(133) x
(x)(x .)
Ameise

This footing is forced both by FOOT-BINARITY and by ALIGN-TROCHEE-RIGHT, as shown in the following tableau. Though candidate a. violates ALIGNHEAD, it fulfills FAITH and this is crucial. Candidate b. violates FOOT-BINARITY and candidate c. ALIGN-TROCHEE-RIGHT; they are thus eliminated.

μ μ μ x \/ | x /ɑmaɪzə / Ameise	FAITH	ONE HEAD	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x) (x .) ☞ A meise						*	*
b. x (x .) (x) Amei se			*!	*		*	*
c. x (x .) Amei se				*!			

Tableau 16

It remains to be explained why *Paprika* does not have the same pedification as *Ameise*, i.e. (Pá)(prìka). For the reasons mentioned before, the footing in (132) and in Candidate b. of Tableau 15 is preferable. A constraint must express the fact that after main stress, the adjacent syllable is less stressed than the final one. This constraint, which we call MEDIALWEAK, must be ranked before ALIGN-TROCHEE-RIGHT to prevent the formation of a trochee on the right edge. This constraint has no effect on words with a regular main stress on the medial syllable (*Pyjáma*), but only on medial unstressed syllables.

(134) MEDIALWEAK
A medial unstressed syllable is weaker than a peripheral full syllable.

In the following tableau, the effect of MEDIALWEAK is shown. Only in candidate a. is the medial syllable weaker than the peripheral one. In candidate b. the medial syllable is the head of the foot of which the final

syllable is the weak member, and in candidate c., the last syllable is not footed. In this case, too, MEDIALWEAK is violated.

μ μ μμ μ x | \/\/ x /papʀi k ɑ / Paprika	FAITH	MED WEAK	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) (x) ☞ Papri ka			*		*	*
b. x (x) (x .) Pa prika		*!			*	*
c. x (x .) Papri ka		*!	*			*

Tableau 17

The second explanation for the stress pattern of *Paprika* is superior to the first one because it accounts for the fact that the second syllable is less stressed than the final one. In the first explanation, which uses extrametricality, the last syllable does not count for metrification, contrary to the phonetic facts.

The last stress pattern, with a final bimoraic stressed syllable as in *Karusell*, involves a lexically prespecified stress on a final bimoraic syllable, similarly to the disyllabic *Spinett*. The first two syllables build a foot together in accordance with ALIGN-FOOT-LEFT. In Tableau 18, the winning candidate a. has two feet, the first of which comprises the first two syllables, and the second one being the last syllable. This candidate violates ALIGN-TROCHEE-RIGHT and FOOT-FORM (TROCHAIC) only once. Candidate b. violates FAITH, ALIGN-TROCHEE-RIGHT, ALIGN-HEAD and FOOT-FORM (TROCHAIC), and candidate c. violates ALIGN-TROCHEE-RIGHT, and crucially FOOT-FORM (TROCHAIC) twice.

μ μ μ x | | | x /kaʀusɛl / Karusell	FAITH	FT-BIN	MED WEAK	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) (x) ☞ Karu sell				*		*	*
b. x (x .) (x) Karu sell	*!			*			*
c. x (x) (. x) Ka rusell				*			**!

Tableau 18

This completes the analysis of the stress patterns of trisyllabic words. The trisyllabic words are largely accounted for by the same constraints used for the disyllabic words. Only one additional constraint has been introduced in this section, MEDIALWEAK, which takes care of the second syllable in initially-stressed trisyllabic words.

3.4 Words with more than three syllables

3.4.1 Survey of data

3.4.1.1 Quadrisyllabic words

It turns out that the results obtained so far are confirmed by words of four or more syllables. Let us consider quadrisyllabic words first. CELEX lists about 19,400 of them, only 991 of which are monomorphemes, which can be divided into the following stress patterns:

- σσσσ: 17 words with stress on the first syllable
- σσσσ: 101 words with stress on the second syllable

- σσόσ: 273 words with stress on the penultimate syllable
- σσσό: around 590 words with stress on the final syllable

Of the 17 quadrisyllabic monomorphemic words with main stress on the first syllable, 9 are linguistic terms and the remaining 8 look like compounds. These latter words already served as counterexamples to Vennemann's Reduced Syllable Rule in section 3.3.2.1 and are repeated here.

(134)a.	Imperativ	'imperative'	Indikativ	'indicative'
	Akkusativ	'accusative'	Infinitiv	'infinitive'
	Superlativ	'superlative'	Nominativ	'nominative'
	Komparativ	'comparative'	konsekutiv	'consecutive
b.	Kuddelmuddel	'muddle'	Abenteuer	'adventure'
	Knickerbocker	'knickerbockers'	Pampelmuse	'grapefruit'
	Pumpernickel	'pumpernickel'	Tingeltangel	'night-club'
	Konterbande	'contraband'	hanebüchen	'outrageous'

The rarity of quadrisyllabic monomorphemes with initial stress confirms the three-syllable-window rule (Wurzel 1970, Giegerich 1985, Vennemann 1986, 1992, Jessen 1994, Yu 1992, etc.), formulated by Vennemann as in (135). The fact that the words in (134b) contain two schwa syllables makes them in a way exceptional, but not in terms of (135), which explicitly excludes words with schwa syllables from the rule's structural description anyway.

(135) Vennemann's (1992:406) THREE SYLLABLE RULE
Only the last three full syllables can be accented.

Since schwa syllables do not count, the words in (b) conform to the rule, but the words in (a) do not; however, these words belong to a clearly delimited class and can be considered as the exceptions that confirm the rule.

Consider now the words in (134b). Jessen (1994:24) analyzes them as potential counterexamples to Vennemann's Three Syllable Rule and comments:

> In most of the words in [134b] the initial stress pattern can be explained in a way that does not leave them as true counterexamples of the three syllable rule. The words in [134b] are similar in shape to compounds consisting of two stems, although neither of the putative stems occurs independently or in other compounds. [...] For most of the words in [134b] there is independent phonological evidence for a strong morpheme boundary. In *Abenteuer, Konterbande, Pampelmuse, Pumpernickel, Tingeltangel* we find a tautosyllabic sequence of schwa and sonorant [ən, ər, əl], or in more colloquial pronunciation a syllabic sonorant [ən, əl] and vocalic r-coloured schwa for [ər] [...]. This tautosyllabic sequence is untypical word-medially in monomorphemic words and instead occurs usually only word-finally in monomorphemic words. Thus, the presence of this sequence in the words above indicates morpheme-final position and motivates the compound analysis *Aben#teuer, Konter#bande, Pampel#muse, Pumper#nickel, Tingel#tangel*.

Two remarks are in order here. First, since these words contain two schwas, they do not correspond to the structural description of the Three Syllable Rule. Second, Jessen's argumentation is circular: the words look like compounds *because* they have an initial stress and a schwa in their second syllable. But of course this is not sufficient to make them compounds. The argument that a schwa followed by a sonorant in the second syllable forces the presence of a morpheme boundary does not hold. Compare *Kabeljau* 'cod', *Kakerlak* 'cockroach', and the like, which also have a schwa in their second syllable, but which are not analyzed as compounds. Thus, we claim that they are simply monomorphemic quadrisyllabic words with stress on the first syllable, albeit odd ones.

Let us now turn to the 101 quadrisyllabic monomorphemic words with main stress on the antepenult (σόσσ). Out of the 25 of them that have a final schwa syllable (136), 21 have a penult [i] which is realized as a glide, and the remaining 4 have three full vowels after the stressed one. At least *Apokope* and *Apostrophe* have an alternative, more common stress realization: *Apostróphe, Apokópe*. So only two words with antepenultimate stress, are true exceptions to Vennemann's Reduced Syllable Rule: *Kantabile* and *simpliciter*.

(136) a.	Arterie	'artery'	Bakterie	'bacterium'
	Komödie	'comedy'	Geranie	'geranium'
b.	Apóstrophe	'apostrophe'	Kantabile	'cantabile'
	simpliciter	'absolutely'	Apókope	'apocope'

Of the 76 remaining words with a full vowel in their last syllable, 35 have a final
-ium syllable, as in (137), and are thus generally pronounced trisyllabically.

(137)	Imperium	'empire'	Aquarium	'aquarium'
	Ammonium	'ammonium'	Präludium	'prelude'
	Symposium	'symposium'	Stipendium	'grant'

There remain 41 words, partly listed in (138), of which 15 have a final open syllable: 12 with final [a] (138a) and 3 with final [o] (138b). 12 words have final *-um* without a preceding glide, as in (138c), 7 have final *-on* (138d) and 3 have final *-is* (138e). Finally, there are four words with various other endings, listed in (138f).

(138)	a. [a]			
	Anaphora	'anaphora'	Malaria	'malaria'
	b. [o]			
	inkognito	'incognito'	Laudatio	'laudatio'
	c. Spezifikum	'something characteristic'		
	Curriculum	'curriculum'		
	d. *-on*			
	Analogon	'analogy'	Chamäleon	'chameleon'
	e. *-is*			
	Metropolis	'metropolis'		
	f. Magnifikat	'magnificat'	Ingredienz	'ingredient'
	Asparagus	'asparagus'	Superior	'superior'

Consider next the 273 words with main stress on the penult (σσόσ). 209 have a final schwallable. The other 64 words have typically unstressed syllables: 15 final *-or*, 13 [a], 8 [o], 8 *-um*, 6 *-ik*, 2 *-is*, 1 *-ur*, 1 *-it* (Affidavit) and 1 *-es*

(Diabetes). Examples of words with final schwa are given in (139); the other categories are illustrated in (140).

(139)	Karavane	'caravan'	Brillantine	'brilliantine'
	Antilope	'antelope'	Synagoge	'synagogue'
	Variante	'variation'	Schokolade	'chocolate'

(140)	*-or*			
	Informator	'informant'	Alligator	'alligator'
	[a]			
	Banderilla	'banderilla'	Propaganda	'propaganda'
	[o]			
	allegretto	'allegretto'		

Finally, the words with final stress present the same problems of classification as the trisyllabic ones. The distinction between complex and simplex words is a delicate matter. Most final syllables are trimoraic, as shown in (141) and (142). The words in (142) are generally pronounced as trisyllabics.

(141)	exorbitant	'exorbitant'	Installateur	'plumber'
	Adrenalin	'adrenalin'	Affinität	'affinity'
	Adoleszenz	'adolescence'	Barbiturat	'barbiturate'
	Bibliothek	'library'		
(142)	Aggression	'aggression'	Ammoniak	'ammonia'
	Assertion	'assertion'	Atelier	'studio'
	Distraktion	'distraction'	mysteriös	'mysterious'

Some finally stressed words have a prespecified stress on a bimoraic syllable.

(143)	Abonnement	'subscription'	Infanterie	'infantry'
	Orthographie	'orthography'	spirituell	'spiritual'

3.4.1.2 Words with more than four syllables

CELEX lists 4,312 words with five syllables and 1,878 words with more than five syllables, the vast majority of which are complex words. After elimination of all nonmonomorphemic words, there remain 384 monomorphemic words with five syllables, which can be divided into the following stress patterns:

- σσσσσ: 0 words with stress on the first syllable
- σσσσσ: 0 words with stress on the second syllable
- σσσσσ: 41 words with stress on the antepenultimate syllable
- σσσσσ: 42 words with stress on the penultimate syllable
- σσσσσ: 301 words with stress on the final syllable

The absence of words with initial and postinitial stress confirms the Three Syllable Rule.

Of the 41 words with antepenultimate stress, 38 have a penultimate glide (31 *-ium*), which makes them quadrisyllabic. The three other words are listed in (145); all three have final *-um*.

(144) Ordinarius 'professor'
Auditorium 'auditorium'
Territorium 'territory'
Krematorium 'crematorium'
Petersilie 'parsley'
Repressalie 'reprisal'

(145) Analeptikum 'analeptic'
Analgetikum 'analgesic'
Individuum 'individual'

Of the 42 words with penultimate stress, 30 have a final schwallable.

(146) Archäologe 'archaeologist'
Initiale 'initial (letter)'
Apokalypse 'apocalypse'

Alternative 'alternative'
Apotheose 'apotheosis
Kommilitone 'fellow student'
Lokomotive 'locomotive'

The remaining 12 words have final *-or* (in 9 cases), *-us* (one case), final [a] (1 word) and final [o] (1 word).

(147) Akkumulator 'accumulator'
Staphylokokkus 'staphylococcus'
Abrakadabra 'abracadabra'
Violoncello 'violoncello'

Of the 301 words with final stress, 252 have a final *-ion* syllable (148); the others have a final *-ie*, *-ät*, *-är*, and a few more (149).

(148) Exhibition 'exhibition'
Expedition 'expedition'
Intonation 'intonation'
Spekulation 'speculation'
Installation 'installation'
Affektation 'affectation'
Amputation 'amputation'
Distribution 'distribution'
Faszination 'fascination'
Kombination 'combination'

(149) Enzyklopädie 'encyclopaedia'
Etablissement 'establishment'
Universität 'university'
intermediär 'intermediate'
initiativ 'initiative'

Finally, there are 98 six-syllable monomorphemes. 89 have final stress, the majority of them ending in *-ion*, exactly as in the case of the five-syllables.

(150) Extrapolation 'extrapolation'
Organisation 'organization'
Assoziation 'association'
Manipulation 'manipulation'
Imagination 'imagination'
Ratifikation 'ratification'
Eventualität 'eventuality'

The remaining 9 have antepenultimate stress, but are actually five-syllable words:

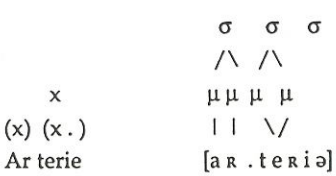
(151) Observatorium 'observatory'
Laboratorium 'laboratory'
Vokabularium 'vocabulary'
Repositorium 'bookshelves'
Initiative 'initiative'

To conclude this short overview of polysyllabic words, it can be observed that nothing new has been gained from them. All interesting observations and generalizations about monomorphemes could be gathered from the di- and trisyllabic words.

