Umlaut and Inflection in German[1]

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0. Introduction

The present paper examines the prosodic constituent Foot as the domain of phonological phenomena in German. Several processes take place in this constituent, such as Glottal Stop Insertion and Final Devoicing, as well as the phenomena that are described below: productive umlaut and infinitive inflection. The status of the trochaic Foot as the unmarked constituent in German is also discussed. The framework used here is Optimality Theory (OT) as developed in a series of recent papers by Prince, Smolensky and McCarthy (Prince -- Smolensky 1993, McCarthy -- Prince 1993a, 1993b, 1994a, 1994b). OT considers grammars as sets of violable and ranked universal constraints; for more information on the framework, I must refer the reader to the above-mentioned papers .

German is a language with a rich morphology and peripheral affixation but few sandhi-rules and a poor inventory of segmental alternations. However, the interaction between morphology and prosody is not uninteresting. It will be proposed that the trochaic Foot is the preferred prosodic unit in German, being formed whenever possible. Stems are often trochaic in German: they are either monosyllabic and bimoraic (Heu 'hay', Müll 'garbage', froh 'happy') or bisyllabic with a weak second syllable (Lampe 'lamp', Fenster 'window'). In tri- and quadrisyllabic words, the last Foot is generally trochaic.[2] In most cases, derivation and inflection add a single unstressed syllable, the unmarked result of which is a syllabic trochee.

In terms of OT, the constraint FOOTFORM (TROCHAIC) is active in German. This constraint has been proposed by McCarthy -- Prince (1993b:10) to express that Feet are preferably binary (see below). The fact that numerous morphological forms contain more material than a trochee is explained by the ranking of FOOTFORM below constraints requiring that the input and output of each form be as exact as possible. See McCarthy -- Prince (1993a, 1994a) for some elaboration of this point.

As an introduction and to see that the Foot (F) has a phonetic reality in German, compare the crisp edges[3] of Prosodic Words (PW), as in these examples from McCarthy -- Prince (1993b:47). A dot under a consonant indicates ambisyllabicity.

(1)	bergab	'downhill'	[(.bɛʀk.)$_{Ft}$]$_{PW}$ [(ʔàp.)$_{Ft}$]$_{PW}$
	aufessen	'to eat up'	[(.ʔáu̯f.)$_{Ft}$]$_{PW}$ [(ʔɛ̀s̩n̩.)$_{Ft}$]$_{PW}$
	verirren	'to lose one's way'	[(.fɐ.)$_{Ft}$]$_{PW}$ [(ʔɪr̩n̩.)$_{Ft}$]$_{PW}$
	Zollamt	'customs office'	[(.tsɔ́l.)$_{Ft}$]$_{PW}$ [(ʔàmt.)$_{Ft}$]$_{PW}$

In these examples, a glottal stop is inserted before initial vowels, indicating the left edge of a new Prosodic Word word-internally. As shown in (2), not only the left Prosodic Word boundary triggers Glottal Stop Insertion, but also the left Foot boundary, since the words in (2) 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.

(2)	a.	Ruin	'ruin'	[.ʀu.(ʔí:n.)$_{Ft}$]$_{PW}$
		Chaot	'anarchist'	[.ka.(ʔó:t.)$_{Ft}$]$_{PW}$
	b.	Fluor	'fluorine'	[(.flú:.ɔʀ.)$_{Ft}$]$_{PW}$
		Museum	'museum'	[.mu.(zé:.ʊm.)$_{Ft}$]$_{PW}$

The clear syllable, Foot and Prosodic Word boundaries of (1) and (2a) contrast with blurred syllable edges within a Foot, as in (2b) and (3):

(3)	Adler	'eagle'	[(á:.dlɐ)$_{Ft}$]$_{PW}$ or [(á:t.lɐ)$_{Ft}$]$_{PW}$
	Handlung	'action'	[(hán.dlʊŋ)$_{Ft}$]$_{PW}$ or [(hánt.lʊŋ)$_{Ft}$]$_{PW}$
	Ordner	'file'	[(ɔʀ.dnɐ$_{Ft}$]$_{PW}$ or [(ɔʀt.nɐ)$_{Ft}$]$_{PW}$
	Kadmium	'cadmium'	[(ká.dmiʊm)$_{Ft}$]$_{PW}$ - [(kát.miʊm)$_{Ft}$]$_{PW}$
	Magma	'magma'	[(má.gma)$_{Ft}$]$_{PW}$ or [(mák.ma)$_{Ft}$]$_{PW}$
	Leibniz, Wagner		[(vá:.gnɐ)$_{Ft}$]$_{PW}$ or [(vá:k.nɐ)$_{Ft}$]$_{PW}$

