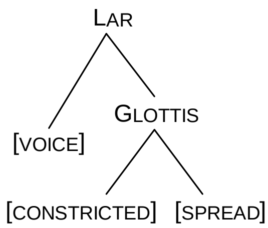
FEATURAL ALTERNATION AND FORMAL REPRESENTATION: THE PHONOLOGY OF GERMAN LARYNGEALS

1. Introduction

Systematic alternation patterns ideally determine the design of representational linguistic frameworks. Therefore the common goal of formal representations is to restrict the predictive power of linguistic descriptions to the set of attested alternations. If we find some individual categories being in parallel distribution, we might want to capture this pattern in our representations. Thus for instance, the theory of FEATURE GEOMETRY reflects the class behaviour of phonological features by proposing class nodes – i.e. abstract entities without featural content – to represent single features or even certain sets of features as a unit. If for example the laryngeal features consistently behave in a similar way in language-specific alternation, a tree structure like the following is an appropiate representation:

(1) laryngeal feature tree



The feature tree in (1) therefore implies that the following empirical evidence is given: the three features for vibration of the vocal chords, glottal constriction and glottal spreading occur in nearly parallel environments while the glottal features which appear deeper in the feature tree underlie additional, i.e. more specific context dependencies.

The present paper will provide evidence for the uniform systematic behaviour of the laryngeal feature class in the framework of Declarative Phonology. The current mismatch between featural alternation of laryngeal features and their formal representation in FEATURE GEOMETRY (cf. section 3.1) is resolved by assuming a strictly phonological, i.e. language-specific organization of features rather than a universal phonetic one. The appropriate feature structure is motivated by Prosodic Licensing constraints which crucially rely on the theoretical assumption that prosodic structure building is based on parsing fully structured feature sets rather than segments. This set of inviolable constraints allows then to deduce a structured laryngeal feature set identical to the hierarchy in (1).

1.1 Data – the distribution of laryngeals in German

The phonology of German shows laryngeal contrasts only in certain prosodic domains. The data in (2) introduces the relevant alternations for the laryngeal feature [VOICE]. The phenomenon is traditionally refered to as *final devoicing* which means that underlyingly voiced obstruents surface as voiceless in somehow final position. In the shaded column the alternation patterns of voiced vs. voiceless obstruents are given. Voiced obstruents appear in onset and in ambisyllabic position only, while voiceless obstruents appear in any context including final positions.

(2) [VOICE]-alternation in German

a.	Rat	'counsel'	[ʀɑː	t		]	
b.	Rad	'bike'	[ʀɑː	t		]	
c.	Räte	'counsels'	[ʀɛː	t	ə	]	
d.	Räder	'bikes'	[ʀɛː	d	ɐ	]	
e.	robbe	'crawl'	[ʀɔ	b	ə	]	[b] in ambisyllabic position
f.	robbt	'crawls'	[ʀɔ	p	t	]	

The examples (2) d., and e. show that voiced obstruents only appear in onset and in ambisyllabic position. The distribution of features characterizing the status of glottal width is presented in the table below. To a certain extent the glottal stop and the glottal fricative seem to be in parallel distribution with voiced obstruents considering the fact that they are realized in onset position as well but are absent elsewhere.

(3) glottal/∅-alternation in German

a.	Hemd	'shirt'		['h]	emd	no alternation		
b.	Bahnhof	'station'	Bahn	[h]	hof	vs. Bahn	∅	of
c.	Sahara	'sahara'	Sa	['h]	ara	vs. Sa	∅	ara
d.	Atem	'breath'		['ʔ]	atem	no alternation		
e.	einatmen	'to breathe in'	ein	[ʔ]	atmen	vs. ein	∅	atmen
f.	chaotisch	'chaotic'	cha	['ʔ]	otisch	vs. cha	∅	otisch

But a close look at the data shows that glottals in contrast to voiced obstruents are excluded from the ambisyllabic position. However, even further prosodic information is likely to intervene here since presence of [h] and [ʔ] seems to pattern with the presence of primary stress at least for the cases a., c., d., and f. The upcoming tables (4) a., and b. summarize the laryngeal contrasts found in Modern Standard German.

(4) German laryngeal contrasts

a.	obstruents					
–	p	t	k	f	s	ʃ
[VOICE]	b	d	g	v	z	ʒ

b.	glottals
[SPREAD]	[h]
[CONSTRICTED]	[ʔ]

Aspiration data is not considered here since the distribution of aspirated stops is not that transparent with respect to current phonetic investigations.

