Vowel weakening and vowel deletion in German*
A constrained-based analysis

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0. Introduction

During the Middle Ages, full vowels in German were weakened to schwa in most unstressed positions. In many cases, these vowels were subsequently deleted in a syncope process. An example is given in (1).

(1) OHG[1] *´êristo* > MHG *´êr(ə)stə*[2] > NHG *érstə*

I will show that both sound changes (i.e. the weakening of full vowels to schwa and the subsequent deletion of schwa) were caused by an interaction between prosodic and segmental criteria. Within the constraint-based approach of Optimality Theory (McCarthy/Prince 1993a, Prince/Smolensky 1993), these interactions can be described in a precise way. This description is the first aim of this study.

The second goal relates to the theoretical framework. Like most recent phonological theories, Optimality Theory was developed based on synchronic data only, and hence case studies in this framework relating to sound change are very rare (e.g. Zubritskaya 1994). However, it can be shown that the description of diachronic developments sheds a new light on several aspects of the theory itself. First, it will be shown that constraint reranking can serve as a descriptive base for variation and sound change data. Second, sound change also causes an alteration in the input that are not motivated grammatically but rather economically and thus relate to Lexicon Optimization (Prince/Smolensky 1993:192-196). Faithfulness relations between inputs and optimal candidates change because of the reranking of constraints. In this context, sound change can be interpreted as a lexicon optimization process in which inputs are changed according to modifications in faithfulness relations.

In the first part of this paper, the data will be presented. The following section is an introduction into the basic assumptions of Optimality Theory. Section 3 contains an analysis referring to segmental and syllable-related constraints whereas section 4 focuses on the prosodic context in which weakening and deletion processes occurred. In the last section I will sketch the interaction of segmental and prosodic conditions that favoured the given sound change phenomena.

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[1] The following abbreviations will be used: OHG (Old High German), MHG (Middle High German), NHG (New High German).

[2] The parentheses around schwa indicate that the deletion of this vowel was optional in this stage.

1. Weakening and deletion of vowels in OHG and MHG

In OHG and MHG, vowels in unstressed syllables were very regularly weakened to schwa. Weakening did not take place in some derivational suffixes if these suffixes could bear secondary accent.[3] The words in (2) show that the morphological domains were not crucial to both weakening and syncope phenomena: Both processes took place in prefixes (2a) as well as in suffixes (2b) and stems (2c). As in many OHG and MHG texts, the circumflex is used to mark vowel length.

(2)

	OHG	MHG	NHG	
a.	*gil'îhnissa*	*gəl'îchnissə*	*Gléichnis*	'parable'
	ginâda	*g(ə)n'âdə*	*Gnádə*	'mercy'
b.	*góugalâri*	*góukəlærə*	*Gáuklər*	'clown'
	óffanunga	*óffənungə*	*'Öffnung*	'opening'
	áhsalôm	*áhsəl(ə)n*	*Áchsəln*	'shoulders', dat.pl.
c.	*'êristo*	*'êr(ə)stə*	*érstə*	'first'
	giméinida	*gəméinde*	*Gəméində*	'community'
	h'ulisa	*h'ülsə*	*H'ülsə*	'husk'
d.	*hémidi*	*hém(ə)də*	*Hemd*	'shirt'
	héngist	*héng(ə)st*	*Hengst*	'stallion'
	hérbist	*hérb(ə)st*	*Herbst*	'autumn'
	mérzo	*mérz(ə)*	*März*	'March'
	óbaʒ	*ób(ə)ʒ*	*Obst*	'fruit'

The words in (2d) are not subject to the following analyses. Relating to prosodic structure, they are special because the NHG words are monosyllabic after vowel deletion has taken place whereas syncope caused disyllabic foot structures in all the other words in (2). In addition to prosodic and segmental conditions, the data in (2d) also require reference to morphological markedness conditions which are not considered in this study.[4]

Vowel weakening in unstressed syllables was favoured by several conditions. As the examples in (2) show, main stress in all three stages is usually on the first stem syllable. There are only some very rare exceptions, some of which are listed in (3).

(3)

OHG	MHG	NHG	
fórhana	*fórhel*	*Foréllə*	'trout'
hóluntar	*hólundər*	*Holúndər*	'elder'
hórnaʒ	*hórniʒ*	*Hornissə*	'hornet'
lébêntîg	*lébəndic*	*lebéndig*	'alive''

[3] Such suffixes are *-ig*, *-in*, *-lich*, *-ung*, etc.

[4] See Löhken (to appear) for an analysis of the data in (2d).

In MHG, main stress was still on the first stem syllable (Paul 1969:24). Subsequently it shifted to the second stem syllable. Apart form these exceptions, however, the position of main stress in native German words is very regular.[5] This regularity contributed to the weakening of unstressed syllables.