Native speakers do not agree on the syllabification of these words: according to some phonologists (e.g., Vennemann 1992: 404), 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; according to other authors (e.g., Kloecke 1982, Giegerich 1992, Yu 1992),[4] the syllable boundary is located either before or in the middle of the consonant cluster, in which case the voicing of the stop is an exception to Final Devoicing, which, according to most German phonologists (following Vennemann 1972), takes place before a syllable boundary. As a matter of fact, some, but not all, speakers apply Final Devoicing in these cases, and it is subject to variation even in the speech of

one and the same speaker. However, aspiration of the stop, which can normally go with Final Devoicing, is never applied.

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. In the OT framework, this is expressed by the ALIGN-L constraint (Prince -- Smolensky 1993:104, McCarthy -- Prince 1993b), which requires that to the left edge of each foot there corresponds the left edge of a syllable.

(4) ALIGN-L

Align (Ft, L, σ, L)

No constraint of the Align format requires crisp syllable edges inside a Foot in which syllabification is resolved by constraints other than Alignment. A discussion of the Foot-internal syllabification would take me too far from the topic of the paper and it would add no further argument to the point made here. Summing up, then, it is important to keep in mind that the Foot is always clearly defined by syllabification.

The paper is organized as follows: Section 1 examines the productive umlaut in the OT framework. German umlaut is a largely lexicalized process; however, it is productive in the morphological affixation of some diminutive suffixes (essentially -<u>chen</u> and -<u>lein</u>), but only when a Foot is formed by the last syllable of the stem and the suffix itself.

Section 2 discusses the infinitive template, which ideally has the size of a syllabic trochee. Whenever a stem is monosyllabic or has one (or exceptionally two) sonorants as its last segment(s), the template is met. If the stem is bi- or polysyllabic, the template is violated since the infinitive is bigger than a trochee.

Section 3 is a summary of the main points.

1. Umlaut

(5) gives a complete picture of the German vowels.

(5) German vowels

i. tense vowels	ii. lax vowels	iii. diphthongs
i, y u	ɪ, ʏ ʊ	a͡i, ɔ͡y, a͡u
e, ø o	ə	
	ɛ, œ ɔ	
a	ɑ	

German umlaut is the fronting of back vowels, as illustrated in (6). In the last three cases (6e-g), tongue raising is also involved, though /a/ –>/ ɛ/ (6e,f) and /a/ –> /ɔ/ (6g) must be distinguished. /a/ is low and back in German.[5] 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 alternation of the diphthong /a͡u/ –> /ɔ͡y/ 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 (/u̯/ –> /y̯/), and the primary vowel adopts its rounding.

(6) Umlaut

a.	[ʊ]	–>	[ʏ]	Mutter/Mütter	‘mother/mothers’
b.	[u:]	–>	[y:]	Gut/Güter	‘goods, sg./goods, pl.’
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.	[au̯]	–>	[ɔy̯]	Baum/Bäume	‘tree/trees’

Though umlaut takes place in the environments listed in (7), the suffixes that at first sight seem to trigger umlaut do not systematically do so, as can be seen from (8).

(7) 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 ‘goods,sg./goods, pl.’

– 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’

(8) Derivation and inflection without umlaut

a. Affixation with diminutive affixes: -chen: /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/wooly’, 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 sg’

f. Infinitive: Lob/loben ‘praise/to praise’

For nearly all morphological contexts with umlaut in (7) there are corresponding forms without umlaut in (8). The only exception is the plural *-er* morpheme, which always accompanies an umlauted stem. However, this plural formation is completely unproductive,[6] 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 by a stem (Wiese 1987, 1994), either as a phonological or as a morphological phenomenon. In my opinion, the over-whelming majority of occurrences of umlaut are lexicalized forms. The learners of German have to learn the forms in (7) and (8) by heart. The examples in (9), in which the suffix *-ig* is sometimes associated with an umlauted stem and sometimes with a non-umlauted stem, are a further illustration of the arbitrariness of umlaut.