2.1 [VOICE] and syllabic prosody

While we have already investigated the German paradigmatic [VOICE]-contrast between voiced and voiceless obstruents in onset position, the question whether there is also a syntagmatic opposition in syllable onsets is unexplored yet. In table (5) all attested onset clusters are summarized. We expect syntagmatic [VOICE] constrasts only to show up in obstruent+obstruent clusters since we assume sonorants not to be marked distinctively for the feature [VOICE]. Sonorants are analyzed as being voiced in the unmarked case and therefore their voicing turns out to be phonologically redundant (cf. Steriade 1995). Only the combinations in the shaded cells in the table below constitute problematic clusters for our question since we seem to face syntagmatic laryngeal constrasts.

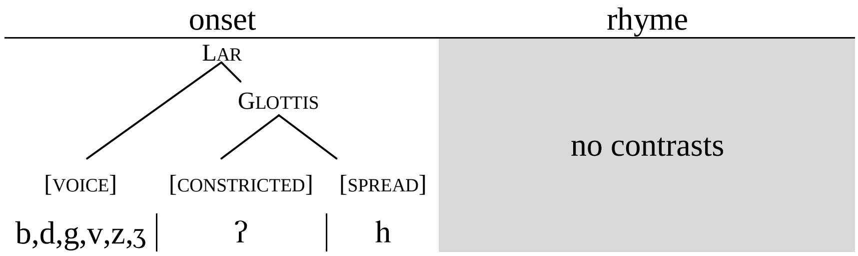
(5) Attested onset clusters (cf. Wiese 2000:262)

	sonorants				obstruents	
	l	ʀ	n	m	s	v
obstruents						
p	+	+	-	-	+	-
t	-	+	-	-	-	(+)
k	+	+	(+)	(+)	(+)	+
b	+	+	-	-	-	-
d	-	+	-	-	-	-
g	+	+	+	-	-	-
f	+	+	-	-	-	-
v	(+)	+	-	-	-	
ts	-	-	-	-	-	+
pf	+	+	-	-	-	-
ʃ	+	+	+	-	-	+

However, since there is lack of positive evidence for any voiced property of the fricative in the shaded clusters in (5), *Tweed*, *Quell*, *Zwerg* and *Schwert* are analyzed as [tf]*eed*, [kf]*ell*, [t͜sf]*erg* .

position only. Epenthesis ([CONSTRICTED]), and deletion ([VOICE], [SPREAD]) of laryngeal specifications crucially depends on prosodic information, and the distribution of glottal features is – in contrast to the feature [VOICE] – related to prosodic categories above the syllable.

(7) The distribution of laryngeals in German

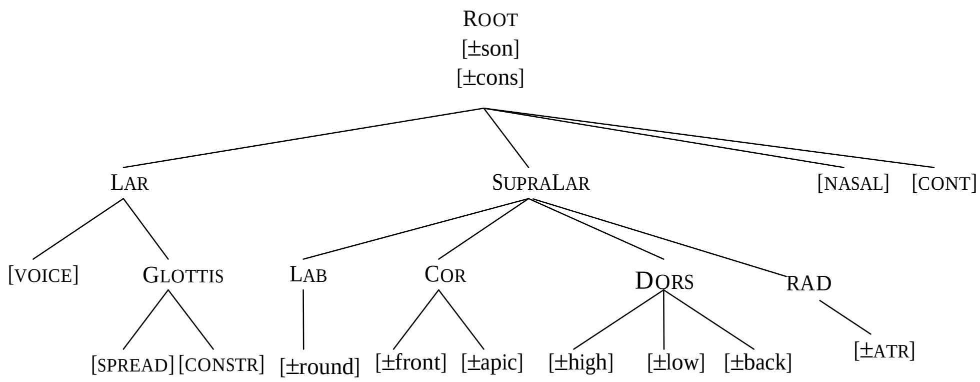


Having outlined similar phonological behaviour of individual phonological entities, FEATURE GEOMETRY seems to offer the adequate representational framework to capture the partial class behaviour of glottal sounds with regard to the distribution of laryngeal sounds in general. The invention of class nodes allows us to assume a unifying representational means to categorize an otherwise unordered feature bundle.

3. FEATURE GEOMETRY

The use of feature bundle representations include the false prediction of unbounded combination of each individual feature. Thus feature bundle representations turn out to be underdetermined: „It is less apparent, but nevertheless true, that the feature-matrix formalism incorporates certain implications for feature organisation that do not follow from the vaguer notion of bundle." (cf. Clements 1985:202). Clements (1985) proposes a feature tree as the one in (8) to limit the number of possible feature combinations by class nodes like the nodes LAR and GLOTTIS situated on the left hand side.