3.4.2 Optimality account

The regular stress patterns for the quadrisyllabic words are listed in 1 to 3. Patterns 4 to 6 are irregular.

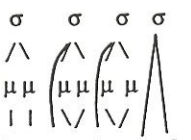
1. Four syllable words realized as trisyllabics with main stress on the penultimate syllable.



(152) a. 'artery'

b. 'empire'

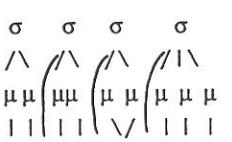
2. Real quadrisyllabic words with penultimate stress and a last non- or bimoraic syllable.



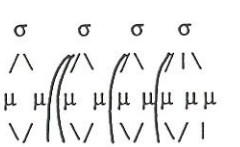
(153) a. 'antelope'

b. 'propaganda'

3. Words with final stress on a last trimoraic syllable.



(154) a. 'exorbitant'



b. 'adrenalin'

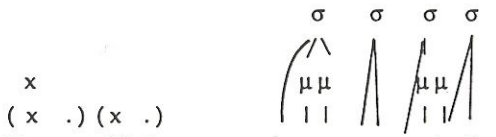
Now for the irregular stress patterns:

4. Words with prespecified initial stress.

(155) a.

'imperative'

b.



'pumpernickel'

5. Words with prespecified stress on the second syllable.

(156)

'anaphora'

6. Words with prespecified final stress on a bimoraic syllable.

(157)

'spiritual'

Quadrisyllabic words are analyzed in OT with the same constraints we used for the trisyllabics. One example of regular stress is illustrated in Tableau 19, for *Antilope*. The optimal candidate fulfills all constraints.

μμ μμ μ | \/\/ /anti l opə / *Antilope*	FOOT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCHAIC)
a. x (x .) (x .) ☞ Anti lope					
b. x (x .) Anti lope			*!		
c. x (x) (. x .) An tilope	*!	*			*

Tableau 19

The irregular stress patterns do not need any new constraint either. Consider first the word *Pumpernickel*. It has a prespecified stress on the first syllable. Its tableau resembles that of *Ameise* (Tableau 16), except for the fact that the first foot is now a syllabic trochee. *Imperativ* is accounted for by nearly the same tableau, except that it has a trimoraic final syllable. Thus the final monosyllabic foot is guaranteed by THREEMORAS = TWOGRIDPOSITIONS.

μ μ x | | x /pumpenɪkl̩ / Pum	FAITH	ONE HEAD	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .)(x .) ☞ Pumper nickel						*	
b. x (x .)(x .) Pumper nickel	*!						
c. x (x)(. x .) Pum pernickel			*!	*		*	**

Tableau 20

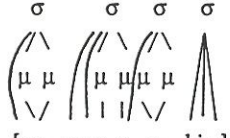
The two other irregular stress patterns are straightforward, too. *Anáphora* has a prespecified stress on the antepenult and *spirituéll* has one on the last syllable. *Anaphora* is similar to *Páprika*, and *spirituell* to *Karuséll*. Only *Anaphora* is illustrated in the next tableau. Candidate a., which violates ALIGN-TROCHEE-RIGHT but fulfills MEDIALWEAK, is better than candidate b., which does the reverse. Thus, according to our constraint ranking, a candidate with a medial trochee and a final monosyllabic foot is superior to one with a final syllabic trochee.

μ μμ μμμμ μ \/\/\/\/ /ɑ nɑ f o rɑ /*Anaphora*	FAITH	MEDWEAK	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCHAIC)
a. x (x)(x .)(x) ☞ A napho ra			*	*	**
b. x (x)(x)(x .) A na phora		*!		*	**
c. x (x)(x . .) A naphora		*!	*		**

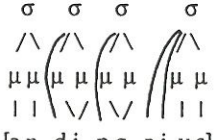
Tableau 21

The five-syllable words have three regular stress patterns and only two irregular ones, because stress is never located on the first or second syllable.
1. Five-syllable words which are realized as quadrisyllabic ones and have their main stress on the medial syllable.

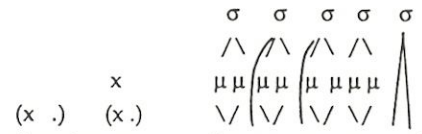
(158) a. x
(x .)(x .)
Repres salie [ʀe.pʀɛs ɑ.lɻə] 'reprisal'



b. x
(x .)(x .)
Ordi narius [ɔɻ.di.nɑ.ʀɻʊs] 'professor'



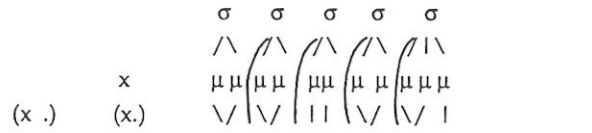
2. Real five-syllable words with penultimate stress and a non- or bimoraic last syllable.



(159) a. Apo the ose [ɑ . p o . t e . o . z ə] 'apotheosis'

b. Marsu pi lami [ma ɻ . s u . p i . l ɑ . m i] 'marsupilami'

3. Words with final stress on a trimoraic last syllable.



(160) Uni versi tät [u . n i . v ɛ ɻ . z i . t e t] 'university'

Now for the irregular stress patterns:

4. Words with stress on the third syllable.

(161) Indi vidu um [ɪ n . d i . v i . d u . ʊ m] 'individual'

5. Words with final stress on a bimoraic syllable.

(162) Enzy klopä die [ɛ n . t s y . k l o . p e . d i] 'encyclopaedia'

Apotheose illustrates the regular stress pattern for real five-syllable words with a final nonheavy syllable. (*Marsupilámi* has an identical tableau.) Since there is a syllable between the two peripheral trochees, it can in principle form a foot on its own. However, candidate a. is better than candidate c., because the latter violates FOOT-FORM (TROCHAIC) once, whereas the former does not violate any constraint at all.

μ μ μμμ μμ μ \/ \/\/ \/ /ɑ po te o zə/ *Apotheose*	FOOT-BIN	MED WEAK	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROC)
a. x (x .) (x .) ☞ Apo the ose						
b. x (x .) (x .) A pothe ose				*!		
c. x (x .) (x) (x .) Apo the ose						*!

Tableau 22

In regular *Universität*, two candidates, a. and b., are selected as optimal by the constraints introduced so far. In this case, the medial foot of candidate a. is a trochee, too, and does not violate FOOT-FORM (TROCHAIC).

✳ μ μμμ μ μ μμ μ \/\/ ǀ \/ \/ /un i f ɛɐ̯ zi t et/ *Universität*	3 μ =2**	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TRO)
a. x (x .)(x .)(x.) ☞Uni versi tät						
b. x (x .) (x.) ☞ Uni versi tät						

Tableau 23

The flaw in candidate a. is that the first two feet are predicted to be equally strong, since they have the same number of grid positions. But, in fact, only the first syllable systematically has a secondary stress in five- or six-syllable words. There is thus a preference for the nonparsing of the medial syllables, and candidate b. must be evaluated as superior to candidate a. We propose expressing this by a new constraint, *FTFT, which is due to Kager (1994b) and avoids foot adjacency.

(163) *FTFT

Feet must not be adjacent.

*FTFT must be ranked below ALIGN-TROCHEE-RIGHT and ALIGN-FOOT-LEFT to guarantee the presence of peripheral feet in di-, tri- and quadrisyllabic words. Only in words of five or more syllables is this constraint active. Its effect is illustrated in Tableau 24.

μ μμ μ μ μ μμ μ \/\/ ǀ \/ \/ /un i fɛ ɐ̯ zi t et/ *Universität*	3 μ =2**	FT-BIN	AL-TRO-RIGHT	AL-FT-LEFT	AL-HEAD	*FTFT	FOOT-FORM (TRO)
a. x (x .) (x.) ☞ Uni versi tät							
b. x (x .)(x .)(x.) Uni versi tät						*!*	
c. x (. x) (x.) Uni versi tät							*!
d. x (x .) (x) Uni versi tät	*!						*
e. x (x .)(x .) (x.) Uni versi tät					*!	**	

Tableau 24

Enzyklopädie illustrates the last irregular stress pattern. It has a prespecified main stress on the last syllable. Two footings are compared, an exhaustive and a nonexhaustive one, and the nonexhaustive one wins, because the other one violates *FTFT.

μ μ μμ μ μ μμ μ | \/ \/ \/ \/ /ɛnt syk lo pe di / x x Enzyklopedie	FAITH	MED WEAK	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	*FT FT	FOOT-FORM (TROCH)
a. x (x .) (x) ☞ Enzy klopä die			*				*
b. x (x .) (x .) (x) Enzy klopä die			*			*!	*

Tableau 25

The constraints that are responsible for longer monomorphemes are thus basically the same ones that play a role in shorter words. Only one constraint, *FTFT, has been newly introduced in this section.

3.5 Interaction between syllable structure and stress pattern

The constraints responsible for the syllable structure and those responsible for the stress pattern apply simultaneously, i.e. on the same level. This section illustrates some interactions between the two sets of constraints. The main interactions have something to do with the number of moras the syllables consist of, and the resulting footing.

First, MORAICITY must be ranked before ALIGN-TROCHEE-RIGHT, ALIGN- FOOT-LEFT and FOOT-FORM (TROCHAIC) because, according to the constraints for foot formation alone, a word like *Symptom* can consist of only one foot, like candidate b. of Tableau 26. MORAICITY, however, forces the coda segments to be moraic. As a result, each syllable consists of three moras and, due to the pressure of undominated THREEMORAS=TWOGRIDPOSITIONS, two feet are erected.

μ μ μ | \/ /zymptom/	TRI MAX	3 μ =2**	MORAICITY	NO CODA	ALIGN-TRO-RT	AL-FT-LEFT	FOOT-FORM (TRO)
a. σ σ /| /|\ μμ μ μ μμ | | | \/ | ☞ S y m p t o m (x .) (x .) x				**			
b. σ σ /\ /\ μ μ μ μ | | \/ S y m p t o m (x .) x			*!*	*			

Tableau 26

Second, NOCODA must be ranked before FOOT-FORM (TROCHAIC). This is demonstrated by the word *Pyjama* in Tableau 27. Candidate b., with a first trimoraic syllable, is crucial. It is blocked by NOCODA, which is responsible for the fact that ambisyllabicity is avoided in bimoraic syllables. If NOCODA were ranked below FOOT-FORM (TROCHAIC), candidate b. would be preferred to candidate a.

μ μμ μμ μ \/ \/ \/ /pyʤama/	TRI MAX	3 μ =2**	BI MOR	ONS ET	AL-TRO-RT	AL-FT-LT	AL HD	NO CO DA	FOOT-FORM (TRO)
a. σ σ σ /\ /\ /\ μ μ μ μμ μ \/ \/ \/ ☞ P y j a m a (x) (x .) x									*
b. σ σ σ /| /\ /\ μ μμ μ μμ μ \/| \/ \/ P y j a m a (x.) (x .) x								*!	

Tableau 27

The constraints responsible for the sonority relationships and the ones relevant for the syllable boundaries do not interact with foot formation. Similarly, some constraints determining the stress pattern, like ONEHEAD, ALIGNHEAD, FAITH and MEDIALWEAK, are also completely independent of the internal make-up of syllables.

3.6 Conclusion

German lexical stress has the following general properties:

(164) a. Stress is on a final heavy syllable, or else penultimate.

b. Stress is antepenultimate when there is a hiatus between a penultimate syllable whose nucleus is a high vowel and a final naked syllable (without onset). In this case the penultimate syllable generally

disappears, the high vowel becoming a glide and thus part of the onset of the last syllable. Stress is then regularly penultimate.

c. Stress is often antepenultimate when the penult is open and the last syllable is bimoraic.

d. Some final bimoraic syllables are lexically stressed.

e. Some stresses are lexically prespecified.

It has been shown in this chapter that OT is a good framework to account for the stress properties of German words. Since the constraints can be violated, more flexibility is allowed than in earlier generative accounts. The obligatory application of rules has been replaced by a comparison of different possibilities.

This chapter has established two important things. First, the existence of the foot as the domain for stress assignment. The syllabic trochee is especially important in determining the regular main stress. In the absence of stress prespecification, a syllabic trochee is formed at the right edge of the word, and if there are enough syllables left, another one appears at the left edge of the word. Second, the weight of a syllable, in other words the number of moras it contains, plays an important role in determining how the feet are erected and, as a consequence, what the stress pattern of a given word looks like. A trimoraic syllable attracts stress, especially in the final position. Bimoraic syllables are not completely equal with respect to the stress attraction property. True CVC syllables in medial position attract stress, whereas open syllables in this position do not, at least not systematically so.

The constraints introduced in this chapter are listed in (165) and (166).

(165) Undominated constraints
FOOT-BINARITY, THREEMORAS=TWOGRIDPOSITIONS, FAITH, ONEHEAD

(166) Dominated constraints
ALIGN-TROCHEE-RIGHT, ALIGN-FOOT-LEFT, MEDIALWEAK, *FTFT, ALIGN-HEAD, FOOT-FORM (TROCHAIC)

These constraints are divided into two classes: those which determine the formation and size of feet: FOOT-BINARITY, ALIGN-TROCHEE-RIGHT, ALIGN-FOOT-LEFT and FOOT-FORM (TROCHAIC), and those responsible for the prominence relationships between the feet: ONEHEAD, MEDIALWEAK, *FTFT and ALIGN-HEAD.

Finally, some interactions between syllable structure constraints and stress pattern ones have been demonstrated in the last section of this chapter.

The last chapter considers stress pattern in complex words and the influence of foot formation on some phonologically-conditioned morphological operations.

Chapter 4
Foot formation and stress pattern in complex words

4.1 Preliminaries

This chapter examines foot formation and prominence relationships in complex words. The general stress properties of inflection and derivation are considered in turn. It will be shown that, in complex words, too, the syllabic trochee plays a role – and this not only in the stress pattern but also in some morphological processes. The location of the syllabic sonorant in the infinitive and the presence of umlaut in a word derived with the diminutive affix both depend on the prosodic domain of the foot.