Secondly, German is an accent-counting language, meaning that the distance between stressed syllables tends to be equal. In accent-counting languages, vowel weakening is particularly frequent (Wurzel 1994:50ff.). However, not all weakened vowels were deleted. Factors favouring syncope are listed in (4).

(4) **Factors favouring syncope in MHG**
- three or more syllables per prosodic word
- vowel position left or right from *n* or *l*

The data in (2) mostly meet these factors. Note that these are only general tendencies but not necessary conditions for vowel deletion. Especially the consonantal environment has to be interpreted only as a statistical but not as a decisive factor. However, both factors show that prosodic as well as segmental conditions should be considered with respect to the given data.

The rules in (5) formalize the weakening and syncope processes that took place in German. Since schwa does not have any terminal articulator features (Kenstowicz 1994a:159), weakening means that full vowels in unstressed syllables lost their place specification (5a). Since this affected all kinds of vowels, reference to place in general is sufficient and need not be specified. Syncope (2b) is a process in which a whole segment is removed from the syllable structure. In the present cases, the word had to be resyllabified because a nucleus was deleted.

(5)

a. weakening	b. syncope
σ_w	σ_w
|	|
V	=
|	|
=	V
|	|
PL	ə

(5) illustrates that weakening and syncope are subject to segmental and syllable-related conditions. These conditions can be formulated in terms of constraints. The next section introduces the theoretical framework.

2. Optimality Theory

During the last few years, phonological theory has changed its focus. Instead of derivational approaches and rule-governed processes, representations have become the basic instrument of structural descriptions. One of these non-derivational models is Optimality Theory.

[5] See Eis (1950:20f.), Paul (1969:25f.), and von Kienle (1969:16f.) for differences between nominal and verbal compounds since the Germanic period.

Within this theory, the evaluation of surface structures is essential. A morphological chain consisting of one or more lexical entries serves as an input. This chain is assigned phonological structure (such as syllables, feet, etc.). This assignment is formalized by the function GEN (6a). Via different ways of structure assignment, GEN generates a set of candidates.

(6) a. GEN (input) $\rightarrow$ $\{cand_1, cand_2, cand_3, ..., cand_n\}$
b. EVAL ($\{cand_1, cand_2, ..., cand_n\}$) = output

The evaluation function EVAL accounts for the selection of the candidate with the optimal structure. Evaluation parameters are universally valid constraints. The functions GEN, EVAL, and the constraint inventory form the three modules of a grammar. Within a language, constraints are ranked in a specific way. Due to this ranking, the degree of well-formedness of single candidates can be measured. Constraints refer to all areas of phonological structure, such as syllable structure, foot structure, correspondence between affixes and syllables, epenthesis, deletion, etc.

The importance of a constraint in a language depends on whether the constraint is active in this language, and - if this is so -, how it is ranked in relation to other constraints. Constraints can be violated. The higher a constraint is within the ranking, the more selective is a violation. A violation of a lower ranked constraint can be accepted to avoid a violation of more important constraints.

For example, the constraint ONSET ("Syllables have onsets") has a high ranking position in German. Therefore, epenthesis of additional segments can take place to avoid a violation against ONSET, although epenthesis causes a violation of the constraint FILL ("Syllable structures are filled with underlying segmental material"): FILL is dominated by ONSET (7a). The tableau in (7b) shows how the optimal candidate is evaluated.

(7)
a. ONSET >> FILL
b.

Input: *teatər*	ONSET	FILL
te.a.tər	*!	
☞ *te.ʔa.tər*		*

Explanatory note: The dot (.) indicates a syllable boundary. The candidates which are generated by GEN are listed underneath the input. Potentially, the number of candidates is infinite. It is for the sake of transparency that the list contains only two candidates. The hand (☞) points to the optimal candidate. The asterix (*) indicates a constraint violation. The exclamation mark is placed at the right hand side of a violation that is crucial for the ruling out of a candidate. Shaded fields are not relevant for the selection.

In the course of GEN, candidates can be assigned both too much or not enough phonological structure. In the first case ('overparsing'), the segmental chain is parsed into more prosodic constituents than necessary, or additional segments are inserted and thus cause FILL violations. Underrepresentation of phonological structure ('underparsing') occurs if segments or prosodic constituents (8) are not parsed into constituents of the next level of the prosodic hierarchy.

(8) **Prosodic Hierarchy** (Nespor/Vogel 1986)

prosodic word
foot
syllable
subsyllabic constituents

Unparsed features are excluded from the phonetic surface of the respective segment. Unparsed segments belong to the candidate but are similarly not phonetically realized. The PARSE-constraints that will be needed in the following analysis are listed in (9).