(9) 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 occasionally triggering umlaut, and stay nonumlauted with another one. In cases like (10), too, German learners must memorize the forms. Thus, Wiese's alternative approach analyzing 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.

(10) 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 morphologically-triggered phonological phenomenon. From now on, I 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 (11). In all words in (11) and (12), the stress is given. Constraints in OT are responsible for the stress pattern, but they are not considered here (see Féry 1994).

(11) 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, several alternatives are possible. First, the stem is suffixed with -chen but not umlauted, as in (12a). Second, the stem is not suffixed with -chen at all, as in (12b). Monatchen, Monätchen, Europachen and Europächen all sound strange.

(12) 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. I asked ten native speakers of German for their judgments of words like (12) with a main stress on a non-final 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, I will first concentrate on the data in (11), where the main stress is on the stem’s last syllable, and show how the

Optimality framework accounts for them. After that, I will return to the data in (12).

As I have already mentioned in the introduction, the trochee is the preferred and unmarked prosodic constituent of German. It is also, without exception, the Minimal Word of German.[7] A monomorphemic stem is often moraically or syllabically trochaic. (13a) shows a monosyllabic bimoraic stem, and (13b) a bisyllabic one. Most inflectional and derivational suffixes just add an unstressed syllable. The adjunction of such a suffix in (13a) leads to the formation of a bisyllabic trochee. In contrast, the word Däne 'Dane' in (13b) is already bisyllabic. (13b) illustrates a very common process 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.

(13) a. Hund- Hunde- Hundin 'dog-dogs-bitch'

b. Däne- Dänin- dänisch 'Dane, masc.-Dane, fem.-Danish'

Thus the fact that umlaut applies in a syllabic trochee does not come as a surprise: -chen is an unstressed derivational suffix, which preferably adjoins to a stressed syllable, and together they form this unmarked prosodic constituent. The preference of German for the unmarked trochee is expressed by the constraint FOOTFORM (TROCHAIC) in (14). If the last foot of a word is a trochee, FOOTFORM is fulfilled; otherwise it is violated. FOOTFORM is a low-ranking constraint, often violated in the language. However, its fulfillment is a case of Emergence of the Unmarked (McCarthy -- Prince 1994a).[8]

(14) FOOTFORM (TROCHAIC)

Feet are syllabic trochees.

It expresses that the preferred foot is the syllabic trochee, as illustrated in (15):

(15) Bisyllabic trochee

σ_S σ_W

Since -chen is a monomoraic unstressed syllable (see section 2), the only way to fulfill (14) is that it be added to a stem ending in a stressed syllable. If it is added to a stem with a final unstressed syllable, (14) is violated. The fulfillment and violation of constraints are illustrated below in Tableaux 1 to 5.

Besides its domain of application, umlaut has a few interesting phonological properties, which are reviewed in the following paragraphs and expressed in terms of positive or negative constraints. 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, I assume that in productive umlaut a floating feature [front] comes with the suffix -chen, as illustrated in (16). This is the kind of analysis proposed by Lieber (1987) and Lodge (1989).

(16) 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. The constraint PARSEFEAT is one of several in a group of Faithfulness constraints which regulate the correspondence between input and output (but see McCarthy -- Prince 1994b for a different proposal), positing that all features must be parsed. It is formulated as in (17) (Prince -- Smolensky 1993, McCarthy -- Prince 1993a, Itô -- Mester -- Padgett 1994 : 24-25):

(17) PARSEFEAT

All input features are parsed.

In our case, association of the floating feature, as shown in (18), satisfies (17), whereas non-association of this feature counts as a violation:

(18) Association of the floating feature

V X]$_{Stem}$ chen

[front]

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] and [back], which are distinct privative features, the unspecified status being reserved 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 (19). Why this view is better than the underspecification approach will become clear below.