4.2 Inflection

In section 2.2.1.1 (Chapter 2), it was shown that German inflection can be syllabic or nonsyllabic and that the inflectional suffixes are always nonmoraic, because the nucleus of the added syllable is always a schwallable. Some examples, which are not repeated here, were shown in Chapter 2. As a consequence of its nonmoraicity, inflection has no effect on the prominence pattern of the word. However, a final schwallable is footed with the stem it attaches to whenever possible, as in (2). If more than one schwallable occurs at the end the word, only the first one is footed, as in (3). (1) illustrates a nonsyllabic inflection.

```
      x
     (x  . )
(1)  Auto-s     'car, gen. sg.'
```

```
       x                          x
     ( x  .)                    (x  .)
(2)  a. schön-er 'more beautiful'  b. red-est  'speak, 2nd pers. sg. pres.'
```



```
       x                          x
     ( x  .)                    (x  .)
(3)  a. trocke n-e 'dry, inflected'  b. red-e ten  'speak, plural, past'
```

As shown in Tableaux 1 and 2, the constraints introduced in the preceding chapters account for the footing of inflected words in a straightforward way. Remember that ALIGN-R is violated in inflected words because of the domination of ONSET. Thus, the inflectional suffixes are syllabified with their stems.

μ μ \/ ʃ ö n l ɐ *schöner*	FT-BIN	NOMOSCH	ALIGN-TRO-RIGHT	LIGN-FOOT-LEFT	FOOT-FORM (TRO)
a. (x .) ☞ schöner					
b. (x) (x) schö ner	*!				**
c. (x) schö ner			*!		*

Tableau 1

μ | t r ɔ k n̩ l ə *trockene*	FT-BIN	NO MOSCH	ALIGN-TRO-RIGHT	ALIGN-FOOT-LEFT	FOOT-FORM (TRO)
a. (x .) ☞ trocke ne			*		
b. (x .) (x) trocke ne	*!		*		*
c. (x . .) trockene	*!		*		*
c. (x) (x .) tro ckene	*!				*

Tableau 2

The adjectival form *trockene* is obligatorily realized with two schwallables, since the stem is obligatorily disyllabic, though *trockne* would be well formed (compare the forms *Tockner* 'drier', *trocknen* 'to dry'). The disyllabicity of the stem has independent reasons which we do not attempt to explain here (but see Féry 1991 for more about this).

Even if inflection has no influence on the stress pattern of the word it attaches to, there are some interesting interactions between the size of the inflected word and the position and number of schwallables. The formation of infinitives may serve as an illustration.

In line with the general preference of German for trochees, the infinitive also forms this constituent whenever possible (Eisenberg 1991, Féry 1991, Giegerich 1987:459, Wiese 1986:713, Wurzel 1970). In practically all infinitives, a syllable is added whose nucleus must be a syllabic sonorant; there are only two lexical exceptions: the monosyllabic verbs *tun* 'to do' and *sein* 'to be'. Consider the infinitives listed in (4) and (5), where two transcriptions are given for each verb: the first one has a syllabic sonorant as the nucleus of the last syllable (the commonly realized form) and the second one has a schwa plus a consonantal sonorant (the marked realization).

(4)	lach- lachen	[la.xn̩/la.xən]	'to laugh'
	hol-holen	[ho:.ln̩/ho:.lən]	'to fetch'
	heul-heulen	[hɔɣ.ln̩/hɔɣ.lən]	'to cry'
	mäh-mähen	[mɛ:.n̩/mɛ:.ən]	'to mow'
	bau-bauen	[baʊ̯n̩/baʊ̯ən]	'to build'
	form-formen	[fɔɐ̯.mn̩/fɔɐ̯.mən]	'to form'
(5)	segl-segeln	[ze:.gl̩n/ze:.gəln]	'to sail'
	liefr-liefern	[li:.fɐn/ʔli:.fəɐ̯n]	'to deliver'
	wandr-wandern	[van.dɐn/ʔvan.dəɐ̯n]	'to hike
	feur-feuern	[fɔɣɐn/ʔfɔɣəɐ̯n]	'to fire'
	atm-atmen	[a:t.mn̩/ a:t.mən]	'to breathe'

The usual pronunciation of the last syllable of these verbs is a syllabic sonorant, taken here as the default realization. However, in affected or very clear pronunciations, this syllabic sonorant is realized as a sequence of a schwa plus a consonantal sonorant, which is usually considered to be the

default realization in the literature (Wiese 1986, Giegerich 1987, Hall 1992a). This traditional analysis assumes an epenthetic schwa, which is a marked process and which in an OT approach would imply a violation of FILL, the constraint which counts each epenthesis as a violation (see Chapter 1 and 2). A second problem with the schwa approach is that the sonority hierarchy cannot explain why (but only describe that) schwa is inserted before the most sonorous sonorant (see below), since it is always more sonorous than a sonorant. In contrast, in our approach, excrescent schwa is a phonetic variant of the syllabic sonorant, and the choice of the nucleus depends on independent principles of syllabification.

The verbs under (4) have stems which can be syllabified as such. The infinitive suffix *-n* is just added to these stems and it is syllabic in order to fulfill the requirement of a final trochee (see below). On the other hand, the verbs in (5) have an unsyllabifiable stem-final sonorant whose sonority is higher than that of the preceding consonant. In *feuern*, *-er* is vocalized and is thus more sonorous than a glide (see Chapter 2). These stems form nouns by making the sonorant syllabic.

(6)	segl-Segel	[ze:.gl̩]	'sail'
	feur-Feuer	[fɔɣɐ]	'fire'
	atm-Atem	[a:tm̩]	'breath'

As before, the infinitives in (5) are formed with an inflectional *-n*, but in this case it is only syllabic when the stem-final sonorant is a nasal, as in *atmen* or *segnen* 'to bless'. In all other cases it is the stem-final sonorant which is syllabic. This is captured naturally by the sonority hierarchy (see (10) in Chapter 2). The most sonorous sonorant is the syllable nucleus. If, as in *atmen*, the last sonorants are both nasals, other, phonotactic, principles play a role: a coda cannot be occupied by two nasals.

In OT terms, this is expressed by the constraint HNUC introduced in Chapter 2 and repeated here:

(7) HNUC (The Nuclear Harmony Constraint)

A higher sonority nucleus is more harmonic than one of lower sonority.

Apart from HNUC, the following constraints are active:

- ALIGN-SUFF, given in (8), expresses that, like all affixes in German, the infinitive suffix [n] is peripheral.
- ALIGN-TROCHEE-RIGHT, which was already introduced in Chapter 3, guarantees that the last syllable of an infinitive has a syllabic sonorant as its nucleus, which also implies that this syllable must be weak.

These two constraints cannot be fused into one because, as (6) shows, [n] is not always the syllabic sonorant, though it is always final.

(8) ALIGN-SUFF
Align (Suffix, Right, Prosodic Word, Right)
The right edge of every suffix coincides with the right edge of some Prosodic Word.

The effect of these two constraints can be illustrated with the verb *bauen* 'to build'in Tableau 3. In this verb, the infinitive suffix *-n* adds a syllable by being syllabic itself. Notice that a monosyllabic (*)*baun* is well formed in German, as one can see from the words *Baum* 'tree' or *braun* 'brown'. In fact, *bauen* is often pronounced monosyllabically in connected speech, like *fahren* 'to drive', *gehen* 'to go', *sehen* 'to see' and other similar verbs [fa:n, ge:n, ze:n]. Moreover, this verb does have monosyllabic forms: *du baust* 'you build', *sie baut* 'she builds'. Only the disyllabic realization of such verbs is taken into consideration (see also footnote 1).

In the tableaux of this section, syllabicity of a sonorant is indicated by a preceding schwa, in order to reflect the German orthography.

/ b aụ /+/n/ *bauen*	ALIGN-SUFF	ALIGN-TROCHEE-RIGHT
a. (x .) ☞ bauen		
b. (x .) baune	*!	
c. (x) baun		*

Tableau 3

ALIGN-SUFF and ALIGN-TROCHEE-RIGHT are unviolated and thus undominated by any constraints relevant for infinitive formation. However, ALIGN-SUFF is undominated in the whole German phonology whereas this is not true of ALIGN-TROCHEE-RIGHT. For this reason, in the tableaux of this section, ALIGN-SUFF dominates ALIGN-TROCHEE-RIGHT.[1]

Let us now see how the constraints introduced so far block the formation of **segelen* or **wanderen* with two syllabic sonorants. In Tableau 4, all the candidates fulfill ALIGN-SUFF. Only candidates a. and b. satisfy ALIGN-TROCHEE-RIGHT, since they have a peripheral *n* and a syllabic sonorant in their last syllable's nucleus. ALIGN-TROCHEE-RIGHT is violated by c., which does not end in a syllabic trochee. The final decision between the remaining candidates a. and b. is made by HNUC. Since candidate a. has the most sonorous sonorant in its nucleus, it is the optimal candidate.

/zegl/+/n/ *segeln*	ALIGN-SUFF	ALIGN-TROCHEE-RIGHT	HNUC
a. (x .) ☞ segeln			
b. (x .) seglen			*!
c. (x . .) segelen		*!	

Tableau 4

Now consider the verb *holen* 'to fetch', which has a syllabifiable stem. According to the constraints so far, **hoeln* [ho:.ln], rather than the grammatical *holen* [ho:ln], should be the selected candidate since [l] is more sonorous than [n]. ONSET selects the optimal candidate in Tableau 5. Syllables without an onset violate ONSET. This constraint is ranked higher than HNUC, so that a candidate which fulfills it but violates HNUC, like a. in Tableau 5, is better

[1] Two more arguments can be given in support of the dominance of ALIGN-SUFF over ALIGN-TROCHEE-RIGHT. First, the former is fulfilled in the two exceptional verbs *tun* and *sein*, but the latter is not. (However, these two verbs are lexical exceptions and probably not subject to the constraints introduced here anyway.) And second, Tilman Höhle (p.c.) has suggested that the constraints responsible for the infinitive are so relaxed that both the disyllabic and the monosyllabic realizations of this verb (and other verbs which can be realized monosyllabically) are selected as equally good. This would mean that ALIGN-TROCHEE-RIGHT is dominated. We do not develop this idea here.

than one violating ONSET but fulfilling HNUC, like candidate b.[2] Some rare verbs like *mähen* 'to mow' violate ONSET, since there is no segment that can be used as an onset of the final syllable. The disyllabicity of such verbs is nevertheless ensured by ALIGN-TROCHEE-RIGHT. Candidate c. violates ALIGN-TROCHEE-RIGHT and is thus readily eliminated.

/hol/+/n/ *holen*	ALIGN-SUFF	ALIGN-TROCHEE-RIGHT	ONSET	HNUC
a. (x .) ☞ holen				*
b. (x .) hoeln			*!	
c. (x . .) hoelen		*!	*	

Tableau 5

The fact that the stem's syllabification can play a role in the choice of one candidate over another can be seen by comparing *segeln* to *quirlen* 'to mix', a unique member in its category. Up to this point, **quireln*, with a syllabic [l] and an onset to the second syllable, should be the optimal candidate, but it is not. The difference between *quirlen* and *segeln* lies in the fact that *quirlen* belongs to the first category of verbs with a syllabifiable stem in (4), whereas *segeln* has an unsyllabifiable sonorant in its stem (5). In other words, the sequence [rl] in *quirlen* is of decreasing sonority, whereas the sequence [gl] in *segeln* is of increasing sonority. The [l] in *Segel* must trigger a new syllable, whereas the sequence [rl] is well formed as a coda, as attested by the words *Kerl* 'guy', *Kipferl* 'croissant' and *Quirl* 'mixer'. Notice that *quirl-* is never realized as **quirel-*, whereas *segl-* is often realized as *segel-*.

We propose that the constraint ALIGN-R (Chapter 2), though generally violated in the infinitives (except in verbs like *mähen*), is nevertheless active in the choice of the optimal candidate. Remember that this violable constraint requires that the right edge of a

[2] Raffelsiefen (1994) remarks that verbs like *knäueln* 'to tangle' and *kraueln* 'to fondle' are generally pronounced *knäulen* and *kraulen*. This evolution is in our opinion due to ONSET. The second syllables of *knäulen* and *kraulen* have their own onset, whereas those of *knäueln* and *kraueln* do not.

syllable. Each segment that is an onset of the last syllable (the one with a syllabic sonorant) counts as a violation of ALIGN-R. To achieve minimal violation, these onsets are minimized, which has the side effect of leaving the stems intact. Thus, ALIGN-R is a gradient constraint. In *segeln*, it does not matter if [l] or [n] is syllabic; in both cases [g] is the onset of the last syllable, and the decision is taken by HNUC, as illustrated in Tableau 4. In contrast, the effect of this constraint is visible in *quirlen* as is evident from the following tableau.

/kvɪrl/ +/n/ *quirlen*	ALIGN-SUFF	ALIGN-TROCHEE-RIGHT	ONSET	ALIGN-R	HNUC
a. (x .) ☞ quirlen				*	*
b. (x .) quireln				**!	
c. (x . .) quirelen		*!		*	

Tableau 6

Both **quireln* and *quirlen* fulfill the high ranking constraints ALIGN-SUFF, ALIGN-TROCHEE-RIGHT, and ONSET, but the form **quireln* has one more segment in the onset of the last syllable than *quirlen*, and is thus eliminated.

The last set of data to be discussed are verbs whose stems have at least two syllables. The final syllabic trochee consists of the stem's last syllable and the syllabic inflection: ALIGN-TROCHEE-RIGHT is always fulfilled. Consider first the finally stressed stems. Examples of such verbs are listed in (9).

(9) spazíer-/spazíeren 'to take a walk'
trompét-/trompéten 'to play the trumpet'
genúg-/genügen 'to suffice'

Our constraints select the optimal candidate in a straightforward way. Only candidate a. in Tableau 7 fulfills the undominated constraints and ONSET. The optimal candidate also fulfills ALIGN-HEAD, which is not shown in the tableau.