(9)	a.	**PARSE-FEATURE**	Features are parsed into segments.
specification:		**PARSE-PLACE**	Place features are parsed into segments.
	b.	**PARSE-SEGMENT**	Segments are parsed into syllables.
	c.	**PARSE-SYLLABLE**	Syllables are parsed into feet.

PARSE-PLACE is one of the possible specifications of PARSE-FEATURE.[6] As I show below in section 3, PARSE-PLACE is the constraint that accounts for vowel weakening. Both vowel weakening and vowel deletion violate one of the PARSE constraints: In the first case, PARSE-PLACE is violated (10a), whereas vowel deletion can be described as a violation of PARSE-SEGMENT. In the latter case, a whole vowel is not parsed into syllable structure (10b).

(10) a. OHG *gina:da* > MHG *gəna:də*
b. MHG *gəna:də* > NHG *gna:də* 'mercy'

A violation of PARSE-SYLLABLE (9c) occurs if a syllable is not licensed by a metrical foot. In contrast to PARSE-PLACE and PARSE-SEGMENT, PARSE-SYLLABLE does not influence the phonetic realization of the unparsed syllable. German prosody allows unparsed syllables in certain contexts. Vowel weakening could arise either in non-heads or in unparsed syllables.

3. An analysis relating to segments and syllable structure

A first analysis of the data given in (2) can be presented by focussing on constraints that belong to the PARSE family. Since all phonological features are supposed to be contained in the input, the non-specification of a feature implies a PARSE violation.[7]

[6] Other possible specifications are PARSE-[voice], PARSE-[nasal], etc.

[7] However, the assumption that features are specified in the input does not cause a change in the candidate evaluation. If certain features had to be assigned to candidates (e.g. default values in underspecification theory), this would cause violations of another FAITHFULNESS constraint, namely FILL-F ("Features are underlyingly

(11) $*\sigma_w$
|
V
|
PLACE

Vowels in unstressed syllables do not have a place specification.

The PARSE constraint in (11) (Kiparsky 1994) relates to both prosodic and segmental structure. In many languages, vowels in non-prominent metrical positions have less phonetic specification, whereas vowels in prominent syllables contain relatively more features and/or a higher degree of scalar values, such as sonority (Trubetzkoy 1939, Kiparsky 1994).

Within the framework of OT, sound change can be described by a reranking of constraints: Due to changes in the hierarchy, the optimal candidate in ranking 1 can differ from the one in ranking 2 (12).

(12) Ranking 1 (t_1) ---> $cand_{opt} = x$
Ranking 2 (t_2) ---> $cand_{opt} = y$

However, this concept is idealized: In the course of language change, there are also variation phenomena which have to be accounted for. Candidate x and candidate y may both be acceptable variants during a certain period. Since Ranking 1 and Ranking 2 are two different grammars, variation can be accounted for as grammar competition.[8]

I will show that the variation phase can also be described as a reranking that has not yet been fixed because the dominance relations are not yet established. In that respect sound change is not reduced to a switch from ranking 1 to ranking 2, but is rather seen as a gradient shift of one or more constraints within a given hierarchy. During this development, dominance relations weaken, are neutralized and rearranged, and eventually new dominance relations emerge. The analysis will show that this concept can account for the empirical facts in a more adequate way.

The example in (1) has the input *êrist+o* in OHG. The tableau in (13) shows the evaluation of the optimal candidate. It contains only candidates that can be evaluated with the constraints given in (9) and (11). The prosodic structure is not considered yet so that syllable and feet edges are assumed without evaluation.[9] In section 4, prosodic conditions will be accounted for separately.

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specified"). Aside from the content of underlyingly featural specification, the optimal candidate remains the same (cf. Itô/Mester/Padgett 1994).

[8] In historical linguistics, the notion of competition between parts of the grammar is well-known. For instance, Zubritskaya (1994:335) relates the notion of grammar competition in terms of markedness to the wave model which was developed by Bailey (1973).

[9] Round brackets mark edges of metrical feet. Square brackets enclose unparsed segments or syllables.

(13) **OHG**

Input: *êrist+o*	PARSE-SEG	PARSE-PL	$*V(\sigma_w)$ | PL	PARSE-SYLL
1. ☞ *(´ê.ri)<sto>*			**	*
2. *(´ê.rə)<stə>*		*!*		*
3. *(´êr<i>sto)*	*!		*	

In OHG, PARSE-PLACE dominated the constraint militating against place features in the nuclei of unstressed syllables. Therefore, place features were assigned in the optimal candidate. PARSE-SYLLABLE is violated by two candidates. However, this constraint is ranked so low that it does not have any influence on the selection of the optimal candidate. PARSE-SEGMENT dominates all the other constraints: Syncope (as in candidate 3) was prevented whereas it could well occur at later stages after vowel weakening had taken place. In addition, a chronological ordering has to be assumed because PARSE-PLACE had to get a lower position within the ranking before PARSE-SEGMENT could also be violated and thus cause syncope.