(19) a. Input b. Optimal Output

Lámp	chen	Lämpchen
[back]	[front]	[front]

Tableau 1 compares the optimal candidate Lämpchen with the suboptimal one Lampchen. Lämpchen, with umlaut, respects both FOOTFORM and PARSEFEAT, whereas Lampchen, without umlaut, fulfills FOOTFORM but violates PARSEFEAT because of the nonassociation of the floating feature [front].

Tableau 1

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 (20). 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, spreading features counts as a violation.

(20) 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 (21) from Twaddell (1938), Braune (1961) and Penzl (1949):

(21) 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 2 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.

Tableau 2

The third property of umlaut is the obligatory adjacency of -chen and the umlauted vowel (but see (24)). NOCROSSING (22) accounts for the ungrammaticality of words like Cäféchen (instead of Cafechen 'little café'), in which FOOTFORM is respected, but where umlaut takes place across full specified vowels as in (23).

(22) NOCROSSING
Association lines do not cross.

(23) * C ä f e ch e n

[front]

In Tableau 3, NOCROSSING is unviolated and undominated: its violation is always fatal.

Tableau 3

Words with a final syllabic sonorant syllable as in (24) and (25) do not behave homogeneously: Brüderchen 'little brother', Väterchen 'little father', etc. in (24a) are lexicalized hypocoristics and are umlauted. The words in (24b) 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 (24c) 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 (25):

(24) a.	Brúder/Brüderchen/*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/Tálerchen/*Tälerchen	'Thaler/little Thaler'
	Dótter/Dótterchen/?Dötterchen	'yolk/little yolk'

(25)	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 I assume, syllabic sonorants have no vocalic features (see section 2), the floating segment can be associated: in (26) no line blocks the association.

(26) M äu ʁ ch e n

[front]

FOOTFORM is responsible for the non-homogeneity of the stems in (24) and (25). 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 (24a,b) or Kügelchen (25) 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.[9] There is a series of phenomena in German indicating that syllabic sonorants or schwas are not perceived as syllabic peaks: they are always unstressed, no word begins with a schwa or with a syllabic sonorant, schwa is often epenthetic and so on. Furthermore, as Kager (1989) has shown for Dutch, a 'schwallable' does not play any role in the metrical structure of words. It is ignored by the accent rules. 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 (23c).

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 alternation Matratze /Maträtzchen and (13b), this is not true for the syllabic sonorant. 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 be 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, *Atemung do not form syllabic trochees, but rather dactyls, and thus violate FOOTFORM.

To sum up, some of the stems with a syllabic sonorant in their final syllable behave like bisyllabic trochees and are non-umlauted 'normal cases', whereas other 'exceptional cases' behave as if they were monosyllabic in being umlauted.[10]

Now consider the forms in (12) which violate FOOTFORM 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.

Tableaux 4 and 5 account for the data in (12). All candidates have main stress on the first syllable and thus make a tie on FOOTFORM: they all violate it. The other constraints used until now, NOCROSSING, PARSEFEAT and FILLLINK, have the same ranking as before. However, they are not able to eliminate all suboptimal candidates. More constraints are needed that play

no role in the evaluation of the first set of data. The first of these additional constraints accounts for the fact that an umlauted vowel is generally stressed.[11] This is true not only of productive umlaut, but to a lesser extent, of all occurrences of umlauted vowels as well as other marked vowels like nasals[12] (see also Steriade 1993). An unstressed umlauted vowel counts as a violation of the constraint MAV(PRO), formulated in (27):

(27) MAV(PRO) (Marked Vowel (Prominent))

A marked vowel appears in a prominent syllable.

The second constraint is M-PARSE (28) proposed by McCarthy -- Prince (1993a:112):

(28) M-PARSE

Morphemes are parsed into morphological constituents.

Autochen is illustrated in Tableau 4 and the non-existence of the parsed realization of Monat + chen in Tableau 5.

Tableau 4

Tableau 5

Notice that both forms, Autochen and Monat, are accounted for by the same constraints and ranking. The tableaux illustrate the fact that both candidates, the one with unparsed -chen and the one with the unparsed floating feature,

are equally good, and that it is a lexically-driven matter which of the two options a given word adopts. In these data, 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 OT 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 former one. In data in which the competence of the native speakers fluctuate 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 (12), those words already forming a syllabic trochee on their own, and violating FOOTFORM under derivation. Candidates like Autochen and Monat…, which fulfill NOCROSSING and MAV(PRO), are definitely better than *Äutöchen or *Mönatchen, which violate those constraints. No derivational approach can account for such a ranking.