(8) Feature tree



Subsequent work on feature geometry, however, neglects basic formal preliminaries which are crucial for the interpretation of feature trees. These shortcomings are explored in the following section.

3.1 Past theoretical shortcomings

In past work on FEATURE GEOMETRY a confusion of class nodes and features is quite common. While Clements (1985:209) states that „class nodes do not contain any featural content“ very few analyses implement a formal distinction between class nodes and features and representations like those given in (9) are quite common.

(9) Representations confusing class nodes and features

[+DORSAL] | [-vorne]	root | laryngeal	voiced $=_{def}$ {[voiced]} Laryngeal $=_{def}$ {[aspirated], [voiced], [glottalized]}
Wiese (2000:165)	Clements/ Hume (1995:272), Kenstowicz (1995:483)	Padgett (2002:25)

Following Dogil (1989:200), Hall (1992:17), Hall (2000:117 f.), Kenstowicz (1995:463), Wiese (2000:165) and Yu (1992:157 ff.), class nodes are specifiable features. According to Avery/ Idsardi (2001), class nodes are terminal phonological categories. The latest version of the common misconception is presented in Padgett (2002): „The central proposal of Feature Class Theory is that rules or constraints mentioning feature classes thereby target (or hold true of) the relevant features directly and individually. In particular, no class nodes mediate as in Feature Geometry.“ (cf. Padgett 2002:24). He regards class nodes in Clements‘ work as entities that manipulate feature matrices in a way that (terminal) features are not accessible anymore for phonological description in a direct way. Padgett (2002) reinterprets class nodes sets of elements, relying on false assumptions about work on FEATURE GEOMETRY by Clements (1985); Clements does not present a different but exactly the same view on class nodes as Padgett (2002).

The relevant question is therefore what the source of these differing assumptions about the nature of class nodes might be? I’d like to propose that two different structural relations are represented identically. The associations between a class node and a feature (Bird 1991:137 dubs (10) b. Category Membership) are (mis)interpreted in the same way as those between a segment and its feature (Bird 1991:137 dubs (10) a. Dominance) .

(10)

a. $\{a\} \notin \{H\}$
(H = high tone)

b. [VOICE] $\in$ LAR
LAR := {[VOICE], GLOTTIS}

As we are now sure about the formal nature of class nodes we need to consider the question which kind of evidence motivates these new entities. Is the evidence for class nodes to find in phonetics? Clements (1985:202) gives a clear answer to this question: „If we find that certain sets of features consistently behave as a unit [...] we have good reason to suppose that they

3.2 Typed feature structures in FEATURE GEOMETRY

In this paper the feature structures of FEATURE GEOMETRY are reinterpreted as inheritance hierarchies. This requires every class node apparent in phonological representation to be motivated by the constraint pool of the phonological system: terminal features subsumed by a class node are necessarily in parallel distribution, while complex classifications represent partial class behaviour of the feature classes subsumed by higher nodes.
FEATURE GEOMETRY is in this conception a language-specific formal representational variant of the declarative lexical restrictions, i.e. the conjunction of objects and descriptions.

3.2.1 Definitions

The subsequent definitions 1-3 state that a feature structure, consisting of a root node and an additional finite set of nodes, is exhaustively defined by sets of functional features and types of features. The hierarchical order is deducible from the subsumption relation between one type and another (cf. Copestake 2001).

(11) *Definition 1* – Type Inheritance hierarchy

A type inheritance hierarchy is a finite bounded complete partial order <TYPE, $\subseteq$>.

(12) *Definition 2* – Feature structure

A feature structure F is defined over a set of features FEAT and a type hierarchy <TYPE, $\subseteq$>.
It is a quadruple $<Q, q, \theta, \delta>$, where:

- Q is a finite set of nodes (where q' constitutes the node of the structure)
- $q' \in Q$ is the root node
- $\theta : Q \rightarrow$ TYPE is a partial typing function
- $\delta : Q \times$ FEAT $\rightarrow Q$: is a partial feature value function

(13) *Definition 3* – Subsumption

F subsumes F', written F'$\subseteq$ F', iff:

- $\pi \equiv_F \pi'$ implies $\pi \equiv_{F'} \pi'$
- $P_F(\pi) = t$ implies $P_{F'}(\pi) = t'$ and $t' \subseteq t$

In consequence, a well-formed typed feature structure is achieved in a consistent match between the constraints, types, and features on the one hand, and the graph representation on the other hand.