/ʃpatsi ʀ /+/n/ *spazieren*	ALIGN-SUFF	ALIGN-TROCHEE-RIGHT	ONSET	ALIGN-R	HNUC
a. (x) (x .) ☞ spa zieren				*	*
b. (x) (x .) spa zieern			*!	*	
c. (x) (x . .) spa zieeren		*!	*	*	

Tableau 7

The verbs in (10) have a di- or trisyllabic stem, and they have their main stress on the penult, i.e. the infinitive's antepenult.

(10) a.
x
(x) (x .)
ár beit-en 'to work'

b.
x
(x) (x .)
be wíl lig-en 'to allow, to approve'

c.
x
(x) (x .)
ver éin baren 'to agree, to arrange'

In verbs like (10a, b), an extra syllable is formed on the suffix because otherwise *-n* is unsyllabifiable: it is more sonorous than [t] or [g] and it cannot be integrated into the preceding syllable. In (10a), stress is prespecified. In the verb *vereinbaren*, on the other hand, *-n* can be part of the preceding syllable, because it is less sonorous than [ʁ̩]. However, candidate d. in Tableau 8 cannot be optimal because there is a prefix boundary between *ein-* and *baren* which forces separate footings. This is expressed by the undominated constraint ALIGN-R.

/vɐ/+/aɪ̯nbɑɐ/+/n/ *vereinbaren*	ALIGN-L	ALIGN-SUFF	ALIGN-TROCHEE-RIGHT	ONSET
a. (x) (x .) ☞ ver ein baren				
b. (x) (x .) ver ein baern				*!
c. (x) (x . .) ver ein baeren			*!	*
d. (x .) ver einbarn	*!			

Tableau 8

To sum up this section, inflection has no influence on the position of the main stress in a word. However, the preference of German for syllabic trochees can influence the realization of an inflectional suffix, which can be syllabic or nonsyllabic. This is a remarkable fact which a traditional generative framework is totally unable to express in a straightforward way.

4.3 Derivation

Derivation differs from inflection in that some derivational affixes always bear (or govern) the main stress of the word they are part of, and others are always unstressed. Let us consider suffixation first.

4.3.1 Suffixation

It is in some cases a delicate matter to decide if a particular ending is a suffix, or if it is part of the stem (see also Eisenberg 1991:40, 59 for the same remark). The ending *-tion*, for instance, is often analyzed as a suffix. But in many cases it is attached to some phonological material that cannot stand alone, as in *Operation* 'operation', *Nation* 'nation', *Ration* 'ration' and the like. For this reason, many words with final *-tion* were considered as monomorphemes in Chapter 3. This ending, and others with similar characteristics, like *-ie*, *-(er)ei*, are listed here again, this time as suffixes, because they appear

as suffixes to words that can stand alone. The ambiguous classification of some endings has no consequence for the stress pattern of the words they appear in.

Examples of suffixes which influence stress are given in (11). Those in (11a) to (11c) attract the main stress themselves and those in (11d) force a final trochee: the penult syllable is stressed. Though most of the stress-bearing suffixes have a trimoraic syllable (11a), some have a bimoraic one (11b). The suffixes in (11c) have a regular penultimate stress.

(11) a.	-tion	Balkanisatión	'Balkanization'	
	-al	nationál	'national'	
	-ös	nervös	'nervous'	
	-ant	Musikánt	'musician'	
	-ist	Kapitalíst	'capitalist'	
	-ität	Nationalität	'nationality'	
b.	-(er)ei	Meuteréi	'mutiny'	
c.	-ismus	Kommunísmus	'communism'	
	-ieren	galoppíeren	'to gallop'	
d.	-isch	platónisch	'platonic'	(from *Pláto*)
		paradiesisch	'heavenly'	(from *Paradíes*)
	-ig	ártig	'well-behaved'	
	-ik	Motórik	'motor activity'	(from *Mótor*)
		Themátik	'thematic'	(from *Théma*)

As illustrated by the examples in (12), the words derived with suffixes in (11) have the same stress patterns as underived words. As Tableau 9 shows, stress on a final trimoraic syllable as well as stress on the penultimate syllable in cases where the final syllable is bimoraic is accounted for by the constraints introduced in Chapter 3. There is no trace in those words of possible 'earlier' stages of the derivation: the word *Kapitalist*, for example, has its main stress on the last syllable and a secondary stress on the first one; but there is no trace of the final stress of the word *Kapitál*. This fact speaks against a cyclic application of word stress rules.

(12) a. Kapi tal

x
(x .)(x)

b. Kapitalist

x
(x .) (x)

μμμ μμ μ μ \/\/\/ | /kap i t al/+/ɪst/ *Kapitalist*	3μ = 2**	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) (x.) ☞ Kapi ta list *Kapitalist*						
b. x (x .) (x .) Kapi talist	*!					
c. x (. x) (x.) Kapi ta list						*!

Tableau 9

The suffix *-(er)ei* has a prespecified stress, and words derived with this suffix do not differ from monomorphemes with a prespecified final stress like *Spinett* or *Karusell*. And, finally, words derived with *-ismus*, *-isch* and the like have completely regular stress as well, since they force the formation of a final trochee. Besides being the preferred and unmarked constituent of German, the trochee is also, without exception, the Minimal Word of German.[3] A monomorphemic stem is often moraically or syllabically trochaic. (13a) shows a monosyllabic bimoraic stem, and (13b) a disyllabic one. The adjunction of a suffix in (13a) leads to the formation of a disyllabic trochee. In contrast, the word *Däne* 'Dane' in (13b) is already disyllabic. (13b) illustrates a process that is very common in German: in order to be inflected and derived, the stem drops its final schwa and the result is a monosyllabic stem *dän*, as in (13a): the derived stem is a syllabic trochee.

[3] Pronouns and other function words can be realized monomoraically, like *so* [zo:] or [zɔ] 'so', *sie* [zi:] or [zə] 'she' (Kohler 1977: 224-225), but they are always underlyingly bimoraic.

(13) a. Hund/ Hund-e/ Hünd-in 'dog-dogs-bitch'
b. Däne/ Dän-in/dän-isch 'Dane, masc.-Dane, fem.-Danish'

The forming of a foot comprising the stem (or the stressed syllable of the stem) plus the suffix is sometimes a condition on suffixation, as for instance in *-keit* and *-ig*. This last suffix is attested only in disyllabic words, at least if it is attached directly to the stem, not if it is part of a longer suffix sequence, as *-losigkeit* in *Zweifellosigkeit* 'undoubtfulness'. This means that it only attaches to monosyllabic stems, with the exception of *kalib(e)rig* 'of a caliber' (see Muthmann 1991), or to stems with a final schwa, in which case the schwallable can be present or not (as in *kug(e)lig* 'spherical', *flatt(e)rig* 'fluttering'). The metrification of schwallables will be addressed in the next section.

(14) artig 'well-behaved'
richtig 'right'
schwind(e)lig 'dizzy'
wäss(e)rig 'watery'

The suffix *-ik* has an ambiguous behavior. In some cases, as illustrated by *Motorik* and *Thematik*, it is regular; but in other cases, it has a prespecified final stress, as in (15). In these cases, they can be considered as monomorphemes.[4]

(15) -ík Musík 'music'
Mathematík 'mathematics'

A certain number of derivational suffixes are stress neutral. They are merely adjoined to the metrified stem, and they do not require a syllabic trochee. (16) is a list of some such suffixes.[5]

[4] Thanks to Kirsten Brock who drew my attention to this point.
[5] The two suffixes *–heit* and *-keit* are almost in complementary distribution: *-heit* attaches to finally stressed stems and stems with final *-en* (*Wáhrheit* 'truth', *Tróckenheit* 'dryness'); *-keit* attaches only to stems with penultimate stress (*Héiterkeit* 'joy', *Müdigkeit* 'tiredness'). We do not consider these suffixes in detail here. It suffices to observe that they are never stressed and behave, as far as their stress properties are concerned, similarly to the suffixes in (16).

(16) -ung Wírkung 'effect'
Bewílligung 'allowance'
-er Árbeiter 'worker'
-in Árbeiterin 'worker, fem.'
-los zwéifellos 'doubtless'
-haft héldenhaft 'heroic'

The nonstressability of these suffixes must be guaranteed by some device. We adopt a prespecified nonmoraicity (at least as far as the stress pattern is concerned), which renders them unstressable. In other words, those suffixes behave as if they were schwallables. We assume that they are footed if they can be part of a foot erected on the stem (17a); otherwise they are unfooted (17b), and are just part of the Prosodic Word.

(17) a. x
(x .)
Wirkung

b. x
(x .)
zweifel los

It is assumed that some suffixes are lexically prespecified as being nonmoraic. In OT terms, their nonmoraicity is ensured by a parameterization of FAITH.

In sum, the constraints introduced in Chapter 3 are responsible for the stress pattern of the stem, and an additional constraint ensures the invisibility of the suffix.

(18) FAITH (Nonmoraicity)
The nonmoraicity of the suffixes *-ung*, *-los*, *-in*, etc. is preserved.

The next tableau illustrates how nonmoraic suffixes are accounted for.

μμ | | /tsv a ɟ fl̩/+/los/ *zweifellos*	FAITH	FT-BIN	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) ☞ zweifel los			*			
b. x (x .) (x) zweifel los	*!	*	*		*	*
c. x (x) (x .) zwei fellos		*!				*!

Tableau 10

Extrametricality cannot explain the complete invisibility of these suffixes, since there can be several of them (plus inflectional suffixes) in a row, as for instance in the word *Zwéifellosigkeiten* 'undoubtfulnesses'. All such suffixes are invisible, whereas extrametricality predicts that only the last one is invisible and all nonfinal suffixes are visible.

The next subsection examines a very interesting phenomenon in German derivation: umlaut induced by the suffix *-chen*. Umlauting is dependent on the presence of a foot. But the fact that umlaut applies in a syllabic trochee should not come as a big surprise: *-chen* is another example of an unstressed derivational suffix which preferably adjoins to a stressed syllable to form this unmarked constituent.

4.3.2 Umlaut in the syllabic trochee

German umlaut is a largely lexicalized process; however, it is productive in the morphological affixation of some diminutive suffixes (essentially *-chen* and *-lein*).

(19), repeated from Chapter 2, gives a complete picture of the German vowels.

(19) German vowels

i. tense vowels	ii. lax vowels	iii. diphthongs
i, y u	ɪ, ʏ ʊ	aɻ, ɔɣ, aʉ
e, ø o	ə	
	ɛ, œ ɔ	
a	ɑ	

German umlaut is the fronting of back vowels, as illustrated in (20). In the last three cases (20e-g), tongue raising is also involved. The difference between /a/ –>/ ɛ/ (20e,f) and /a/ –> /ɔ/ (20g) must be addressed. /a/ is low and back in German.[6] Since there is no front low vowel in German, fronting of /a/ implies a simultaneous tongue raising to /ɛ/, the lowest of the front vowels. The shift of the diphthong /aʉ/ –> /ɔɣ/ requires another explanation. There is agreement in the literature (Wurzel 1970, 1980, 1984, Kloeke 1982, Wiese 1987) that the rounded glide plays a crucial role: it is fronted (/ʉ/ –> /ɣ/), and the primary vowel adopts its rounding.

(20) Umlaut

a.	[ʊ]	–>	[ʏ]	Mutter/Mütter	'mother/mothers'
b.	[u:]	–>	[y:]	Gut/Güter	'possession/goods'
c.	[ɔ]	–>	[œ]	Horn/Hörnchen	'horn/little horn'
d.	[o:]	–>	[ø:]	Hohn/höhnisch	'scorn/scornful'
e.	[a]	–>	[ɛ]	Mann/Männer	'man/men'
f.	[ɑ:]	–>	[ɛ:/e:]	Vater/Väterchen	'father/little father'
g.	[aʉ]	–>	[ɔɣ]	Baum/Bäume	'tree/trees'

Though umlaut takes place in the environments listed in (21), the suffixes that at first sight seem to trigger umlaut do not systematically do so, as can be seen from (22).

[6] This is evidenced by the choice of the velar fricative /x/ (ach-Laut) after /a/, as after the back vowels /u, o/, when a dorsal fricative must be realized; see, e.g., Hall (1989). After all other vowels, the palatal fricative /ç/ (ich-Laut) is realized.

(21) Derivation and inflection with umlaut

a. Affixation with diminutive affixes *-chen, -lein*: Horn/Hörnchen 'horn/little horn'

b. Other derivational affixes:

- *er*: tanzen/Tänzer 'to dance/dancer', saufen/Säufer 'to drink/drunkard'
- *in*: Hund/Hündin 'dog/bitch', Arzt/Ärtzin' doctor/woman doctor'
- *lich*: Tag/täglich 'day/daily', zart/zärtlich 'soft/tender', rot/rötlich 'red/reddish'
- *isch*: Europa/europäisch 'Europe/European', Hohn/höhnisch 'scorn/scornful'
- *ig*: Bart/bärtig 'beard/bearded', Korn/körnig 'grain/grainy'
- *Ge ... (e)*: Darm/Gedärm 'intestine/bowels'

c. Plural suffixes:

- *er*: Mann/Männer 'man/men', Gut/Güter 'possession/goods'
- *e*: Baum/Bäume 'tree/trees', Stuhl/Stühle 'chair/chairs'
- Null-suffixation: Vogel/Vögel 'bird/birds', Mutter/Mütter 'mother/mothers'

d.Comparative-Superlative: hoch/höher/höchst 'high/higher/highest'

e. Verbal inflection: fahren/fährst 'to drive/drive, 2nd pers. sg.'

f. Infinitive: genug/genügen 'sufficient/to suffice'

(22) Derivation and inflection without umlaut

a. Affixation with diminutive affixes: *-chen*: Frau/Frauchen 'woman/mistress (for a dog)'

b. Other derivational affixes:

- *er*: malen/Maler 'to paint/painter', fahren/Fahrer 'to drive/driver'
- *in*: Kunde/Kundin 'client/female client', Gatte/Gattin 'husband/wife'
- *lich*: rund/rundlich 'round/plump'
- *isch*: Symbol/symbolisch 'symbol/symbolic'
- *ig*: Wolle/wollig 'wool/woolly', Wolke/wolkig cloud/cloudy'
- *Ge ... (e)*: husten/Gehuste 'to cough/coughing'

c. Plural suffixes:

- *er*: no example
- *e*: Schuh/Schuhe 'shoe/shoes', Tag/Tage 'day/days'
- Null-suffixation: Araber/Araber 'Arab/Arabs', Kabel/Kabel 'cable/cables'

d. Comparative-Superlative: klar/klarer/klarst 'clear/clearer/clearest'

e. Verbal inflection: lachen/lachst 'to laugh/laugh, 2nd pers. sg.'

f. Infinitive: Lob/loben 'praise/to praise'

For nearly all morphological contexts with umlaut in (21) there are corresponding forms without umlaut in (22). The only exception is the plural *-er* morpheme, which always accompanies an umlauted stem. However, this plural formation is completely unproductive,[7] and the absence of plural *-er* forms without umlaut seems accidental.