The weakening of [o] to [ə] in MHG is evidence that *-sto* was left unparsed and not parsed into a degenerate foot which would have had secondary stress (cf. section 4): Such stress would have prevented the later weakening process since vowels in stressed syllables are supposed to keep their place specification via PARSE-PLACE.

The data in (2) show that in MHG the ranking had changed: The assignment of place features was now disfavoured in the nuclei of unstressed syllables so that the candidates which contained weakened vowels were better than the candidate with full place specifications in all vowels. This development can be accounted for by a reranking within the hierarchy: The third constraint, $*V(\sigma_w)$, gained importance and hence changed places with PARSE-PLACE. The tableau in (14) shows the new evaluation.

(14) **MHG** (preliminary)

Input: *êrist+o*	PARSE-SEG	$*V(\sigma_w)$ | PL	PARSE-PL	PARSE-SYLL
1. *(´ê.ri)<sto>*		*!*		*
2. ☞ *(´ê.rə)<stə>*			**	*
3. *(´êr<ə>stə)*	*!		**	

However, the ranking in (14) is still incomplete because PARSE-SEGMENT also changed its position: In MHG, syncope became so common that PARSE-SEGMENT, which is violated by vowel deletion, obviously lost influence in the evaluation process and therefore lost its position in the ranking. The example in (1) shows that the variant *erste* instead of *erəstə* was already possible. Candidate 3, which contained an unparsed segment, met the constraint PARSE-SYLLABLE because the remaining syllables could be parsed into one binary foot. Since both variants were of equal importance in MHG, it is empirically inadequate to assume a ranking between PARSE-SYLLABLE and PARSE-SEGMENT. Since there is no further evidence for direct conflicts between both constraints, they can be equally ranked. The absence of ranking is indicated by the dotted line in (15).

(15) **MHG**

Input: *êrəst+ə*	*V(σ_w) | PL	PARSE-PL	PARSE-SYLL	PARSE-SEG
1. *(´ê.ri)<sto>*	*!*		*	
2. ☞ *(´ê.rə)<stə>*			*	
3. ☞ *(ê´r<ə>stə)*				*

The MHG tableau in (15) contains a different input in which the place features in unstressed vowels are no longer specified. The new input accounts for the fact that vowel weakening in unstressed positions turned out to be a systematic phenomenon in MHG. However, it is essential that the different input does not have any influence on the candidate selection. Even if the input contained place specifications in all vowels, candidate 3 would win.[10] However, in (15) PARSE-PLACE is not violated by the candidates 2 and 3 any more.

The quality of the input therefore does not depend on grammatical criteria but rather on learnability aspects: The less difference there is between input and output, the less information has to be learnt during the acquisition process and the more harmonic is the input-output-relation (Lexicon Optimization; cf. Prince/Smolensky 1993:192ff., Itô/Mester/Padgett 1994:20ff.). Implications for the description of sound change will be discussed in section 4. The tableau in (16) shows the evaluation in NHG.[11]

[10] Candidate 1 would be ruled out because of the dominating constraint. Candidates 2 and 3 would both violate PARSE-PLACE. The result of EVAL would be the same. Note that candidate 1 also violates FILL because non-underlying place specifications are added. Since FILL would not influence the candidate selection, it is not introduced here.

[11] In the next section it will become clear that the input changed not only in MHG (*êrəstə*) but also in NHG (*erstə*). For the sake of transparency I do not introduce constraints which will be needed in a prosodic context, hence the MHG input is still preserved in the segment-related analysis. The most harmonic input will be introduced in section 4.

(16) **NHG**

Input: *êrəst+ə*	*V(σ_w) | PL	PARSE-PL	PARSE-SYLL	PARSE-SEG
1. *(´ê.ri)<sto>*	*!*		*	
2. *(´ê.rə)<stə>*			*!	
3. ☞ *(ê´r<ə>stə)*				*

The difference between the MHG and the NHG tableau consists in a ranking relation that emerged between PARSE-SEGMENT and PARSE-SYLLABLE. Candidate 2 and candidate 3 are not longer of equal importance: The variant with an unparsed vowel is the only one that is accepted in NHG whereas candidate 2, containing an unparsed syllable, is not well-formed. Therefore, PARSE-SYLLABLE now dominates PARSE-SEGMENT.