(14) *Definition 4* – Well-formed typed feature structure

$F = <Q, q_0, \theta, \delta>$ is a well formed typed feature structure iff
$q \in Q \mid F' = <Q', q, \theta, \delta> \subseteq C(\delta(q))$ and FEAT(q) = *Appfeat*($\delta(q)$), where
C:<TYPE, $\subseteq$> $\rightarrow F$ is the constraint function

A similar approach seems to be outlined in Bird/Klein (1994). The following section will point out the most important differences compared to the view presented in this paper.

3.2.2 Theoretical background

According to section 3.2.1, the result of the phonological analysis is a lexical type hierarchy as stated in HPSG work on syntax and semantics (cf. Pollard/ Sag 1987). Although Bird/ Klein (1994) aim to present „inheritance and type hierarchies in phonology“ the evidence for the presented hierarchy remains untold:

> Each of these [cf. Table (15); MN] types may have further structure. For example, following Clements (1985:248) we may wish to classify segments in terms of their place and manner of articulation, using the following appropiateness declaration (Bird/ Klein 1994:461)

(15) Phonological type hierarchy according to Bird/ Klein (1994:462)

LARYNGEAL	:	SPREAD	:	boolean	
		CONSTRICTED	:	boolean	
		VOICED	:	boolean	
SUPRALARYNGEAL	:	MANNER	:	NASAL :	boolean
				CONTINUANT :	boolean
				STRIDENT :	boolean
		PLACE	:	CORONAL :	boolean
				ANTERIOR :	boolean
				DISTRIBUTED :	boolean
segment					

Whith reference to Pollard/ Sag's appropiateness declaration which says that „each feature structure type comes equipped with a set of attributes appropriate to this type“ (Pollard/ Sag 1987:196) internal segmental complexity is simply st(ipul)ated: Which constraint motivates e.g. the type LARYNGEAL proposed in the structure above? What sort of distributional properties (i.e. a part of the constraint inventory) is shared by CORONAL, PLACE and MANNER?

In constrast to Bird/ Klein (1994) the typing of phonological properties is not argued to be adapted from phonetic classification. In this talk a notion of *subsumption ordering* is applied not only to semantic and syntactic hierarchies but also to tree structures in phonology which can be established by phonological facts alone.

4. Analysis – FEATURE GEOMETRY and PROSODIC LICENSING in constraint-based grammar

In this section the preliminaries elaborated in the previous chapters will be put to use. We will develop a set of phonological wellformedness conditions which allows us to derive a typed feature structure straight from our language-specific phonological grammar. The result is representable as a feature tree including all properties defined above such as subsumption and inheritance. The three laryngeal features [SPREAD], [CONSTRICTED], and [VOICE] will be the terminal elements of our feature tree which follows from the fact that they are the arguments our constraints apply to.

4.1 Redundancy rules in monostratal frameworks

In the data section we already mentioned that we assume the laryngeal features to be privative and that we aim to characterize the [VOICE]–specialization of sonorants as redundant. Below in (16) a rule expressing this redundancy is formulated. (17) does the same, expressing the redundancy of continuity for segments specified for glottal spreading.

(16) Redundancy rule for sonorants
[+son] ⊃ [VOICE]

(17) Redundancy rule for [SPREAD]
[SPREAD] ⊃ [CONT]

In derivational theories this kind of rules is intended to apply as late in the derivation as possible to exclude them from the core part of the rule machinery. Since we intend to implement our approach in a monostratal framework just like Declarative Phonology we need to consider an alternative for the multistratal interpretation of redundancy rules in derivational frameworks such as Lexical Phonology. For this purpose we will adopt an approach known as Licensing Cancellation (cf. Itô/ Mester/ Padgett 1995).

(18) LICENSING CANCELLATION (Itô/ Mester/ Padgett 1995:57)
If F ⊃ G, then ¬(FλG)
„If the specification [F] implies the specification [G],
then it is not the case that [F] licenses [G].“

In (19) application of this approach to our two redundancy rules is demonstrated.

(19) LICENSING CANCELLATION for (16)/ (17)
[+son] ⊃ [VOICE], then ¬([+son]λ[VOICE])
[SPREAD] ⊃ [CONT], then ¬([SPREAD]λ[CONT])

In the following analysis we do not expect the voicing of sonorants to be licensed. This includes the effect that e.g. the feature [VOICE] for a nasal is not apliccable for any constraint as long as it is not licensed indirectly by [-son]-segments, i.e. obstruents.