The usual treatment of umlaut in the literature is that it is always productively triggered by a suffix (Kiparsky 1968, Vennemann 1968, Wurzel 1970, Bach & King 1970, Janda 1987, Lieber 1987, 1992, Lodge 1989 and Yu 1992) or a stem (Wiese 1987, 1994), either as a phonological or as a morphological phenomenon. In our opinion, the overwhelming majority of occurrences of umlaut are lexicalized forms. German speakers must learn the forms in (21) and (22) by heart. The examples in (23), in which the suffix *-ig* is sometimes associated with an umlauted stem and sometimes with a nonumlauted stem, are a further illustration of the arbitrariness of umlaut.

(23) a. Bart/bärtig 'beard/bearded', Korn/körnig 'grain/grainy'
b. Affe/affig 'monkey/affected', Rose/rosig 'rose/rosy'

In the same way, a particular stem can be umlauted when derived with a suffix that occasionally triggers umlaut, and stay nonumlauted with another one. In cases like (24), too, German learners must memorize the forms. Thus, Wiese's alternative approach, which analyzes umlaut as triggered by stems instead of suffixes, suffers from the same flaw as the traditional approach, and for the same reason: umlaut is lexical in most cases, not productive.

(24)	a. fahren/fährt/Fahrer	'to drive/drives/driver'
	b. Tag/Tage/täglich	'day/days/daily'
	c. Kalb/Kälber/kalben	'calf/calves/to calve'

Very few, indeed only two suffixes seem to trigger umlaut productively, namely the diminutive suffixes *-chen* and *-lein*. In their case only, umlaut is a

[7] Productive plural formations are *-s*: *Film-s, Bit-s, Chip-s, Yuppie-s*; ø-suffix: *Computer, Scanner, Hacker, Manager*; *-en* or *-n*: *Diskette-n, Kassette-n*, and maybe a few more.

morphologically-triggered phonological phenomenon. From now on, we will concentrate on the suffix *-chen*. Derivation with *-lein* has essentially the same properties as with *-chen*, except for a few lexical and phonologically conditioned variations, like the preference of *Bächlein* over *Bächchen* 'little stream' to avoid an unusual gemination.

As a regular process, productive umlaut needs a syllabic trochee consisting of the last syllable of the stem, which must be stressed, and the unstressed suffix *-chen*, as in (25).

(25)

Rád	->	Rädchen	'wheel/little wheel'
Núß	->	Nüßchen	'nut/little nut'
Halló	->	Hallöchen	'hello/little hello'
Skandál	->	Skandälchen	'scandal/little scandal'
Persón	->	Persönchen	'person/little person'

If no syllabic trochee arises by suffixation, two alternatives are possible. First, the stem is suffixed with *-chen* but not umlauted, as in (26a). Second, the stem is not suffixed with *-chen* at all, as in (26b). *Monatchen, Monätchen, Europachen* and *Europächen* all sound strange.

(26)

a. Áuto	->	Áutochen/*Áutöchen	'car/little car'
Óma	->	Ómachen/*Ómächen	'gran/granny'
b. Mónat	->	*Mónatchen/* Mónätchen	'month/little month'
Európa	->	*Európachen /*Európächen	'Europe/little Europe'

These realizations are highly idiosyncratic. We asked ten native speakers of German for their judgments on words like (26) with a main stress on a nonfinal syllable of the stem, and came to the conclusion that speakers are extremely uncertain. They were generally reluctant to judge these words, making comments like: 'I don't know, I have no intuition about these words.' However, they were usually able to rank the words. The same words suffixed with *-chen* but without umlaut, like *Autochen, Omachen* and *Koboldchen* are usually (though not always) more readily accepted than those with umlaut.

In the remainder of this section, we will first concentrate on the data in (25), where the main stress is on the stem's last syllable, and show how the Optimality framework accounts for them. After that, we will return to the data in (26).

Besides its domain of application, umlaut has a few interesting phonological properties, which are reviewed in the following paragraphs. None of these constraints are idiosyncratic to umlaut; on the contrary, all of them are needed in the phonology of other languages for purposes other than umlaut.

First, we assume that in productive umlaut a floating feature [front] comes with the suffix *-chen*, as illustrated in (27). This is the kind of analysis proposed by Lieber (1987) and Lodge (1989).

(27) Umlaut as a floating feature

chen

[front]

When *-chen* is suffixed to a stem, the floating feature associates with the last vowel of the stem whenever possible.[8] The constraint PARSEFEAT, one of several in a group of Faithfulness constraints (Itô, Mester & Padgett 1994: 24-25, see Chapter 3), forces its association:

(28) PARSEFEAT

All input features are parsed.

In our case, association of the floating feature, as shown in (29), satisfies (28), whereas nonassociation of this feature counts as a violation:

(29) Association of the floating feature

V X]$_{Stem}$ *chen*

[front]

[8] It cannot associate with *-chen* because *-chen* ([çn̩]) has no vowel. Also *-lein* cannot bear the floating feature [front] because the result of umlauting the diphthong [aj] would be [ɛj], wich is not attested in German: [aj] is not umlauted.

In the inventory of German vowels, front vowels have been analyzed as marked and specified and back vowels as unmarked and unspecified (Rice 1989:68, Lieber 1992:170). Vowels without specification for backness or frontness are then [back] by default. According to this view, umlaut specifies an unspecified vowel for the feature [front]. Another view that makes correct predictions on the umlaut data is that all full vowels are specified for [front] or [back], which are distinct privative features, the unspecified status being restricted to schwa. Under the pressure of umlaut, a stressed segment specified for [back] in the input becomes specified for [front] in the output, as shown in (30). Why this view is better than the underspecification approach will become clear below, when NOCROSSING is introduced.

(30) a. Input b. Optimal Output

Tableau 11 compares the optimal candidate *Lämpchen* with the suboptimal one *Lampchen*. *Lämpchen*, with umlaut, respects both ALIGN-TROCHEE-RIGHT and PARSEFEAT, whereas *Lampchen*, without umlaut, fulfills ALIGN-TROCHEE-RIGHT but violates PARSEFEAT because of the nonassociation of the floating feature [front]. The ranking of ALIGN-TROCHEE-RIGHT above PARSEFEAT is justified in Tableau 13 for *Cafechen*.

μ | /lamp/ +/ç̣n̩/ *Lämpchen* [front]	ALIGN-TROCHEE-RIGHT	PARSEFEAT
a. (x .) ☞ Lämpchen		
b. (x .) Lampchen		*!

Tableau 11

The second property of umlaut is its non-iteration (see also Klein 1994). It is accounted for by the constraint FILLLINK, another Faithfulness constraint, formulated in (31). This constraint has also been proposed by Itô, Mester & Padgett (1994:25) and it has the same claim to universality as the preceding one. Inserted association lines are a marked option, and in particular, the spreading of features counts as a violation.

(31) FILLLINK
All association relations are part of the input.

Standard German umlaut does not iterate, though in Old High German it probably did. Compare the data in (32) from Twaddell (1938), Braune (1961) and Penzl (1949):

(32) Umlaut in Old High German

[zahar-zæheri]	'tear-tears'	(written as zahari or zahiri)
[fræveli]	'bold'	(written as fravali or fravili)
[mægedi]	'girl, girls'	(written as magadi or magedi)
[jægeri]	'hunter'	(written as jagari or jagiri)

PARSEFEAT and FILLLINK make contradictory claims. PARSEFEAT requires that a floating feature be linked by an association line and FILLLINK requires that no association line be inserted, i.e. that a floating feature remain unassociated. Obviously, both constraints are needed in the phonology of the world's languages. In our case, PARSEFEAT is crucially ranked above FILLLINK, so that the inserted line wins. Compare Tableau 12, which illustrates the effect of FILLLINK. *Skandalchen* is eliminated because it violates PARSEFEAT. The optimal candidate, *Skandälchen*, violates FILLLINK only once, whereas in *Skändälchen* it is violated twice, since a spreading of [front] has taken place.

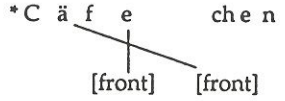
μ μ μ | \/ /skandɑl/ +/ɕn̩/ *Skandälchen* [front]	ALIGN-TROCHEE-RIGHT	PARSEFEAT	FILLLINK
a. (x) (x .) ☞ Skan dälchen			*
b. (x) (x .) Skan dalchen		*!	
b. (x) (x .) Skän dälchen			**!

Tableau 12

The third property of umlaut is the obligatory adjacency of *-chen* and the umlauted vowel (but see (35)). NOCROSSING (33) (Goldsmith 1976) accounts for the ungrammaticality of words like *Cäféchen* (instead of *Cafechen* 'little café'), in which ALIGN-TROCHEE-RIGHT is respected, but where umlaut takes place across full specified vowels as in (34).

(33) NOCROSSING
Association lines do not cross.

(34)



In Tableau 13, NOCROSSING is unviolated and undominated: its violation is always fatal.[9]

[9] If vowels were unspecified for [back], as proposed by Lieber and Rice, the floating [front] coming with *-chen* would be allowed to cross a back vowel to associate with a preceding back vowel. Both *Skandälchen* and **Skändalchen* would be predicted to be grammatical.

μμ μ |\/ /kafe/ +/ɕn̩/ *Cafechen* [front]	NOCROSS	ALIGN-TROCHEE-RIGHT	PARSEFEAT	FILLLINK
a. (x) (x .) ☞ Ca fechen			*	
b. (x) (x .) Cä fechen	*!			*

Tableau 13

Words with a final syllabic sonorant syllable as in (35) and (36) do not behave homogeneously: *Brüderchen* 'little brother', *Väterchen* 'little father', etc. in (35a) are lexicalized hypocoristics and are umlauted. The words in (35b) are umlauted, too: maybe the fact that no full consonant intervenes between the umlauted vowel and *-chen* plays a role in explaining the difference in grammaticality between these words and those in (35c) which avoid umlaut. However, since only very few words of this sort exist, a generalization is hazardous. Finally, to complicate things, words with a syllabic [l] are regularly umlauted, as illustrated in (36):

(35) a. Brúder/Brűderchen/*Brúderchen 'brother/little brother'
Váter/Väterchen/*Váterchen 'father/little father'
b. Báuer/Bäuerchen/*Báuerchen 'farmer/little farmer'
Máuer/Mäuerchen/*Máuerchen 'wall/little wall'
c. Ánker/Ánkerchen/*Änkerchen 'anchor/little anchor'
Táler/Tälerchen/*Tälerchen 'Thaler/little Thaler'
Dótter/Dötterchen/?Dötterchen 'yolk/little yolk'

(36) Nádel/Nädelchen/*Nádelchen 'needle/little needle'
Nágel/Nägelchen/*Nágelchen 'nail/little nail'
Kúgel/Kügelchen/*Kúgelchen 'ball/little ball'

NOCROSSING is respected in all these forms. Since they have a syllabic sonorant in their stem's last syllable and since, as we assume, syllabic sonorants have no vocalic features, the floating segment can be associated: in (37) no line blocks the association.

(37) Küg l chen

[front]

ALIGN-TROCHEE-RIGHT is responsible for the non-homogeneity of the stems in (35) and (36). On the one hand, all these stems are syllabic trochees. Accordingly, umlaut should not apply, since the last vowel is not stressed. Words like *Anker* and *Dotter* confirm this prediction. On the other hand, words like *Brüderchen* (35a,b) or *Kügelchen* (36) are apparent exceptions to the generalization that umlaut only takes place when *-chen*-suffixation results in a syllabic trochee. A possible solution to this paradox is that the stem's last syllable does not count as part of the trochaic foot, but rather, that the whole stem counts as one heavy syllable. If one takes this metrical invisibility seriously, then *Brüderchen* forms a trochaic foot, and is not a serious exception to the generalization that regular umlauted *-chen*-formation always takes place in a final trochee. Now the exceptional cases are the ones in (35c).

This proposal leads to the following problem: in one respect at least, stem-final schwas and stem-final syllabic sonorants do not behave alike. Whereas schwa always drops in suffixation, as exemplified by the alternations *Matratze /Maträtzchen* and *Däne/Dänin*, this is not true of the syllabic sonorants.[10] A syllabic sonorant remains syllabic if the suffix begins with a consonant (as in *wunderbar* 'wonderful', *atemlos* 'breathless'), but it often becomes consonantal if the suffix begins with a vowel (as in *nieder/niedrig* 'down/low', *Segel/Segler* 'sail/sailor', *Atem/Atmung* 'breath/breathing'). But, if *nieder, Segel, Atem* and other similar words really count as one heavy syllable, there is no reason for the stem-final syllabic sonorant to become consonantal under derivation. The only explanation why it does is the tendency of derived words to form syllabic trochees, which would mean that forms like **niederig*, **Segeler* and **Atemung* do not form syllabic trochees, but rather dactyls, and thus violate ALIGN-TROCHEE-RIGHT.

To sum up, some of the stems with a syllabic sonorant in their final syllable behave like disyllabic trochees and are nonumlauted 'normal cases', whereas other 'exceptional cases' behave as if they were monosyllabic in being umlauted. This curious dichotomy deserves further research.

[10] Thanks to Aditi Lahiri who drew my attention to this fact.