4. The relevance of stress-related constraints in weakening and deletion processes

Up to this point, the prosodic structure was not part of the evaluation. However, the rhythmic structure played an important role in both weakening and deletion processes so that they should be considered in the candidate selection.

Accent is defined as the relative prominence of a syllable within a prosodic word. Suffixes, such as *-in* and *-ung* in (17a-c), are not prosodic words and thus do not form a domain for the assignment of metrical feet.

(17) **a.** [*(G´öttin)*$_\varphi$]$_\omega$ 'goddess'
[*(Máhnung)*$_\varphi$]$_\omega$ 'warning'

b. [*(Léhrə)*$_\varphi$ *(rìn)*$_\varphi$]$_\omega$ 'teacher', f.
[*(Wándə)*$_\varphi$ *(rùng)*$_\varphi$]$_\omega$ 'hike'

c. [*(´Öffnung)*$_\varphi$]$_\omega$ 'opening', sg.
[*(´Öff)(nùngən)*$_\varphi$]$_\omega$ 'openings', pl.

The data in (17) illustrate that a suffix may be stressed or unstressed, depending on its metrical environment. (An exception are schwa syllables, which can never be stressed in any context.) For example, *-in* is unstressed in *Göttin* (17a), but bears secondary accent in *Lehrerin* in (17b). Stress can also vary within a paradigm as illustrated in (17c). Two suffixes can form a foot containing secondary accent if the first suffix does not contain schwa.

Constraints can refer to the edges of phonological and morphological categories.[12] In German, the first syllable of a native stem is always stressed.[13] Therefore, the left edge of a stem has to be simultaneously the left edge of a trochee or a degenerate foot (18).

(18) **ALIGN-L (Stem, L, Foot, L)**
Every stem begins at the left edge of a foot.

German has the following foot structures:

(19) **Inventory of foot structures in German**

a.	('x .)$_\varphi$	*(H'än.də)*	'hands'
b.	(`x .)$_\varphi$	*(Wán.də)(**rùn.gən**)*	'hikes'
c.	('x)$_\varphi$	*(Hand)*	'hand'
d.	(`x)$_\varphi$	*(Wán.də)(**rùng**)*	'hike'

I assume that the maximal foot is binary. Since stress in German native words is not quantity-sensitive,[14] the unmarked foot structure is a syllabic trochee, i.e. a weak syllable following a strong (i.e. accented) one so that the head is on the left as in (19a-b).[15] Degenerate feet as in (19cd) have the logically smallest possible size. In quantity-insensitive systems they consist of one syllable only (Hayes 1995:75) and are marked cases. Accented stems carry primary accent in derived words whereas accented suffixes can only be assigned secondary accent.[16]

The regularities of foot parsing in native German words are summarized in (20).

(20) **Metrical rules for German**

1. The unmarked foot is a syllabic trochee.
2. The first stem syllable is always stressed.
3. The accented stem prevails metrically over accented suffixes.

The constraints in (21) express these stress facts:[17]

(21) **FOOT-MAX**
Feet may be no larger than two syllables.
FOOT-MIN
Feet may be no smaller than two syllables.
RHYTHMTYPE=TROCHEE
Feet are trochees.
***HEADHEAD**
Heads of feet must not be adjacent (Kager 1994).

The maximal foot is binary (Hayes 1995). According to Everett (1994), the constraint FOOTBINARITY ("Feet are binary under moraic or syllabic analysis"), which was proposed

[12] McCarthy/Prince (1993b) show that such alignments should be part of universal grammar. This is expressed in the general constraint format of Generalized Alignment.
[13] Exceptions are listed in (3).
[14] See Giegerich (1985) for a survey on quantity-sensitive stress assignment in non-native words.
[15] See Hayes (1995) for typologically motivated generalizations between quantity-sensitivity and foot structure.
[16] The suffix *-eréi*, which carries primary accent, is not a counterexample because it was borrowed from French during the MHG period (Henzen 1957:185).
[17] Within the given context, main stress and secondary stress need not be distinguished. It is only important to locate any kind of stress that could prevent vowel weakening and deletion.

by McCarthy/Prince (1993a) and Prince/Smolensky (1993), should rather be split into two constraints, FOOT-MIN and FOOT-MAX. As Everett points out, FOOTBINARITY alone can not account for the difference between ternary and degenerate feet: Both would violate FOOTBINARITY although they usually are not equally evaluated in a given language: Degenerate feet are possible in many cases whereas ternary feet are prohibited. By assuming two separate constraints, this distinction can be derived from the ranking of FOOT-MIN, which is dominated by FOOT-MAX. An illustration is given in (22).