Although fulfilling FOOTFORM, 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 5). 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. I do not think that this doublet is necessary. Instead I propose that these forms are lexicalized hypocoristics not in need of an explanation in prosodic terms. -chen is always integrated in 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.

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. It has also been argued in this section that feet (and by projection Prosodic Words) are preferably syllabic trochees. The next section shows that the same is true for some inflected forms. This is illustrated with the infinitive.

2. Infinitive inflection

In line with the tendency of German to prefer syllabic trochees, the infinitive also forms this constituent whenever possible (Wurzel 1970, Wiese 1986:713, Giegerich 1987:459, Féry 1991): a syllable is added whose nucleus is a syllabic sonorant. There are only two lexical exceptions: the monosyllabic verbs, tun 'to do' and sein 'to be'.

Consider the following infinitives. Two transcriptions are given for each verb: the first one has a syllabic sonorant as the nucleus of the last

syllable (the usually realized form) and the second one has a schwa plus a consonantal sonorant (the marked realization).

(29)	lach- lachen	[la.xn̩/la.xən]	'to laugh'
	hol-holen	[ho:.ln̩/ho:.lən]	'to fetch'
	heul-heulen	[hɔɣ.ln/hɔɣ.lən]	'to cry'
	mäh-mähen	[mɛ:..n̩/mɛ:.ən]	'to mow'
	bau-bauen	[baʊ̯n̩/baʊ̯ən]	'to build'
	form-formen	[fɔʀ.mn̩/fɔʀ.mən]	'to form'
(30)	segl-segeln	[ze:.gl̩n/ze:.gəln]	'to sail'
	liefr-liefern	[li:.fɐn/ʔli:.fəʀn]	'to deliver'
	wandr-wandern	[van.dɐn/ʔvan.dəʀn]	'to hike'
	feur-feuern	[fɔɣɐn/ʔfɔɣəʀn]	'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, the 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 1992). This last approach assumes an epenthetic schwa, which is a marked process and which, in an OT approach, implies a violation of FILL, a constraint which counts each epenthesis as a violation. A second problem of the schwa approach is that the Sonority Hierarchy cannot explain (but only describe) why schwa is inserted before the most sonorous sonorant, since schwa is in

all cases more sonorous than a sonorant. In contrast, in my approach, excrescent schwa is a phonetic variant of the syllabic sonorant, and the choice of the nucleus depends on independent principles of syllabification.

The first set of verbs, given in (29), contains 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 that the last syllable have a nuclear syllabic sonorant. On the other hand, all verbs in (30) have an unsyllabifiable stem-final sonorant whose sonority is higher than that of the preceding consonant. These stems form nouns by making the sonorant syllabic.

(31)	segl-Segel	[ze:.gl̩/ze:.gəl]	'sail'
	feur-Feuer	[fɔɣɐ/ʔfɔɣəʀ]	'fire'
	atm-atmen	[a:tm̩/a:təm]	'breath'

As before, the infinitive is formed with an inflectional -n, but in this case it is syllabic only 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 (32). 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.

(32) Sonority Hierarchy

Obstruents Nasals Liquids Vowels

---------->

stops fricatives l r

voiceless voiced

In OT terms, this is expressed by the constraint called HNUC (Prince -- Smolensky 1993: 16) given in (33):

(33) HNUC (The Nuclear Harmony Constraint)

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

In this paper, the formation of syllabic trochees in inflection, rather than the location of the syllabic sonorant, is my primary concern. See, however, Féry (1991) for an approach in Prosodic Morphology and Barkey (1994), Itô -- Mester (1994) and Raffelsiefen (1994) for treatments of this very point in OT.

Apart from HNUC, the following constraints are active:

- ALIGN-n , given in (34), expresses that the infinitive suffix [n] is peripheral (like all affixes in German).
- SYLLSON, given in (35), requires that the last syllable have a syllabic sonorant as its nucleus, which also implies that this syllable must be weak.[13] These two constraints cannot be fused into one because, as (30) shows, [n] is not always the syllabic sonorant, though it is always final.