Now consider the forms in (26), which violate ALIGN-TROCHEE-RIGHT by forming dactyls under derivation. When *-chen* is or should be suffixed, two variants are allowed, and the choice between them is largely lexical and idiosyncratic. First, in *Áuto/Áutochen* 'car/little car', suffixation applies but not umlaut; and second, in *Mónat* 'month', no suffixation and consequently no umlaut takes place. The diminutive formation is avoided altogether. A disjunction of the following form must be accounted for: given a certain (unmarked) prosodic domain, a morphological operation and its phonological consequence are performed, namely suffixation of *-chen* and umlaut. In the absence of the prosodic domain, only the morphological part is performed, or, alternatively, nothing.

The data in (26) show that if the last syllable of the stem is not stressed, umlaut does not apply, though suffixation of *-chen* takes place in some (probably idiosyncratically determined) words. We assume that the stem forms its own syllabic trochee (*Auto*), and *-chen* is simply attached to the stem, whithout being integrated in this foot. Thus, refooting has similarities with syllabification across morpheme boundaries. In the same way as resyllabification is allowed only if the syllable structure improves, refooting is allowed only if the foot structure improves. In *Lämpchen* footing of the stem and the suffix together gives rise to a syllabic trochee. In *Autochen* the stem already forms a trochee. A constraint in the spirit of ALIGN-R, but requiring correspondence of the right edge of a stem with the right edge of a foot must be at play here. However, we do not develop this point here.

One of the main advantages of OT over earlier derivational approaches comes to light. In the constraint-based approach it is possible to account for the fact that phonological phenomena may depend on other, more or less independent aspects of the grammar: in our case, umlaut needs a certain prosodic structure. This variance in the occurrence of phenomena has already been observed in other works in the OT framework and, as a matter of fact, it is one of the reasons for the success of the theory. However, a further property emerges, which is closely related to the first one. In data in which the competence of the native speakers fluctuates as to which candidate is the optimal one, candidates fulfilling the higher constraints should be better than those violating them. This is exactly what happens in the data in (26), those words already forming a syllabic trochee on their own and violating ALIGN-TROCHEE-RIGHT under derivation. A candidate like

Autochen, which fulfills NOCROSSING, is definitely better than **Äutöchen*, which violates this constraint. No derivational approach can account for such a ranking.

Although fulfilling ALIGN-TROCHEE-RIGHT, words like *Frau* 'woman' and *Hund* 'dog' have two variants when suffixed with *-chen*, one with umlaut (*Fräuchen* 'little woman', *Hündchen* 'little dog', ...) and one without (*Frauchen* 'mistress of a dog', *Hundchen* 'doggie', ...). The variant with umlaut is regular and does not require any further attention. The one without umlaut deserves more discussion. Iverson & Salmons (1992) propose that the forms without umlaut form two Prosodic Words, as evidenced by the fact that the dorsal fricative is palatal after a back vowel (see footnote 7). This analysis predicts the existence of two suffixes *-chen*, one forming its own Prosodic Word, and the other included in the Prosodic Word of its host. We do not think that this doublet is necessary. Instead we propose that these forms are lexicalized hypocoristics not in need of an explanation in prosodic terms. *-chen* is always integrated into the Prosodic Word of its host. It always retains its segmental properties (it always begins with a palatal fricative), regardless of the quality of the preceding vowel, and in the hypocoristics, it does not trigger umlaut.

The influence of the foot in German lexical phonology is also felt in other phenomena, like the alternation of the dorsal fricative between the palatal variant [ç] and the velar variant [x]. As observed by Iverson & Salmons (1992), in words like those in (39) the dorsal fricative is for most speakers a velar one, but it is pronounced as a palatal in some dialects, which we think is due to the fact that a foot begins on the syllable having the dorsal fricative as onset.

(39)	Masochíst	'masochist'	[(Maso)$_{Ft}$(chist)$_{Ft}$]
	Masochísmus	'masochism'	
	Eunuchísmus	'eunuchism'	

Inside of a foot and before back vowels, the dorsal fricative is always realized as a velar one.

(40)	Spráche	'language'
	Dáchau	place name
	Tàchométer	'speedometer'
	Róchus	name

Summarizing, this section has shown that morphologically triggered productive umlaut takes place in the domain of a syllabic trochee. Optimality Theory is a good framework to account for the umlaut data because it does not impose an obligatory application of rules, but instead allows variation in the occurrence of umlaut.

4.3.3 Prefixation

Prefixes can have main stress, no stress or level stress. The first class of prefixes has main stress; some of these are listed in (41).

(41)	Ur-	Úreinwohner	'native inhabitant'
	Neben-	Nébeneinkommen	'supplementary income'
	Haupt-	Háuptstadt	'capital'
	Erz-	Érzengel	'archangel'
	Un-	Úntier	'monster'
	un-	únbeeindruckt	'unimpressed'
	aus-	áusarbeiten	'to work out'
	an-	ánlocken	'to attract'
	zu-	zúschauen	'to watch'
	ein-	éinschalten	'to switch on'
	auf-	áufdrehen	'to open'

It has been proposed in the literature (for instance by Eisenberg 1991) that these prefixes can be treated as if they were members of compounds. This implies that they form their own Prosodic Word. Each of the Prosodic Words obeys the constraints of Chapter 3, but an additional constraint is responsible for the fact that in a constituent consisting of two Prosodic Words, the first one gets the main stress of the whole constituent. The resulting stress pattern is shown in (42).

	x	Compound
	x x	Prosodic Word
	(x) (x)	Foot
(42)	[[Haupt][stadt]]	

Stressed prefixes have no influence on the stress pattern of the following word. In particular, they do not cause an application of the Rhythm Rule (this assertion contradicts Hayes 1995, Kiparsky 1966, Wiese 1988 and many others). We find accentuations as in (43):

(43)	sympáthisch/únsympàthisch	'likeable/unlikeable'
	táuglich/úntàuglich	'suitable/unsuitable'
	Berlíner/Úrberlìner	'Berliner/original Berliner'
	Fránkfurter/Úrfrànkfurter	'inhabitant of Frankfurt/original
	(*Úrfrankfúrter)	inhabitant of Frankfurt'

The class of prefixes that are never stressed contains the following schwallables.

(44)	be-	begréifen	'comprehend'
	ge-	Geschréi	'shouting'
	ver-	verkáufen	'to sell'
	zer-	zerréißen	'to tear'

It is to account for these prefixes that ALIGN-FOOT-LEFT is dominated. If it were undominated, it would be in conflict with NOMOSCH which says that schwa syllables are nonmoraic. The relatively low-ranking of ALIGN-FOOT-LEFT allows the first syllable of a word to be unstressed and unfooted.

Some verbal particles can be both stressed (and separable) and unstressed (and inseparable). Compare the minimal pairs in (45). The left column (45a) contains the unstressed particles, and the right column (45b) contains their stressed versions.

(45)	über:	a. übersétzen	'to translate'
		b. übersetzen	'to put above'
	um:	a. umfáhren	'to go round'

	b. úmfahren	'to run over'
unter:	a. unterstéllen	'to assume'
	b. únterstellen	'to keep'

When stressed, these particles again behave as elements of compounds and form their own Prosodic Words, even more so than the ones in (41), since they are separable and can stand alone. In contrast, the inseparable prefixes do not form their own Prosodic Word. This is evident for the prefixes in (44) which are schwallables. They do not fulfill the Minimal Word requirements of bimoraicity or disyllabicity and, consequently, they must be integrated into the following Prosodic Word. This latter point is also true of the cases under (45a), which do fulfill the minimality requirement. However, the verbs consisting of an inseparable prefix and a stem are completely lexicalized and nonproductive. We assume that they form separate feet, but are part of the same Prosodic Word. Tableaux 15 illustrates the unstressed prefix.

Tableau 15 does not contain any new constraints. Candidate c. violates the constraint ONEHEAD introduced in Chapter 2, which says that constituents have at most one head.

μ μ μ \/ | [/y bɐ/+/zɛtsn̩/] *übersétzen*	FT-BIN	ONE HEAD	ALIGN-TROCH-RIGHT	ALIGN-FOOT-LEFT	ALIGN-HEAD	FOOT-FORM (TROCH)
a. x (x .) (x .) ☞ über setzen						
b. x (x .) (x .) über setzen					*!	
c. x x (x .) (x .) über setzen		*!				

Tableau 15

The third category of prefixes contains intensity prefixes, which, at least for some speakers, induce a level stress. As in the case of stressed prefixes, it is unclear if they should be analyzed as elements of compounds. In any case, they behave exceptionally in that they have two heads.

(46)			
	scheiß-	scheißfreundlich	'really friendly'
	tot-	totmüde	'dead-tired'
	stock-	stockdunkel	'pitchblack'
	sau-	saustark	'really good'
	super-	supergeil	'super'
	pott-	pottsimpel	'dead easy'

x x		Compound
x x		Prosodic Word
(x)	(x .)	Foot
stock	dunkel	

(47)

We leave it open for the moment how to account for these prefixes, as well as for compounds. Both cases need constraints other than phonological, since factors as 'intensifier', 'argument structure' etc. play a role in the stress pattern of such words (see Benware 1987 for example).

4.4 Conclusion

This last chapter has reviewed the stress pattern of complex words, though only a small part of the interesting phenomena related to the foot have been considered here. It has been shown that the constraints introduced in Chapter 3 play an important role in complex words, too, even though some new constraints were necessary to account for the morphological facts. No constraint introduced for the monomorphemes appeared to make false predictions for complex words, and no new ranking of the existing constraints was needed. This is an important result, since the analysis proposed in the present study has the advantage to be an homogeneous

account of the stress pattern of German words. It has also been shown that the trochee plays an important role both in inflection and in derivation. This was illustrated with two morphological processes, the infinitive formation and the diminutive derivation.

Conclusion

The present study has examined the syllable structure, the footing, and the stress pattern of German words in the framework of Optimality Theory. Some new results have been obtained, which are summed up in this final section.

After an introduction into the general principles of Optimality Theory in the first chapter, Chapter 2 addressed German syllable structure. It was proposed that the full vowels of German are not intrinsically short or long, but rather mono- or bimoraic: bimoraic vowels are always tense, and they are long when stressed and short or half-long when unstressed; monomoraic vowels are lax and always short, whether stressed or unstressed. Syllables with a full vowel as nucleus are minimally bimoraic. This explains the absence of open syllables with a nucleic lax vowel: such syllables would be monomoraic, and this is not allowed. Thus, syllables with a lax vowel are always closed by a consonant. In contrast, syllables with a tense vowel are generally open. In both cases, the unmarked syllable has a quantity of two moras. It was also shown that syllables have a maximal number of three moras, though trimoraic syllables are largely confined to the word-final position. In a syllable whose nucleus consists of a monomoraic vowel, two moraic consonants can appear in the coda. On the contrary, after bimoraic vowels, only one moraic consonant is allowed. Moreover, some appendical coronal segments can be attached to the last syllable of a word. These segments are nonmoraic (weightless) and they are usually, but not necessarily, inflectional suffixes. Syllables with a schwa or a syllabic sonorant in their nucleus (so-called 'schwallables') are also nonmoraic. Their nonmoraicity accounts for the facts that they are always unstressed and that they often do not enter the metrical structure of the words they are parts of. However, as has been shown in Chapter 4, their nonparticipation to the metrical structure is not absolute.

Complex words can be syllabified like monomorphemes, but only in case of inflectional or derivational suffixation. When the suffix is derivational, resyllabification applies only if the suffix begins with a vowel. In prefixation, compounding and derivational suffixation beginning with a consonant, each morpheme defines its own domain of syllabification.

All these phenomena were accounted for in terms of ranked constraints in the OT framework. The ranking of constraints has the advantage over previous phonological approaches that their fulfilment is not obligatory. Thus, a bimoraic syllable is 'better' than a trimoraic one, because it is less marked in the universal inventory of syllables, but if a syllable has a noncoronal third position, it can be trimoraic. So bimoraicity is not an absolute requirement. On the other hand, no syllable can be quadrimoraic: trimoraic maximality is absolute and unviolated.

Chapter 3 has been devoted to the footing and prominence of monomorphemic words. Footing in German is not exhaustive. This means that medial syllables can be unfooted. In the majority of words, main stress is final or penultimate; this is accounted for by an obligatory foot at the end of the word, preferably trochaic (in the default case), but not necessarily so. Prespecified final stress can be assigned to a bimoraic syllable forming a bimoraic foot. Since a bimoraic foot can be trochaic or iambic, according to Hayes's foot typology, we did not specify their status: monosyllabic feet are just bimoraic. There is also a secondary stress on the first syllable, defined by a word initial foot. In trisyllabic words, the medial syllable is the weakest of the word, unless the last syllable is a schwallable. In longer words, the medial syllables are left unstressed. There can be some rhythmic alternation in the realization of such words, but no medial stress is obligatory or systematic. Again, OT turns out to be a very good framework for describing these facts. Through the ranking of constraints like FOOT-BINARITY, ALIGN-TROCHEE-RIGHT, ALIGN-FOOT-LEFT, FOOT-FORM (TROCHAIC), ONEHEAD, MEDIALWEAK, *FTFT and ALIGN-HEAD, the stress pattern of all German words can be accounted for. The most important constraints in the metrical structure of German words are FOOT-BINARITY and ALIGN-TROCHEE-RIGHT. FOOT-BINARITY is undominated, which implies that nonmoraic syllables cannot form a foot of their own, but can only be integrated in the foot formed by full syllables. ALIGN-TROCHEE-RIGHT expresses that the final two syllables or the final heavy syllable preferably form a trochaic foot. This constraint plays a role not only in monomorphemes but also in many complex word formations. ALIGN-FOOT-LEFT and FOOT-FORM (TROCHAIC) are responsible for the secondary stress defined by the initial foot, and ALIGN-HEAD guarantees that the default placement of the main stress is on the final foot.

MEDIALWEAK and *FTFT are responsible for the medial syllables, which are unfooted or unstressed.