(22)

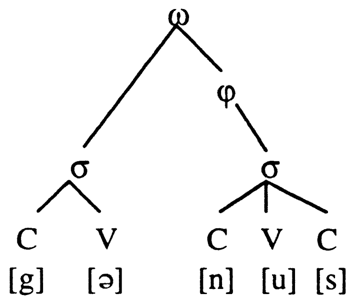
a. FOOT-MAX >> FOOT-MIN

b.

Input: *kolibri*	FOOT-MAX	FOOT-MIN
(kó.li.bri)	*!	
☞ *(kó.li)(brì)*		*

Weak syllables cannot be parsed in certain contexts and are therefore dominated directly by a prosodic word as in (23):

(23)



[<Ge>(nuß)$_{\varphi}$]$_{\omega}$

The prefix [gə] in (9) cannot be stressed and is left unparsed. Since the domain of footing is the prosodic word and the prefix is a prosodic domain on its own (prosodic word or appendix, see Booij 1985: 154), it cannot be incorporated into the foot at its right. The constraint PARSE-SYLLABLE, which was introduced in section 3, is violated in those cases:

In addition to the constraints listed above (including PARSE-SYLLABLE and PARSE-SEGMENT), the present analysis also requires the constraints in (24):

(24) a. **NOCODA**
Syllables don't have codas.
***H/ə**
The head of a foot does not contain schwa.

NOCODA is a well-known syllable structure constraint (see e.g. McCarthy/Prince 1993a: 10). The last constraint in (24) is based on Kenstowicz (1994b), who assumes a ranking expressing the degree of markedness of nuclei in stressed syllables. This markedness is inversely proportional to the degree of sonority of the respective vowel (cf. Prince/Smolensky 1993:127-167). In other words, the more unmarked a vowel is as a syllable peak, the more unmarked it is as a nucleus within a head. The hierarchy underlying this hypothesis is presented in (25).[18]

(25) **Markedness of heads in metrical feet** (Kenstowicz 1994b)
*H/ə >> *H/i,u >> *H/e,o >> *H/a

*H/ə says that [ə] is unstressable. In German, this constraint is undominated because schwa is not stressed under any circumstances. By contrast, constraints such as *H/a are ranked very low. A syllable head must have a nucleus, and the vowel *a* is the most unmarked option. This constraint is only included here for reasons of completeness because all vowels should be specified regarding their degree of markedness in heads of metrical feet.

However, it does not make much sense to consider a constraint like *H/a to be relevant for the EVAL function: A violation is never relevant for the selection of a candidate. Therefore, only the constraint rejecting schwa in a stressed syllable (*H/ə) should be considered. The constraints required in the present analysis are listed in (26):

(26)
PARSE-SEGMENT; PARSE-SYLLABLE
ALIGN-L
FOOT-MAX; FOOT-MIN
RHTP=T
*HEADHEAD; *H/ə
NOCODA

For the sake of descriptive simplicity, I will assume syllable structures in the following tableaux. The candidates are compared with respect to their metrical structure only.
The tableau in (27) shows the OHG ranking.

(27) **OHG**

Input: *êrist+o*	ALIGN-L	FT-MAX	RhTp=T	*HDHD	PARSE-SEG	FT-MIN	PARSE-SYLL	NOCODA
1. *<ê>(rí.sto)*	*!						*	
2. ☞ *(´ê.ri)<sto>*							*	
3. *(´ê.ri)(stò)*			*!			*		
4. *(´ê)(ri.stò)*			*!*			*		
5. *(´ê)(rì.sto)*			*!	*		*		
6. *(´ê)<ri>(stò)*			*!*			**	*	
7. *(´êr<i>sto)*					*!			*
8. *(´ê.ri.sto)*		*!	*					

The structure of candidate 7 implies a structural reanalysis due to syncope: Since the second vowel is deleted, a binary foot can be assigned.

[18] Kenstowicz uses the term 'peak' instead of 'head'.

The constraint ranking in (27) is motivated as follows:

ALIGN-L and FOOT-MAX are both undominated, and there is also no evidence for an internal ranking between them. The rhythm constraint is ranked lower than FT-MAX. This can be justified by considering the scope of RhTp=T: Degenerate and ternary feet both violate the trochaic rhythm constraint. Since degenerate feet are not as bad as ternary feet, the rhythm constraint is ranked below FT-MAX. This ranking accounts for why candidate 8, for instance, is worse than candidate 3. Such a gradation could not be expressed by the violation of FT-MAX in 8 if FT-MAX were not ranked higher than the rhythm constraint.

The rhythm constraint dominates *HDHD because a violation of *HEADHEAD within a prosodic word only occurred if a trochaic foot could be assigned in return. In OHG, stress clash could occur after a long vowel in favour of a binary foot as the example in (28) shows:

(28) OHG *(âh)(tùn.ga)* 'persecution', nom.sing.