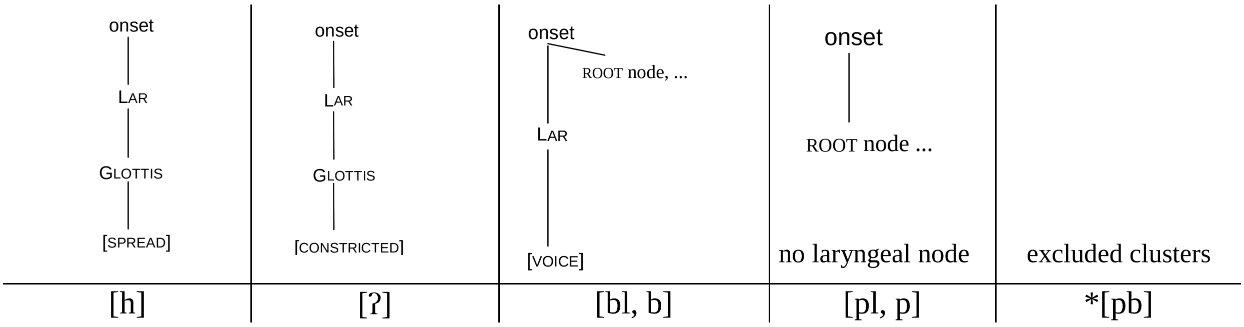
4.2 The representation of laryngeally marked elements

To account for our empirical result that voicing contrasts occur only paradigmatically and only between syllable onsets we need to make reference to the PROSODIC ACCOUNT, a representational model mirroring this scenario:

„The PROSODIC ACCOUNT claims that the laryngeal node attaches directly to the subsyllabic constituents onset, nucleus, coda, rather than to individual segments. The representational model accounts for all occuring contrasts and excludes all non-occurring ones.“ Golston/ Kehrein (1999:1)

The graphic implementation is shown in the table below: the two glottal specifications [SPREAD] and [CONSTRICTED] constitute individual segments if they are (for German) associated to the onset constituent. Clusters of voiced obstruents and sonorants are marked with a voiced property to account for the marked realization of the obstruent. The representation in the middle of table (20) shows that it is not the sonorant which requires the laryngeal specification since their voiced realization is considered to be redundant. However, the Prosodic Account is restritive enough to predict correctly that syntagmatic voicing contrasts do not appear in German at all.

(20) Raising of the laryngeal node (cf. Golston/ Kehrein 1999, Golston/ van der Hulst 1999)



A combination of LICENSING CANCELLATION and the PROSODIC ACCOUNT leads to the representations of sounds in (21) and (22) that are marked by a glottal feature only. The central vowel [ə] appears to be the third segment specified with one laryngeal feature only. The presence of the root node is a consequence from our licensing considerations about the feature [VOICE].

(21) [ʔ]

[LAR: GLOTTIS : [CONSTRICTED]]

(22) [h]
licensing of [CONT] is cancelled

[[LAR: GLOTTIS : [SPREAD]] [CONT]]

(23) [ə]
licensing of [VOICE] is cancelled

[[ROOT : son : + cons: -] LAR: [VOICE]]

Table (24) summarizes all our results about the licensing of sounds marked with a laryngeal feature made so far. It is obvious that we have not yet implemented any prosodic restrictions on the occurence of these sounds. The prosodification issue will be part of our investigation in the next chapter since we need to have a theory of prosodic structure building if we want to restrict featural distribution in clearly defined prosodic contexts.

(24) The licensing of laryngeals (underdetermined for PROSODIC LICENSING)

	prosodically licensed		
	LAR		
licensed by [-son]	[VOICE]	GLOTTIS	
		[CONSTRICTED]	[SPREAD]

4.3 Declarative sonority-based syllabification of feature sets

We assume sonority to be the driving force in the determination of syllable structure, and we refer to a declarative syllabification tool to formalize this issue (cf. Walther 1993, 1999). But while Walther takes the sonority hierarchy to be a hierarchy of segments we will hold on to the assumption that it is feature structures phonology deals with.

4.3.1 Sonority-based syllabification[1]

Taking the Sonority Sequencing Generalization as a motivation for our proposal that sonority relationships between segments are sufficient to assign syllable structure to a segmental string, we decompose each syllable constituent into two features while each feature is determined by the sonority relatoinship of the current segment to the one the right-/ left-hand side.