Chapter 3 also took a look at some interactions between syllable structure and metrical structure, i.e. quantity and weight, starting with those that arise from the moraicity of syllable-final segments and the constraint THREEMORAS= TWOGRIDPOSITIONS, which forces a trimoraic syllable to form its own foot. German has the same kind of weight contrast between open syllables and closed syllables as Dutch; however, in the case of German, it is limited to penultimate non-initial syllables: neither final syllables nor initial ones display this weight contrast. It was shown that a possible explanation for this contrast lies in how moraic structure relates to individual segments. A tense bimoraic vowel can be monomoraic for the sake of the metrical structure, but a closed syllable which projects two moras from two different segments retains its bimoraicity in all cases. The explanation advocated in this study is based on a proposal made by Lahiri & Koreman for Dutch.

Finally, in Chapter 4, the role of the trochaic foot for some morphological processes has been examined. The important role of the syllabic trochee in German phonology was confirmed. Two different processes were discussed in turn, the infinitive formation, an inflectional process, and the affixation of the diminutive suffix *-chen*, a derivational process. First, the infinitive suffix *-n* is always realized on a nonmoraic syllable. A sequence of two unstressed syllables at the end of the infinitive is avoided, and forms like *segeln* or *wandern* are realized instead of **segelen* or **wanderen*. Monosyllabic stems also have trochaic infinitives, as in *bauen* , which can also be realized as *baun* in connected speech. Some infinitives like *arbeiten, bewilligen* etc. seem to violate the trochaic tendency, but in fact, do not. The suffix *-n* cannot be syllabified in the last syllable of the stem because *n* is more sonorous than *t* or *g* and must thus build its own syllable. Second, suffixation of *-chen* causes umlaut of the adjacent syllable if the latter is stressed (*Lämpchen, Skandälchen*), but not if it is unstressed (*Autochen, Omachen*). We have analyzed this as an effect of the trochee formed by the last stressed syllable of a stem and the following unstressed suffix. Moreover, *-chen* suffixation is avoided in many cases in which no trochee can be formed by the last syllable of the stem and the suffix. A final schwa in the last syllable is interesting: if the last syllable of the stem is

schwa it is simply dropped in the suffixation. If it is a syllabic sonorant, it is ignored in most cases (*Väterchen, Kügelchen*), but not always (*Ankerchen*).

The analysis exposed in the preceding pages is a homogeneous account of the lexical stress pattern of both the monomorphemes and the complex words. It does away with the division of the German in native and nonnative vocabularies and use the same constraints for all words.

References

Anderson, Stephen R. (1984) A metrical interpretation of some traditional claims about quantity and stress. In: Aronoff, Mark and Richard T. Oehrle (eds.). 83-106.

Aronoff, Mark and Richard T. Oehrle (eds.) (1984) Language sound structure: Studies in phonology presented to Morris Halle by his teacher and students. Cambridge, Ma: MIT Press.

Bach, Emmon & Robert D. King (1970) Umlaut in Modern German. Glossa 4. 3-21.

Barkey, Reinhild (1993) Die Interaktion von Morphologie und Phonologie-Eine Untersuchung am Beispiel der deutschen Verbflexion. Tübingen: Ms.

Beckman, Jill, S. Urbanczyk & L. Walsh (eds.) (1995) Optimality Theory. Occasional Papers. GLSA, University of Massachusetts at Amherst.

Bennis, H. & W.U. S. van Lessen Kloeke (eds.) (1984) Linguistics in the Netherlands 1984. Dordrecht: Foris.

Benware, Wilbur (1980) Zum Fremdwortakzent im Deutschen. Zeitschrift für Dialektologie und Linguistik 47. 289-312.

Benware, W. A. (1987) Accent variation in German nominal compounds of the type (A(BC)). Linguistische Berichte 108. 102-127.

Bierwisch, Manfred (1966) Regeln für die Intonation deutscher Sätze. In: Studia Grammatica VIII. 99-201.

Birnbaum, H. (ed.) Studia linguistica A.V. Issatchenko a collegis amicisque oblata. Lisse: Peter de Ridder.

Booij, Geert & Jaap van Marle (eds.) (1993) Yearbook of Morphology 1993. Dordrecht: Kluwer.

Borowsky, Tony J. (1986) Topics in the Lexical Phonology of English. Doctoral Dissertation, University of Massachusetts, Amherst.

Braune, Wilhelm (1961) Althochdeutsche Grammatik. 10th edition. Tübingen: Niemeyer.

Broecke, M.P.R. van den , V.J. van Heuven and Wim Zonneveld (eds.) (1983) Sound structures: Studies for Antonie Cohen. Dordrecht: Foris.

Buckley, Eugene (1994) Alignment in Manam Stress. University of Pennsylvania: Ms.

Butt, Matthias & Peter Eisenberg (1990) Schreibsilbe und Sprechsilbe. In: Stetter, Chr. (ed.). 33-64.

Chen, Matthew Y. (1987) The syntax of Xiamen tone sandhi. Phonology Yearbook 4. 109-150.

Chomsky, Noam & Morris Halle (1968) The sound pattern of English. New York: Harper and Row.

Clements, G.N. (1978) Tone and syntax in Ewe. In D.J. Napoli (ed.) Elements of tone, stress and intonation. Washington, D.C: Georgetown University Press. 21-99.

Clements, G.N. (1990) The role of the sonority cycle in core syllabification. In Kingston, J. & M. Beckman (eds.). 283-333.

Clements, G.N. & Keyser, S.J. (1983) CV phonology. A generative theory of the syllable. Cambridge, Ma: MIT Press.

Cohn, Abigail & John McCarthy (1994) Alignment and parallelism in Indonesian Phonology. Cornell University and University of Massachussetts at Amherst: Ms.

Dijkstra, M. (1982) De basiskenmerken van een 'stress scale'. TABU 12. 49-54.

Dogil, Grzegorz (forthcoming) The phonetic manifestation of word stress. In Harry G. van der Hulst (ed.).

Dogil, Grzegorz & Michael Jessen (1989) Phonologie in der Nähe der Phonetik. Die Affrikaten im Polnischen und Deutschen. In Prinzhorn, Martin (ed.). 223-279.

Dresher, Elan and Aditi Lahiri (1991) The Germanic Foot: Metrical Coherence in Old English. Linguistic Inquiry 22. 251-286.

Drosdowsky, Günther (1981) Duden. Das große Wörterbuch der deutschen Sprache. Vols. 1 to 6. Mannheim, Wien, Zürich: Bibliographisches Institut.

Eisenberg, Peter (1991) Syllabische Struktur und Wortakzent: Prinzipien der Prosodik deutscher Wörter. In Ramers, K.H. & R. Wiese (eds.). Zeitschrift für Sprachwissenschaft 10. 37-64.

Eisenberg, Peter, Karl Heinz Ramers und Heinz Vater (eds.) (1992) Silbenphonologie des Deutschen. Tübingen: Narr.

Engel, U. and P. Grebe (eds.) Sprachsystem und Sprachgebrauch. Festschrift für Hugo Moser zum 65. Geburtstag. Düsseldorf.

Féry, Caroline (1991) The German schwa in prosodic morphology. Zeitschrift für Sprachwissenschaft 10. 65-85

Fleischer, W und I. Barz (1992) Wortbildung der deutschen Gegenwartsprache. Tübingen: Niemeyer.

French, Koleen Matsuda (1988) Insights into Tagalog reduplication, infixation and stress from non-linear phonology. MA Thesis, University of Texas, Arlington.

Fujimura, O. (ed.) (1973) Three Dimensions of Linguistic Theory. Tokyo: Taikusha.

Georgopoulos, Carol and R. Ishihara (eds.). Interdisciplinary approaches to language: Essays in honor of S.-Y. Kuroda. Dordrecht: Kluwer.

Giegerich, Heinz J. (1985) Metrical phonology and phonological structure. German and English. Cambridge: Cambridge University Press.

Giegerich, Heinz J. (1987) Zur Schwa-Epenthese im Standarddeutschen. Linguistische Berichte 112. 449-469.

Giegerich, Heinz J. (1992) Onset maximization in German: the case against resyllabification rules. In: Eisenberg, P., K. H. Ramers & H. Vater (eds.). 134-171.

Goldsmith, J. (1976) Autosegmental phonology. Doctoral Dissertation. MIT. (Reprinted in Bloomington: Indiana University Linguistics Club.)

Goldsmith, John (ed.) (1995) Handbook of Phonology. Oxford: Basil Blackwell.

Gonzàlez, Mercè (ed.). Proceedings of the North-EastLinguistics Society 24. Amherst, MA: Graduate Linguistic Student Association.

Grewendorf, Günther, Fritz Hamm & Wolfgang Sternefeld (1987) Sprachliches Wissen. Frankfurt: Suhrkamp.

Hale, Kenneth & Elisabeth Selkirk (1987) Governement and tonal phrasing in Papago. Phonology Yearbook 4. 151-183.

Hall, Tracy Alan (1992a) Syllable Structure and Syllable-Related Processes in German. Tübingen: Niemeyer (= Linguistische Arbeiten 276)

Hall, Tracy Alan (1992b) Syllable final clusters and schwa epenthesis in German. In: Eisenberg, P., K. H. Ramers & H. Vater (eds.). 208-245.

Hall, Tracy Alan (1993) The Phonology of German /R/. Phonology 10. 83-105.

Halle, Morris, H.G. Hunt & H. McLean. (eds). (1956) For Roman Jakobson. The Hague: Mouton.

Halle, Morris & Jean-Roger Vergnaud (1987) An essay on stress. Cambridge: MIT Press.

Hammond, Michael (1994) An OT account of variability in Walmatjari stress. University of Arizona: Ms.

Hayes, Bruce (1980) A metrical theory of stress rules. Doctoral Dissertation. MIT.

Hayes, Bruce 1982 Extrametricality and English stress. Linguistic Inquiry 13. 227-276.

Hayes, Bruce (1986) Review of H. Giegerich (1985). Journal of Linguistics 22. 229-235.

Hayes, Bruce (1987) A revised parametric metrical theory. In Proceedings of NELS 17. 274-89.

Hayes, Bruce (1989) The prosodic hierarchy in meter. In Kiparsky, P. and G. Yougmans (eds.). 201-260.

Hayes, Bruce (1995) Metrical stress theory: Principles and case studies. Chicago: University of Chicago Press.

Hayes, Bruce & Aditi Lahiri (1991) Bengali intonational phonology. Natural Language and Linguistic Theory 9. 47-99.

Heidolph, Karl Erich, Walter Flämig & Wolfgang Motsch (eds.) (1980) Grundzüge einer deutschen Grammatik. Berlin: Akademie-Verlag.

Höhle, Tilman & Heinz Vater (1978) 'Derivational constraints' und die silbischen Konsonanten im Deutschen. In: Birnbaum, H. (ed.). 169-186.

Hyman, Larry (1985) A Theory of phonological weight. Dordrecht: Foris.

Hulst, Harry G. van der (1984) Syllable structure and stress in Dutch. Dordrecht: Foris.

Hulst, Harry G. van der (1995) Metrical Phonology. Glot International 1, 1. 3-6.

Hulst, Harry G. van der (ed.) (forthcoming) Word prosodic systems of European languages. Berlin: Mouton de Gruyter.

Hulst, Harry G. van der and Norval Smith (eds.) The structure of phonological representation. Dordrecht: Foris.

Hulst, Harry G. van der and J. Van Lit (1987) Lettergreepstructuur. GLOT 10. 165-195.

Hung, Henrietta (1993) Iambicity, Rhythm, and non-Parsing. University of Ottawa: Ms.

Hung, Henrietta (1995) The rhythmic and prosodic organization of edge constituents. Doctoral Dissertation. Brandeis University, Waltham.

Inkelas, Sharon (1989) Prosodic Constituency in the Lexicon. Doctoral Dissertation. Stanford University.

Inkelas Sharon (1994) Exceptional stress-attracting suffixes in Turkish: representations vs. the grammar. University of Califoria, Berkeley: Ms.

Inkelas, Sharon, Orhan Orgun & Cheryl Zoll (1994) Subregularities as cogrammars: the theoretical status of nonproductive patterns in grammars. University of Califoria, Berkeley: Ms.

Inkelas, Sharon & Draga Zec (eds.) (1989) The Phonology-Syntax Connection. Chicago: University of Chicago Press.

Isačenko, Alexander (1963) Der phonologische Status des velaren Nasals im Deutschen. Zeitschrift für Phonetik 16. 77-84. Also in: Steger, H. (ed.) (1970). 468-479.

Isačenko, Alexander (1974) Das "Schwa mobile" und "Schwa constans" im Deutschen. , In: Engel, U. and P. Grebe (eds.). 142-171.

Itô, Junko & Armin Mester (1994) Realignment. University of California, Santa Cruz: Ms.

Itô, Junko, Armin Mester & Jay Padgett (1993) Licensing and redundancy: Underspecification in Optimality Theory. University of California, Santa Cruz: Ms.

Iverson, Gregory K.& Joe Salmons (1992) The place of Structure Preservation in German diminutive formation. Phonology 9. 137-143.

Jakobson, Roman (1937) Über die Beschaffenheit der prosodischen Gegensätze. In: Jakobson, Roman (1962).

Jakobson, Roman (1962) Selected writings 1: Phonological studies. The Hague: Mouton.

Janda, Richard D. (1987) On the motivation for an evolutionary typology of sound-structural rules. Doctoral Dissertation. UCLA.

Jessen, Michael (1994) A survey of German word stress. University of Stuttgart: Ms.

Kager, René (1985) Cycliciteit, klemtoon en HGI. Spektator 14. 326-331.

Kager, René (1989) A metrical theory of stress and destressing in English and Dutch. Dordrecht: Foris.

Kager, René (1993) Alternatives to the iambic-trochaic law. Natural Language and Linguistic Theory 11. 381-432.

Kager, René (1994) Ternary rhythm in alignment theory. Utrecht University: Ms.

Kager, René & Ellis Visch (1983) Een metrische analyse van ritmische klemtoonverschijnselen. MA Thesis, University of Utrecht.