RhTp=T dominates PARSE-SEG because variants with vowel deletions in favour of trochaic rhythm can already be observed in OHG. See (29) for examples.

(29) **Syncope in OHG**

ab(a)	'from'
als(ə)	'when'
dritt(i)o	'third'
zunt(a)ra	'tinder'

However, this ranking was not yet fully established: Since the syncopized forms were only optional variants, the inverse ranking PARSE-SEG >> RhTp=T was also possible.

PARSE-SEG and PARSE-SYLL are dominated by *HDHD: Generally, the parsing of neither a syllable nor a segment occurs if a stress clash is the consequence. The only exception is a violation of PARSE-SEG if a trochee can emerge (see (29)). In this case, the violation of RhTp=T can be prevented whereas only the lower ranked PARSE constraint is violated.

PARSE-SYLL is dominated by PARSE-SEG although this ranking is not very stable because syncope also took place in OHG - in favour of the parsing of an additional syllable into a trochaic foot (29). On the other hand, syncope is prevented in cases like *éristo* because, all the other constraints being equally ranked, PARSE-SEGMENT would be violated. Therefore, candidate 2 is more optimal than candidate 7 in OHG.

*HDHD dominates FT-MIN because stress clash was avoided if only one syllable could be parsed into a degenerate foot. An example is shown in (30):

(30) a. *<gi>(n´âda)* 'mercy'
b. **(gì)(n´âda)*

The later weakening of *i* to schwa is evidence that the prefix *<gi>* was rather left unparsed and was not parsed into a degenerate foot carrying secondary stress instead: Such stress would have prevented the weakening process. Thus, a violation of PARSE-SYLL (30a) was not as bad as a violation of FT-MIN (30b).

However, FT-MIN was dominated by PARSE-SEG in OHG: Degenerate feet were preserved although the non-parsing of a segment could have produced a trochee. An example is shown in (31). The syllable in bold type is degenerate. Note that there is also stress clash in OHG.

(31) OHG ***(lé)****(wìn.na)*[19] > MHG *(l´ö.win)* > NHG *(L´ö.win)* 'lioness'

Candidate 3 in (27), which has secondary stress, is not optimal. Evidence for the assumption that the final vowel was unstressed lies in the fact that this vowel was weakened to schwa. Secondary stress would have prevented this weakening (as in OHG *-**ùnga*** > MHG *-**ùngə*** > NHG *-(`)**ung**).*

Candidate 7 with unparsed <i> is the second best alternative following candidate 2. This is already an indication for later syncope.

The MHG tableau in (32) shows that only one change in ranking was necessary to evaluate candidate 7 as optimal.

(32) **MHG**

Input: *êrəst+ə*	*H/ə	ALIGN-L	FT-MAX	RhTp=T	*HDHD	FT-MIN	PARSE-SYLL	PARSE-SEG	NOCODA
1. *<ê>(r´ə.stə)*	*!	*					*		
2. ☞ *(´ê.rə)<stə>*							*!		
3. *(´ê.rə)(st`ə)*	*!			*		*			
4. *(´ê)(rə.st`ə)*	*!			**		*			
5. *(´ê)(r`ə.stə)*	*!			*	*	*			
6. *(´ê)<rə>(st`ə)*	*!			**		**	*		
7. ☞ *(´êr.<ə>stə)*								*	*
8. *(´ê.rə.st ə)*			*!	*					

In MHG, all unstressed syllables were weakened to schwa. Schwa syllables are without exception unstressable both in MHG and in NHG. Therefore *H/ə is undominated. Since there is no evidence for any ranking between *H/ə and ALIGN, both constraints are considered to be equally ranked.

[19] In the OHG form, there is a stress clash and a violatiion of RhTp=T. Both violations should have selected the form as non-optimal. However, the morphological structure is different from the structure of *êristo*, and other constraints (such as a constraint relating to the length of derivational suffixes) would also have to be considered.

The tableau shows that five of the eight candidates are ruled out because the schwa constraint is violated. This is evidence that the 'wrong' rhythm is prevented more effectively by the segmental weakening which had taken place at this time. Conversely, weakening could only occur in unstressed syllables, meaning that there is a mutual dependency between stress and segmental quality.

The modifications are motivated by two changes in the constraint hierarchy: Due to segmental weakening, *H/ə must be considered in the ranking. The second change consists in the lower ranking of PARSE-SEG. Since syncope is so very frequent in MHG, there is sufficient empirical evidence for this new constellation. In section 3 it was shown that there is no dominance relation between PARSE-SYLLABLE and PARSE-SEGMENT in MHG. Of course, the same relation is true within the context of a prosodically motivated ranking: Due to the non-ranking between both PARSE constraints, there were two optimal candidates.