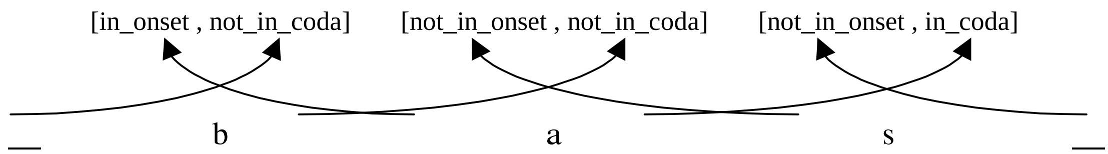
(25) Sonority Sequencing Generalization (Blevins 1995:210)
„Between any member of a syllable and the syllable peak, a sonority rise or plateau must occur.“

(26) Decomposing syllable roles into features (cf. Walther 1993, 1999)

syllable roles	syllable role features	
onset	in_onset	not_in_coda
nucleus	not_in_onset	not_in_coda
coda	not_in_onset	in_coda
codaonset	in_onset	in_coda

While the first three constituents are well-known the fourth constituent *codaonset* is used to syllabify ambisyllabic segments. Table (27) shows a sample syllabification of the German monosyllable *Bass*. Coda-features (i.e. „in_coda“, „not_in_coda“) are determined by the preceding segment while onset-features (i.e. „in_onset“, „not_in_onset“) are instantiated based on the sonority relationship to the following segment.

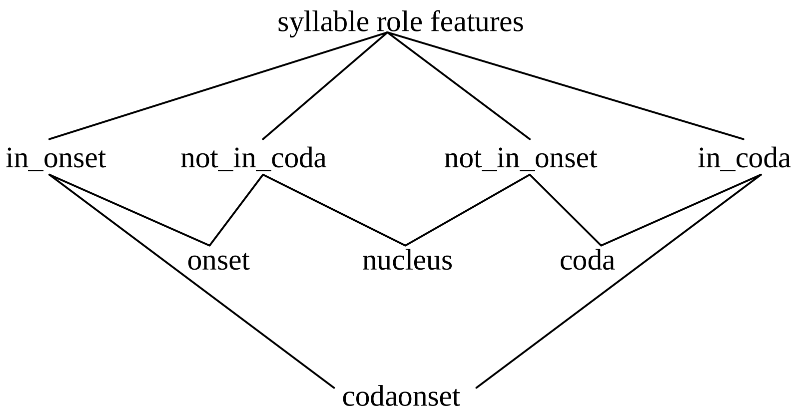
(27) Syllabification of Bass ('bass')



[1] See the appendix for the assumed sonority hierarchy.

The diagram below shows that mentioning one feature only implies reference to two syllabic constituents at the same time. If we e.g. consider segments to appear in onset position and in ambisyllabic position only we just need to say that their distribution is licensed in domains characterized by the feature [in_onset] leaving the coda-feature underspecified.

(28) Hasse-diagram of syllable role features (cf. Walther 1993)



4.3.2 Feature-based constraints

The following feature structures give an impression of how the lexical segmental information is organized in this paper. In constrast to Walther (1993, 1999) the constraints which we will posit right now are separated from the feature structures and they are able to refer to any subsegmental structure at any time. Interaction among constraints and interaction with feature structures is fairly trivial in the proposed framework: only conjunction is possible excluding extrinsic temporal ordering relationships.

(29) Feature structures

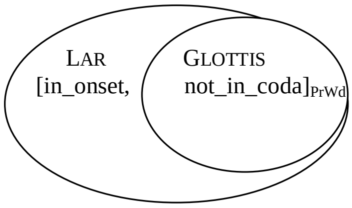
a. Glottals and obstruents
x(F) → [ʔ], {F = [laryngeal: [glottis: constr]]}.
x(F) → [h], {F = [[laryngeal: [glottis: spread]]}.
x(F) → [p], {F = [root: [son: -, cons: +], [supralaryngeal: [labial: [round: -]]]]}.
x(F) → [b], {F = [root: [son: -, cons: +], [supralaryngeal: [labial: [round: -]]], [laryngeal: voice]]}.

b. Vowels
x(F) → [ə], {F = [root: [son: +, cons: -]]}.
x(F) → [a], {F = [root: [son: +, cons: -], [supralaryngeal: [dors: [back: +, high: -, low: +]]]]}.
x(F) → [i], {F = [root: [son: +, cons: -], [supralaryngeal: [dors: [back: -, high: +, low: -]]]]}.
x(F) → [e], {F = [root: [son: +, cons: -], [supralaryngeal: [dors: [back: -, high: -, low: -]]]]}.