(34) ALIGN-n

Align ($[n]_{inf\ aff}$, R, PW, R)

(35) SYLLSON

Align ($[PW]_{inf}$, R, [Nucleus = syll son], R)

The effect of these two constraints can be illustrated with the verb bau/bauen in Tableau 6. In this verb, the infinitive affix adds a syllable by being syllabic. 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]. In other forms this verb can be monosyllabic: du baust 'you build', sie baut 'she builds'.

Tableau 6

ALIGN-*n* and SYLLSON are unviolated and consequently unranked.[14]

As already mentioned, the infinitive preferably forms a trochaic foot (or ends in one). This is expressed by the constraint FOOTFORM, already given in (14) of section 1. FOOTFORM is needed to block the formation of *segelen or *wanderen with two syllabic sonorants.

Tableau 7

In Tableau 7, ALIGN-n eliminates candidate d. because *n* is not the last segment. SYLLSON is respected in candidates a., b. and c. since they have a syllabic sonorant in their last syllable's nucleus. Form d. violates SYLLSON because it has a schwa in this position. FOOTFORM is violated by c. and d. which do not end in a syllabic trochee. The final decision between the remaining candidates is taken by HNUC. Since candidate a. has the most sonorous sonorant in its nucleus, it is the optimal candidate.

Now consider the verb holen. This verb has a syllabifiable stem. According to the constraints so far, *[ho:.l̩n], rather than the grammatical [ho:ln§], should be the selected candidatesince [l] is more sonorous than [n]. The ONSET constraint (36) introduced by Prince -- Smolensky (1993:16) selects the optimal candidate in Tableau 8. Syllables without an onset violate ONSET.

(36) ONSET

Syllables have onsets.

This constraint is ranked higher than HNUC, so that a candidate which fulfills ONSET but violates HNUC, like candidate b. in Tableau 8, is better than one violating ONSET but fulfilling HNUC.[15] Some rare verbs like mähen 'to mow' violate ONSET. The bisyllabicity of such verbs is nevertheless ensured by ALIGN-n.

Tableau 8

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[16] 'to mix', a unique member in its category. Up to this point, *quireln, with a syllabic [l], 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, whereas segeln has an unsyllabifiable sonorant in its stem. 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'.

I propose that the constraint ALIGN (Prince -- Smolensky 1993:103), though always violated in the infinitives, is nevertheless active in the choice of the optimal candidate. This constraint, expressed in (37) requires that the right edge of a stem coincide with the right edge of a syllable.

(37) ALIGN

Align (Stem, R, σ, R)

Each segment that is an onset of the last syllable (the one with a syllabic sonorant) counts as a violation of ALIGN. To achieve minimal violation, these onsets are minimized, which has the side effect of leaving the stems intact. 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 7 for wandern. In verbs with only obstruents (like lachen or behaupten 'to claim'), the last obstruent is the onset of the last

syllable. In those cases, too, ALIGN does not play any role. However, the effect of this constraint is visible in quirlen as is evident from the following tableau.

Tableau 9

Both *quireln and quirlen fulfill the high ranking constraints ALIGN-n, SYLLSON, FOOTFORM and ONSET. The form *quireln has one segment more in the onset of the last syllable than quirlen, and this is crucial for the choice of the optimal candidate. Notice that quirl- is never realized as *quirel-, whereas segl- is often realized as segel-.

The last set of data discussed here is verbs whose stems have at least two syllables; in these cases, too, the infinitive inflection consists of a final *n* and a final additional syllable whose nucleus is a syllabic sonorant. This confirms the unviolability of the highest constraints, ALIGN-n and SYLLSON. On the other hand, these infinitives often violate FOOTFORM. Consider the verbs in (39). Their stems are bi- or trisyllabic, and have their main stress on the stem's penultimate syllable. Inflection in German never affects the stress position, which means that, in the infinitive inflection, the stress of these infinitives is antepenultimate.

Tableau 10 illustrates the effects of the constraints on such stems. Apart from the fact that they violate FOOTFORM in order to fulfill the higher-ranking SYLLSON, there is nothing remarkable about these verbs.