In certain contexts vowel deletion is preferred to an unparsed syllable, especially if stress clash and/or a degenerate foot can be avoided. Therefore *HDHD and FT-MIN dominate PARSE-SEG in (32). Syncope in 'certain contexts' means that segmental adjacency conditions have to be fulfilled: If one consonant can't follow another because of sonority constraints, syncope is blocked. See (33) for such a case: In contrast to *ginâda* becoming *gná:də* (2a), syncope could not occur in the prefix because **gb-* was never a possible syllable onset in German.[20]

(33) OHG *gib'ûidi* > MHG *gəb'ûwədə* > NHG *Gəb'äude* 'building'

Candidate 2 in the MHG tableau is the second best candidate. This is plausible because this was the optimal candidate in OHG. Conversely, the optimal candidate 7 in the MHG tableau was second best in OHG.

The NHG constraint rankings in (34) below do not differ from those in MHG. Some structures have become impossible because the morphological input changed on the base of Lexicon Optimization as it was already shown for MHG in section 3. There are only two syllables left, and so the number of candidates is limited. The optimal candidate has become even better: It only violates the NOCODA constraint (which plays a minor role compared to the metrical constraints) whereas there still was an additional violation of PARSE-SEG in MHG.

[20] This restriction can be formally expressed by a general constraint 'SONORITY'. Since in this context only syncopes that really occurred are considered, such a constraint would never be violated. Therefore, it is not necessary to integrate it into the rankings. However, it is obvious that SONORITY would be undominated because it must be met by acceptable candidates without any exception.

(34) **NHG**

Input: *erst+ə*	*H/ə	ALIGN-L	FT-MAX	RhTp=T	*HD̈HD	*FT-MIN	PARSE-SYLL	PARSE-SEG	NOCODA
1. *<ér>(st`ə)*	*!	*	*	*		*	*		*
2. *(ér)<stə>*			*!	*		*	*		*
3. *(ér)(st`ə)*	*!		**	**	*	**			*
4. ☞ *(ér.stə)*									*

In section 3 it was argued that the most harmonic input in the MHG evaluation also differs from the lexical entry in OHG. Both weakening and deletion thus give evidence for the assumption that a reranking of constraints can subsequently cause a change in the lexicon. This means that sound change is related to two different domains that are connected in a temporal order. The first domain of change is the grammar: Since rankings can conflict, these rankings can lead to more than one optimal candidate at a given stage (such as *êrəstə* versus *êrstə* in MHG). They are the basis of variation. If one of the conflicting rankings gets predominant at a later stage, (which is called selection in historical linguistics), it is highly probable that the most harmonic input will not correspond to the input which was best in the previous stage.

In summary, sound change in its first phase is a turbulence within the grammar which is caused by parameters such as articulatory economy and other factors which are encoded in constraints. Due to this turbulence, there are conflicting rankings and therefore several optimal variants that are all well-formed. In a second phase, sound change affects the lexicon: One variant - and therefore one ranking - prevails, and the most harmonic input with respect to the new hierarchy is supposed to change.

The sequence of phases in a sound change process can be sketched as follows:

(35) **Reranking and change of the input**

Grammar		**Lexicon Economy**	**Sound Change**
Ranking 1 (OHG)			
↓		Input 1 (OHG): *êristo*	
Ranking 2 (MHG)	1. conflict with Ranking 1 2. selection of Ranking 2		*êristo/êrəstə* *êrəstə*
↓	⟶	Input 2 (MHG): *êrəstə*	
Ranking 3 (NHG)	1. conflict with Ranking 2 2. selection of Ranking 3		*êrəstə/erstə* *erstə*
	⟶	Input 3 (NHG): *erstə*	

5. Interaction of segmental and prosodic constraints

In the previous sections, segmental and prosodic constraints were treated separately. However, this should not obscure the fact that these two factors interacted. Certain constraints do not interact, whereas the constraints PARSE-SEGMENT and PARSE-SYLLABLE were active in both contexts. The changes within the ranking that made weakening and deletion processes possible are summarized in (36):

(36) a. **OHG**

PARSE-SEG >> PARSE-PL >> *V(σ_w) >> PARSE-SYLL
FT-MIN

b. **MHG**

*H/ə; *V(σ_w) >> PARSE-PL >> PARSE-SEG; PARSE-SYLL
FT-MIN

c. **NHG**

*H/ə; *V(σ_w) >> PARSE-PL >> PARSE-SYLL >> PARSE-SEG
FT-MIN

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