4.4 PROSODIC LICENSING constraints for German

Reconsidering the facts about the prosodic occurrence restrictions on laryngeally marked segments, we can visualize the superset/ subset-relationship between voicing and glottal features in the following diagram in (30).

(30) Formal task: GLOTTIS-features as a distributional subset of laryngeal features (cf. (7))



In this table we make already use of our prosodic terminology inspired by Walther (1993). In this case we license the realization of glottal features only at the left edge of prosodic words, i.e. onsets of prosodic words. As suggested in (30) the constraint on the feature [VOICE] is less restrictive: since voiced obstruents surface both in onset and in ambisyllabic position we simply require the prosodic feature [in_onset] to be present. As already mentioned this captures at least both prosodic contetxts (cf. (28) for visualization). Right now our licensing constraint for laryngeal features is quite obvious. In (31) we see the appropiate formalization:

(31) Licensing the class of laryngeals: LICENSE-in_onset

LICENSE (LAR) → $\frac{\text{in\_onset}}{\text{X}}$

„Laryngeal features are licensed in onset and codaonset position only.“

This constraint should cover both cases successful licensing and restricted licensing. An example for the latter case is given below for the example *ebbt*: the voiced labial stop [b] has a voiceless alternate [p] in positions that are not explicitely covered by the constraint above. Consequently [VOICE] is not licensed in coda position. Note that we do not implement an instance of delinking here since we do not neutralize underlying information in the surface form. Instead we achieve monotonous alternation of voiced and voiceless obstruents depending on the prosodic context.

(32) Application of the constraint in (31): ‚ebbt‘[2] (=‚ebbs‘)

not_in_onset not_in_coda [ε	not_in_onset in_coda b	not_in_onset in_coda t]	syllabify([ε,b,t],Output). The feature [voice] of the element [b] is not licensed. Output = [s(ε, sonority_rise, not_in_onset, not_in_coda), s(b, sonority_fall, not_in_onset, in_coda), s(t, sonority_hold, not_in_onset, in_coda)] .

In onset and in ambisyllabic position we expect the voiced property to be realized. Table (33) demonstrates successful licensing in ambisyllabic position which is specified with the required feature [in_onset]:

[2] Onset-epenthesis does not apply in this case due to the lack of PRWD-information; compare (33) with (37) for further explication.

(33) Application of the constraint in (31): ‚Ebbe‘[2] (=‚low tide‘)

not_in_onset	in_onset	not_in_onset
not_in_coda	in_coda	not_in_coda
[ɛ	b	ə]

syllabify([ɛ,b,ə],Output).
The feature [voice]
of the element [b] is licensed.
Output = [
s(ɛ, sonority_rise, not_in_onset, not_in_coda),
s(b, sonority_fall, in_onset, in_coda),
s(ə, sonority_rise, not_in_onset, not_in_coda)].

Of course the constraint set is not yet restrictive enough to account for the appropiate licensing of glottals. The following constraint adds the necessary licensing information while refering to GLOTTIS-features only:

(34) Licensing the class of glottals: LICENSE-in_onset, not_in_coda

		PrWd
		in_onset
LICENSE (GLOTTIS)	→	not_in_coda
		X

„Glottal features are licensed in PrWd-initial onset position only."

Successful licensing is shown for *Hall* in (35):

(35) Application of the constraint in (34): ‚Hall‘ (=‚echo‘)

PrWd		
in_onset	not_in_onset	not_in_onset
not_in_coda	not_in_coda	in_coda
[h	a	l]

prwd([h,a,l],Output).
The feature [spread]
of the element [h] is licensed.
Output = [prwd,
s(h, sonority_rise, in_onset, not_in_coda),
s(a, sonority_rise, not_in_onset, not_in_coda),
s(l, sonority_fall, not_in_onset, in_coda)].

While we can already account for the licensing of glottal spreading we have yet no reason to motivate the presence of glottal constriction on the left edge of vowel-initial prosodic words. Therefore we posit a prosodic markedness constraint which requires every prosodic word to be onset-initial.

(36) ONSET-constraint motivating the licensing site (here: standard speech cf. (6))

PrWd		PrWd	
not_in_onset		in_onset	not_in_onset
not_in_coda	→	not_in_coda	not_in_coda
X		Y	X

„Every Prosodic Word left-aligns with an onset."