(39) árbeit-/árbeiten 'to work'

veréinbar-/veréinbaren 'to agree, to arrange'

	bewíllig-/bewílligen	‘to allow, to approve’

Tableau 10

Finally, many German stems have a final stress and, as a consequence, fulfill FOOTFORM in the infinitive since their last foot is a syllabic trochee. (40) contains examples of such verbs.

(40)	spazíer-/spazíeren	‘to talk a walk’
	trompét-/trompéten	‘to play the trumpet’
	genúg-/genügen	‘to suffice’

Tableau 11

To sum up, infinitives in German form a syllabic trochee whenever they can. This tendency is observable not only in monosyllabic stems but also in verbs whose stems end in a sequence of obstruent + sonorant (of increasing sonority). Instead of adding two syllables, one on the sonorant and one on the inflectional n, only one syllable is created, the nucleus of which is occupied by the most sonorous sonorant.

3. Conclusion

In this paper I have shown that the prosodic constituent Foot in German is a domain for morphologically-conditioned phonological operations of which the following have been discussed: first, the umlaut which accompanies the

chen-suffixation, and second, the infinitive formation. An Optimality-theoretic constraint, FOOTFORM, has been formulated, which accounts for the preferred trochaic foot. Not only in these cases does German have a preference for the trochaic foot, but also in general. The trochee is the minimal Prosodic Word and the minimal Foot. Stems often are trochaic, by being either moraically binary (Heu 'hay', Müll 'garbage', froh 'happy') or syllabically binary (Lampe 'lamp', Fenster 'window'). In derivation and inflection, both of which have been looked into in this paper, trochees are generally syllabic, though there are inflections which only add a segment, like the 3.pers. sg. (lachen/lacht 'to laugh/laughs') or the gen. sg. masc. or neut. (Film/Films 'movie').[17]

Some of the advantages of OT over derivational theories have been mentioned in the discussion, e.g. that it shows the ranking of potential forms. The theory is still in its infancy, but it is extremely promising, particularly for accounting for those phenomena whose application is not absolute, but depends on other aspects of the grammar.

[1] I would like to thank Reinhild Barkey, Aditi Lahiri and the audiences of the Inaugural Conference on Universal Grammar and Typological Variation in Berlin, March 1994 and of the Prosodic Morphology Workshop in Utrecht, June 1994 for their comments and suggestions. Thanks are also due to Renate Raffelsiefen, who has patiently listened to different versions of this paper.

[2] As an example, one may consider the 1312 monomorphemic trisyllabic words listed in CELEX, the lexical database of German words developed in the Max-Plank-Institute in Nijmegen:

- 664 words have penultimate stress, of which 528 have a final schwa. These 664 words have a final syllabic trochee.

- 393 words have final stress: 299of these words have a final trimoraic syllable, and 94 a bimoraic one. At least the 299 words have a moraic trochee.

- 255 words have initial stress. However, 85 of these have a hiatus between their second and third syllables, and of these 85 words, many are regularly realized as syllabic trochees (Rádio 'radio', Béstie 'beast', …). 170 dactyls remain (Éstragon 'tarragon', Kámera 'camera', …).

[3] 'Crisp' and 'blurred' edges are terms introduced by Itô -- Mester (this volume) to denote the fact that alignment effects take place at the edges of prosodic constituents.

[4] Giegerich (1992) distinguishes between Colloquial German, where 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).

[5] 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.

[6] Productive plural formations are -s: Film-s, Bit-s, Chip-s, Yuppie-s; ø-suffix: Computer, Scanner, Hacker, Manager; -en or -n: Disketten, Kassetten, and maybe a few more.

[7] 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.

[8] An alternative analysis which I pursued in an earlier version of this paper is that the domain of umlaut is accounted for by a constraint of the Align format which guarantees that *-chen* is suffixed to words ending with a stressed syllable:

(i) ALIGN-*chen*

Align([chen]$_{Af}$, L, stressed syllable, R)

This constraint has the same effect as (14) but is stated in less general terms. I am grateful to Alan Prince for pointing this out to me.

[9] For a proposal to this effect in Indonesian, see Cohn -- McCarthy (1994) who introduce a constraint called NON-FOOT(ə).

[10] I do not have the space to develop this point here, but see Féry (1994) for an extensive discussion of the metrical behavior of schwa syllables in German.