Kager, René & Wim Zonneveld (1986) Schwa, syllables, and extrametricality in Dutch. The Linguistic Review 5. 197-221.

Kahn, D. (1976) Syllable-based Generalizations in English Phonology. New York: Garland (Published version of Doctoral Dissertation MIT 1975).

Kaltenberg, Erika (1994) Typologische Aspekte des Wortakzents. Zum Zusammenhang von Akzentposition und Silbengewicht im Arabischen und im Deutschen. Zeitschrift für Sprachwissenschaft 13. 20-55.

Keating, Patricia A. (ed.) Phonological structure and phonetic form. Papers in Laboratory Phonology III. Cambridge, Ma: MIT Press.

Kenstowicz, Michael (1994a) Cyclic vs Noncyclic constraint evaluation. MIT Working Papers in Linguistics 21. 11-42.

Kenstowicz, Michael (1994b) Sonority-Driven Stress. MIT: Ms.

Kenstowicz, Michael (1994c) Phonology in Generative Grammar. Cambridge: Blackwell.

Kingston, John & Mary Beckman (1990) Between the grammar and physics of speech. Papers in Laboratory Phonology I. Cambridge: Cambridge University Press.

Kiparsky, Paul (1966) Über den deutschen Akzent. Studia Grammatica 7. 69-98.

Kiparsky, Paul (1968) How abstract is phonology? Distributed by Indiana University Linguistics Club. Reprinted in Kiparsky, P. (1982). 119-164.

Kiparsky, Paul (1973) Abstractness, opacity, and global rules. In: O. Fujimura (ed.). 1-136.

Kiparsky, Paul (1979) Metrical structure assignment is cyclic. Linguistic Inquiry 10. 421-441.

Kiparsky, Paul (1982) Explanations in phonology. Dordrecht: Foris.

Kiparsky, Paul and G. Yougmans (eds.) (1989) Rhythm and Meter. Orlando: Academic Press.

Klein, Thomas (1994) Icelandic u-umlaut in Optimality Theory. In Proceedings of Console 5, Tübingen: Niemeyer.

Kloeke, W.U.S. van Lessen (1982) Deutsche Phonologie und Morphologie. Merkmale und Markiertheit. Tübingen: Niemeyer.

Kohler, Klaus J. (1977) Einführung in die Phonetik des Deutschen. Berlin: Eric Schmidt Verlag.

Krakow, R.A. (1989) The articulatory organisation of syllables: a kinematic analysis of labial and velic gestures. Doctoral Dissertation, Yale University.

LaCharité, Darlene und Carole Paradis (1993) Introduction: the emergence of constraints in Generative Phonology and a comparison of three current constraint-based models. Canadian Journal of Linguistics 38. 127-167.

Lahiri, Aditi & J. Koreman (1988) Syllable weight and quantity in Dutch. In H. Borer (ed.). West Coast Conference on Formal Linguistics 1988. Stanford Linguistics Association, Stanford, Cal. 217-228.

Lieber, Rochelle (1987) An integrated theory of autosegmental processes. Albany: State University of New York Press.

Lieber, Rochelle (1992) De-constructing Morphology. Word formation in syntactic theory. Chicago: The University of Chicago Press.

Liberman, Mark & Prince, Alan (1977) On stress and linguistic rhythm. Linguistic Inquiry 8. 249-336.

Lodge, Ken (1989) A non-segmental account of German Umlaut. Linguistische Berichte 124. 470-491.

McCarthy, John & Alan Prince (1986) Prosodic phonology. University of Massachusetts, Amherst and Brandeis University, Waltham: Ms.

McCarthy, John & Alan Prince (1993) Prosodic Morphology I: Constraint interaction and satisfaction. To appear, MIT Press. Technical Report #3, Rutgers University Center for Cognitive Science.

McCarthy, John & Alan Prince (1993) Generalized Alignment. In Geert Booij & Jaap van Marle (eds.). 79-153. (also Technical Report #7, Rutgers University Center for Cognitive Science.)

McCarthy, John & Alan Prince (1994a) The Emergence of the unmarked: Optimality in Prosodic Morphology. In Mercè Gonzàlez (ed.). 333-379.

McCarthy, John & Alan Prince (1994b) Prosodic Morphology: an overview. Part I: Template form in reduplication. Part II: Template satisfaction. Handouts of talks presented at the Worshop on Prosodic Morphgology. (Utrecht, June 1994).

Marchand, H. (1969) The categories and types of present-day English word-formation: a synchronic-diachronic approach. 2nd, rev. edition. Munich: Beck.

Möller, R. (1986) Die verschiedene Betonung von Toponymen als Problem der Namenchronologie. Zeitschrift für Namenforschung 21. 317-350.

Moulton, William G. (1956) Syllabic Nuclei and final consonant clusters in German. In: Morris Halle, H.G. Hunt & H. McLean. (eds). 372-381.

Moulton, William G. (1962) The sounds of English and German. Chicago: University of Chicago Press.

Muthmann, Gustav (1991) 2nd edition. Rückläufiges deutsches Wörterbuch. Tübingen: Niemeyer.

Napoli, D. J. (ed.) (1978) Elements of tone, stress and intonation. Washington, D.C: Georgetown University Press.

Noske, Roland (1992) A theory of syllabification and segmental alternation. With studies on the phonology of French, German, Tonkawa and Yawelmani. Doctoral Dissertation, University of Amsterdam.

Nouveau, Dominique (1994) Language acquisition, metrical theory, and optimality. A study of Dutch word stress. Utrecht University: OTS Dissertation Series.

Paradis, Carole (1988a) On constraints and repair strategies. The Linguistic Review 6. 71-97.

Paradis, Carole (1988b) Toward a theory of constraint violations. Mc Cill Working Papers in Linguistics 5. 1-43.

Paradis, Carole (1993) Ill-formedness in the dictionary: a source of constraint violation. Canadian Journal of Linguistics 38. 215-234.

Penzl, Herbert (1949) Umlaut and secondary umlaut in Old High German. Language 25. 223-240.

Pierrehumbert, Janet (1993) Alignment and Prosodic Heads. Northwestern University: Ms.

Prince, Alan (1983) Relating to the grid. Linguistic Inquiry 14. 19-100.

Prince, Alan & Paul Smolensky (1993) Optimality Theory: Constraint interaction in generative grammar. Univ. of Colorado, Boulder: Ms.

Prinz, Martin & Richard Wiese (1990) Ein nicht-lineares Modell der Graphem-Phonem-Korrespondenz. Folia Linguistica 24. 73-103.

Prinzhorn, Martin (ed.) (1989) Phonologie. Sonderheft 2 Linguistische Berichte.

Raffelsiefen, Renate (1994) Schwa patterns in German verbs, a study in the phonology-morphology interface. Düsseldorf: Ms.

Ramers, Karl Heinz (1988) Vokalquantität und -qualität im Deutschen. Tübingen: Niemeyer (= Linguistische Arbeiten 213).

Ramers, Karl Heinz (1992) Ambisilbische Konsonanten im Deutschen. In Eisenberg, Peter, Ramers, Karl Heinz & Heinz Vater (eds.). 246-283.
Ramers, Karl Heinz & Heinz Vater (1992) Einführung in die Phonologie. Köln: Gabel. (= Klage 16).
Ramers, Karl Heinz & Richard Wiese (eds.) (1991) Zeitschrift für Sprachwissenschaft 10, 1. Themenheft: Prosodische Phonologie.
Reis, Marga (1974) Lauttheorie und Lautgeschichte. Untersuchungen am Beispiel der Dehnungs- und Kürzungsvorgänge im Deutschen. München: Fink.
Rice, Karen (1989) Review of Lieber, R. An integrated theory of autosegmental processes. Canadian Journal of Linguistics 34. 59-78.
Rosenthall, Samuel (1994) Vowel/glide alternation in a theory of constraint interaction. Doctoral Dissertation, University of Massachusetts at Amherst.
Rubach, J. (1989) Final devoicing and cyclic syllabification in German. Linguistic Inquiry 21. 79-94.
Scobbie, James M. (1991) Attribute Value Phonology. Doctoral Dissertation, University of Edinburgh.
Selkirk, Elisabeth O. (1980) The role of prosodic categories in English word stress. Linguistic Inquiry 11. 563-605.
Selkirk, Elisabeth O. (1982a) The syntax of words. Cambridge, Ma: MIT Press.
Selkirk, Elisabeth O. (1982b) The syllable. In: van der Hulst and Smith (eds.). 337-383.
Selkirk, Elisabeth O. (1984) Phonology and syntax. The relation between sound and structure. Cambridge: MIT Press.
Selkirk, Elisabeth O. (1986) On derived domains in sentence phonology. Phonology Yearbook 3. 371-405.
Selkirk, Elisabeth O. (1995) The Prosodic structure of Function Words. In: Jill Beckman, S. Urbanczyk & L. Walsh (eds.). 1-31.
Selkirk, Elisabeth O. & Tong Shen (1990) Prosodic domains in Shanghai Chinese. In: Inkelas, S. & D. Zec (eds). 313-337.
Selkirk, Elisabeth O. & Koichi Tateishi (1991) Syntax and downstep in Japanese, In C. Georgopoulos and R. Ishihara (eds.). 519-544.
Sievers, E. (1901). Grundzüge der Phonetik zur Einführung in das Studium der Lautlehre der indogermanischen Sprache, 5th edition. (1st ed. 1876).

Leipzig: Breitkopf und Härtel. [Reedition: Hildesheim: Georg Olms, 1976 (1st edition 1980)].
Sloan, D.K. (1991) Syllables and Templates: Evidence from Southern Sierra Miwok. Doctoral Dissertation, MIT.
Steger, H. (ed.) (1970) Vorschläge zu einer strukturalen Grammatik des Deutschen. Darmstadt: Wissenschaftliche Buchgesellschaft (= Wege der Forschung 146).
Steriade, Donca (1982) Greek prosodies and the nature of syllabification. Doctoral Dissertation, MIT.
Steriade, Donca (1995) Underspecification and markedness. In: John Goldsmith (ed.). 114-174.
Stetter, Chr. (ed.) (1990) Zu einer Theorie der Orthographie. Tübingen: Niemeyer (= Reihe Germanistische Linguistik 99).
Treiman, R. & C. Danis (1988) Syllabification of intervocalic consonants. Journal of memory and language 27. 87-104.
Trommelen, Mieke & Wim Zonneveld (1993) Word stress in English, Dutch, German, Norwegian and Swedish. In Hulst (ed.) (forthcoming).
Trubetzkoy, Nikolai Sergejewitsch (1939) Grundzüge der Phonologie. Prag (=TCLP 7) (also edited in 1958 by Vandenhoeck & Ruprecht, Göttingen).
Turk, Alice (1994) Articulatory phonetic cues to syllable affiliation: gestural characteristics of bilabial stops. In: Keating, Patricia A. (ed.). Cambridge: MIT Press. 107-135.
Twaddell, W.F. (1938) A note on Old High German umlaut. Monatshefte für deutschen Unterricht, deutsche Sprache und Literatur 30. 177-181.
Vater, Heinz (1992) Zum Silben-Nukleus im Deutschen. In Eisenberg, P., K.-H. Ramers und H. Vater (eds). 100-133.
Vennemann, Theo (1968) German Phonology. Doctoral Dissertation, University of California at Los Angeles.
Vennemann, Theo (1972) On the theory of syllabic phonology. Linguistische Berichte 18. 1-18.
Vennemann, Theo (1982) Zur Silbenstruktur der deutschen Standardsprache. In Vennemann, Theo (ed.). 261-305.
Vennemann, Theo (ed.) Silben, Segmente, Akzente. Tübingen: Niemeyer (= Linguistische Arbeiten 126).
Vennemann, Theo (1986) Neuere Entwicklungen in der Phonologie. Berlin: Mouton de Gruyter.

Vennemann, Theo (1988) Preference laws for syllable structure and the explanation of sound change. With special reference to German, Germanic, Italian and Latin. Berlin: Mouton de Gruyter.

Vennemann, Theo (1992) Syllable Structure and Simplex Accent in Modern Standard German. In: Ziolkowski, M, Noske, M. & Deaton, K. (eds). 399-412.

Visch, Ellis & René Kager (1984) Syllable weight and Dutch word stress. In H. Bennis & W.U. S. van Lessen Kloeke (eds.) Linguistics in the Netherlands 1984. Dordrecht: Foris. 197-205.

Wiese, Richard. (1986) Schwa and the structure of words in German. Linguistics 24. 697-724.

Wiese, Richard (1987) Phonologie und Morphologie des Umlauts im Deutschen. Zeitschrift für Sprachwissenschaft 6. 227- 248.

Wiese, Richard (1988) Silbische und lexikalische Phonologie: Studium zum Chinesischen und Deutschen. Tübingen: Niemeyer (= Linguistische Arbeiten 211).

Wiese, Richard (1994) Phonological vs. morphological rules: On German Umlaut and Ablaut. In: Wiese, R. (ed.). 91-114.

Wiese, Richard (ed.) (1994) Recent Developments in Lexical Phonology. Düsseldorf: Arbeiten des Sonderforschungsbereichs 282, Nr. 56.

Wurzel, Wolfgang Ullrich (1970) Studien zur deutschen Lautstruktur. Studia Grammatica VIII. Berlin: Akademie-Verlag.

Wurzel, Wolfgang Ullrich (1980a) Der deutsche Wortakzent: Fakten-Regeln-Prinzipien. Zeitschrift für Germanistik 1. 299-318.

Wurzel, Wolfgang Ullrich (1980b): Phonologie. In Heidolph, K. E. et al. (eds.). Chapter 5.

Wurzel, Wolfgang Ullrich (1984) Was bezeichnet der Umlaut im Deutschen? Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung 37. 647-663.

Yu, Si-taek (1992) Unterspezifikation in der Phonologie des Deutschen. Tübingen: Niemeyer (= Linguistische Arbeiten 274).

Ziolkowski, M, Noske, M. & Deaton, K. (eds.) Papers from the 26th Regional Meeting of the Chicago Linguistic Society, vol 2. The Parasession on the syllable in phonetics and phonology.