The surfacing of glottal stops is implemented here as an epiphenomenon of the interaction between prosodic markedness (cf. 13) and (absent) featural complexity (cf. 11). This is shown for the example *Ebbe*:

(37) Application of the constraints in (34) and (36): ‚Ebbe‘ (‚low tide‘)

PrWd			
in_onset not_in_coda	not_in_onset not_in_coda	in_onset in_coda	not_in_onset not_in_coda
[ʔ	ɛ	b	ə]

prwd([ɛ,b,ə],Output).
The feature [constricted] of the element [ʔ] is licensed.
Output = [prwd,
s(ʔ, epenthetic, in_onset, not_in_coda),
s(ɛ, sonority_rise, not_in_onset, not_in_coda),
s(b, sonority_fall, in_onset, in_coda),
s(ə, sonority_rise, not_in_onset, not_in_coda)] .

Note that the glottal stop is not syllabified on the basis of local sonority relationships; its prosodic position is in contrast to this view alternating with zero depending on the necessity to satisfy prosodic markedness considerations.

5. Conclusion

The three inviolable contraints posited for the purpose are summarized in the table below. In the rightmost column the segments covered by each constraint are listed to show that (38) a. covers all laryngeally marked sounds as well while (38) b. refers to the subset of glottal features only.

(38) Summary of the posited constraint set

a.	LICENSE-in_onset (cf. (31))	[b,d,g,v,z,ʒ,h,ʔ]
b.	LICENSE-in_onset, not_in_coda (cf. (34))	[h, ʔ]
c.	ONSET-constraint (cf. (36))	[h, ʔ]

To show the straightforward motivation of formal representation by featural alternation on the example of laryngeal features in German, table (39) demonstrates how terminal features (i.) and well motivated constraints (iv.) converge in a typed feature structure which relies on phonological facts alone. Although the nodes LAR and GLOTTIS are named refering to language-independent articulatory considerations, the evidence to assume them is part of the specific phonological system of German.

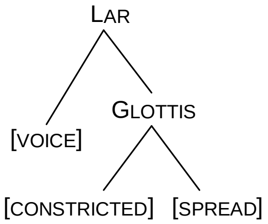
(39) The typed feature structure LARYNGEAL: formal properties

i. set of features FEAT: {[VOICE], [CONSTRICTED], [SPREAD]}
ii. set of nodes Q: {LAR, GLOTTIS}
iii. root node: {LAR} $\in Q$
iv. partial typing functions θ: $Q \rightarrow$ LICENSE-in_onset: <LAR>, LICENSE-in_onset,not_in_coda: <GLOTTIS>

v. resulting Type Inheritance hierarchy TYPE: <LAR $\subseteq$ GLOTTIS>

The appropiate graphical notation corresponding to the Type Inheritance hierarchy TYPE is given below. It is worth stressing that this common feature structure is proofable by the phonological system in a straightforward way.

(40) Geometrical feature tree (phonologically motivated)



To conclude, the most prominent assumptions characterizing the current approach are pointed out. The analysis converges key aspects of Declarative Phonology (DP) and issues of various different frameworks to account for derivational phenomena such as deletion and epenthesis in a single declarative approach: I presented a DP-analysis which asssumes that geometrically structured feature sets (objects) are separated from phonological descriptions; one issue of the latter is the sonority-based syllabification inspired by Walther (1993, 1999), but in contrast to his approach the prosodification operates on a featural basis rather than on the basis of opaque segments. Licensing constraints as a declarative alternative to neutralization and epenthesis (cf. Steriade 1995) ensure the monotonicity while the logical conjunction of feature structures and constraints as the only possibility of constraint-interaction (cf. Coleman 1998, Walther 1999) ensures monostratality. As a final remark, the formal adequacy of the analysis presented here is achieved by the fact that feature structures, syllabification algorithm and constraints are computationally implemented.

As a last programmtic issue I'd like to encourage phonological theory to work on a conception of FEATURE GEOMETRY which is solely motivated by our main subject: by phonological description rather than phonetic articulation. Following this line, we achieve a desirable result when featural alternation and formal representation correspond with each other in a non-trivial way.

<u>Appendix</u>

(41) Minimal sonority hierarchy

GLOTTIS ,	[-son]	<<	[+son, +cons], [NASAL]	<<	[+son, +cons]	<<	[+son, -cons]
[ʔ, h]	obstruents		nasals		rhotics, laterals		vowels

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