[11] John McCarthy suggested that I replace a constraint that I used in an earlier version of this paper and which was too obviously derivational with one more in the spirit of OT.

[12] As an example, compare the following table which lists the vowels appearing in final open syllables in bi- and trisyllabic monomorphemes.

Table 1

[13] Syllables whose nucleus is a syllabic sonorant or a schwa are monomoraic, irrespective of how many segments there are in the coda (see Féry 1994).

[14] Perhaps ALIGN-n must dominate SYLLSON, because 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.

[15] Raffelsiefen (1994) remarks that verbs like knäueln 'to tangle' and kraueln 'to fondle' are generally pronounced knäulen and kraulen. This evolution is in my opinion due to

ONSET. The second syllables of knäulen and kraulen have an onset, whereas those of knäueln and kraueln do not.

16 Thanks to Renate Raffelsiefen, who drew my attention to this verb.

17 Both of these inflectional suffixes have phonologically conditioned syllabic allomorphs: reden/redet ‘to talk/talks’ and Mumpitz/Mumpitzes ‘nonsense’.

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Figures

Candidates	FOOTFORM	PARSEFEAT
☞ (Lämpchen)		
(Lampchen)		*

Tableau 1

Candidates	FOOTFORM	PARSEFEAT	FILLLINK
☞ Skan(dälchen)			*
Skan(dálchen)		*!	
Skän(dälchen)			**!

Tableau 2

Candidates	NOCROSS	FOOTFORM	PARSEFEAT	FILLLINK
[Cä(féchen)]	*!			*
☞ [Ca(féchen)]			*	

Tableau 3

Candidates	NOCROSS	FOOTFORM	MAV(PRO)	M-PARSE	PARSEFEAT	FILLLINK
☞Áutochen		*			*	
Áutöchen		*	*			*
{Auto, chen}		*		*		
Äutochen	*	*				
Äutöchen		*	*			

Tableau 4

Candidates	NOCROSS	FTFORM	MAV(PRO)	M-PARSE	PARSEFEAT	FILLLINK
Mónatchen		*			*	
Mónätchen		*	*			
☞{Monat,chen}		*		*		
Mönatchen	*	*				
Mönätchen		*	*			

Tableau 5

Candidates	ALIGN-n	SYLLSON
☞ .bau.n̩.		
.bau.ne.	*	
.baun.		*

Tableau 6

Candidates	ALIGN-n	SYLLSON	FOOTFORM	HNUC
a. ☞ (.wan.dr̩n.)				
b. (.wan.drn̩.)				*!
c. .wan.dr̩.n̩.			*!	
d. .wan.dr̩.ne.	*!	*	*	

Tableau 7

Candidates	ALIGN-n	SYLLSON	FOOTFORM	ONSET	HNUC
a. (.ho.l̩n.)				*!	
b. ☞ (.ho.ln̩.)					*
c. .ho.l̩.n̩.			*!	*	
d. .ho.l̩.ne.	*!	*	*	*	
e. (.ho.lne.)	*!	*			

Tableau 8

Candidates	ALIGN-n	SYLLSON	FOOTFORM	ONSET	ALIGN	HNUC
a. (.qui.r̩l]n.)					**!	
b. ☞ (.quir.l]n̩.)					*	*
c. .quir.̩l.n̩.			*!	**!		

Tableau 9

Candidates	ALIGN-n	SYLLSON	FOOTFORM	ONSET	ALIGN	HNUC
a. ☞ ver(.ein.ba.)rn̩.			*		*	*
b. ver(.ein.ba.)r̩n.			*	*!	*	
c. ver(.ein.ba.)r̩.n̩.			*	**!		
d. ver(.ein.barn.)		*!				
e. ver(.ein.bar.)ne.	*!	*	*			

Tableau 10

Candidates	ALIGN-n	SYLLSON	FOOTFORM	ONSET	ALIGN	HNUC
a. ☞ spa(.zie.rn̩.)					*	*
b. spa(.zie.r̩n.)				*!	*	*
c. spa.zie.r̩.n̩.			*!	**!		

Tableau 11

	a	o	i	e	u	y	ø	˜v
stressed	3	14	44	39	4	8	2	30
unstressed	158	101	54	8	9	0	0	0

Table 1