Relative Clauses in Head-Driven Phrase Structure Grammar

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Aims of the Course

- introduction to the basic ideas of Head-Driven Phrase Structure Grammar
- in particular nonlocal dependencies
- application to relative clauses
- discussion of free relative clauses
- on the way: motivation of the feature geometry that is used in current publications
  enable you to read HPSG specific publications

General Things

- Prerequisits: Some knowledge of phrase structure grammar

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- Who are you?

General Things

- Prerequisits: Some knowledge of phrase structure grammar
- Who are you?
- Ask Questions!

Outline

- Phrase Structure Grammars and Features
- The Formalism
- Valence and Grammar Rules
- Complementation
- Semantics
- Adjunction
- Nonlocal Dependencies
- Relative Clauses

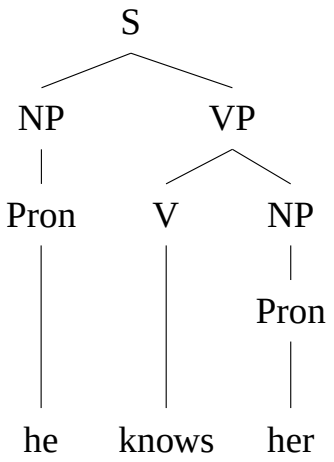
Why Formal?

Precisely constructed models for linguistic structure can play an important role, both negative and positive, in the process of discovery itself. By pushing a precise but inadequate formulation to an unacceptable conclusion, we can often expose the exact source of this inadequacy and, consequently, gain a deeper understanding of the linguistic data. More positively, a formalized theory may automatically provide solutions for many problems other than those for which it was explicitly designed. Obscure and intuition-bound notions can neither lead to absurd conclusions nor provide new and correct ones, and hence they fail to be useful in two important respects. I think that some of those linguists who have questioned the value of precise and technical development of linguistic theory have failed to recognize the productive potential in the method of rigorously stating a proposed theory and applying it strictly to linguistic material with no attempt to avoid unacceptable conclusions by ad hoc adjustments or loose formulation. (Chomsky, 1957, p. 5)

As is frequently pointed out but cannot be overemphasized, an important goal of formalization in linguistics is to enable subsequent researchers to see the defects of an analysis as clearly as its merits; only then can progress be made efficiently. (Dowty, 1979, p. 322)

- What does an analysis mean?
- What does it predict?
- Why are alternative analyses excluded?
- Only formal grammars can be used with computers.

A Simple Phrase Structure Grammar for English



S → NP, VP

VP → V, NP

NP → Pron

Pron → *he*

Pron → *him*

Pron → *her*

V → *knows*

(1) a. He knows her.

b. * We knows her.

What is wrong?

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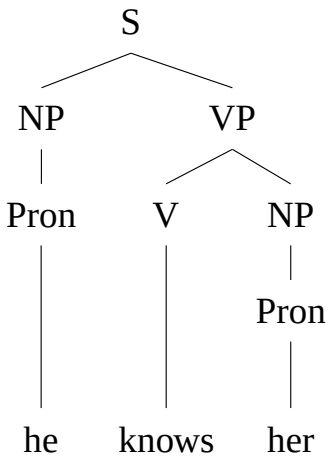

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Person and number of *we* and verb

Person Number Agreement

(2) a. I/you/we/you/they sleep.

b. He sleeps.

(3) I am / you are / he is / we/you/they are . . .

To capture the fact that subject and verb agree in person and number we have to use more complex symbols:

S → NP_1_sg, VP_1_sg

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S → NP_3_sg, VP_3_sg

. . .

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. . .

VP_1_sg → V_1_sg, NP

VP_2_sg → V_2_sg, NP

VP_3_sg → V_3_sg, NP

. . .

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. . .

NP_1_sg → Pron_1_sg

NP_2_sg → Pron_2_sg

NP_3_sg → Pron_3_sg

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VP_1_sg → V_1_sg, NP

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VP_1_sg → V_1_sg, NP

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VP_3_sg → V_3_sg, NP

. . .

NP_1_sg → Pron_1_sg

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. . .

Pron_3_sg → *he*

Pron_3_sg → *him*

Pron_3_sg → *her*

V_3_sg → *knows*

Problems with this Approach

- the number of non-terminal symbols explodes
- in rules like

  VP_1_sg $\rightarrow$ V_1_sg, NP

  VP_2_sg $\rightarrow$ V_2_sg, NP

  VP_3_sg $\rightarrow$ V_3_sg, NP

  what does NP stand for?
  Instead we had to write NP_1_sg or NP_2_sg or . . . in each rule
  $\rightarrow$ explosion of the number of rules
- missing generalization
- Solution: Features

Person Number Agreement: Rules with Features

(4) a. I/you/we/you/they sleep.

b. He sleeps.

(5) I am / you are / he is / we/you/they are . . .

S → NP(Per,Num), VP(Per,Num)

VP(Per,Num) → V(Per,Num), NP(Per2,Num2)

NP(Per,Num) → Pron(Per,Num)

Pron(3,sg) → *he*

V(3,sg) → *knows*

things in the brackets written in capital letters are variables

the value of Per and Num in the rules does not matter

important: Per and Num of NP and VP are equal

Per2, Num2 do not matter since they do not appear anywhere else

Feature Bundles

- are there rules where Per values have to be identical, but Num values may be not?

  S → NP(Per,Num), VP(Per,Num)

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- structuring of information: Per and Num are grouped together and referred to with Arg:

  S → NP(Agr), VP(Agr)

  VP(Agr) → V(Agr), NP(Agr2)

  NP(Agr) → Pron(Agr)

  Pron(agr(3,sg)) → *he*

  V(agr(3,sg)) → *knows*

- value of Agr is a complex structure that contains information about person and number
- important in HPSG: information is shared by mothers and daughters or between daughters in a rule

Heads

A head determines the most important features of a phrase/projection.

(6) a. Karl sleeps.
b. Karl talks about linguistics.
c. about linguistics
d. a man

A (finite) sentence is a maximal projection of a (finite) verb.

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A (finite) sentence is a maximal projection of a (finite) verb.

main categories are:

category	projected features
verb	part of speech, verb form (*fin*, *bse*, . . .)
noun	part of speech, case
preposition	part of speech, form of the preposition
adjective	part of speech

Abstraction over Rules

$\overline{\text{X}}$ -Theory (Jackendoff, 1977):

$\overline{\text{X}}$ – Rule	examples with instantiated part of speech
$\overline{\overline{\text{X}}} \rightarrow \overline{\overline{\text{Specifier}}}\ \overline{\text{X}}$	$\overline{\overline{\text{N}}} \rightarrow \overline{\overline{\text{DET}}}\ \overline{\text{N}}$
$\overline{\text{X}} \rightarrow \overline{\text{X}}\ \overline{\overline{\text{Adjunct}}}$	$\overline{\text{N}} \rightarrow \overline{\text{N}}\ \overline{\overline{\text{REL\_CLAUSE}}}$
$\overline{\text{X}} \rightarrow \overline{\overline{\text{Adjunct}}}\ \overline{\text{X}}$	$\overline{\text{N}} \rightarrow \overline{\overline{\text{ADJ}}}\ \overline{\text{N}}$
$\overline{\text{X}} \rightarrow X\ \overline{\overline{\text{Complement}}}*$	$\overline{\text{N}} \rightarrow \text{N}\ \overline{\overline{\text{P}}}$

X stands for an arbitrary category (the head), '*' for arbitrarily many repetitions

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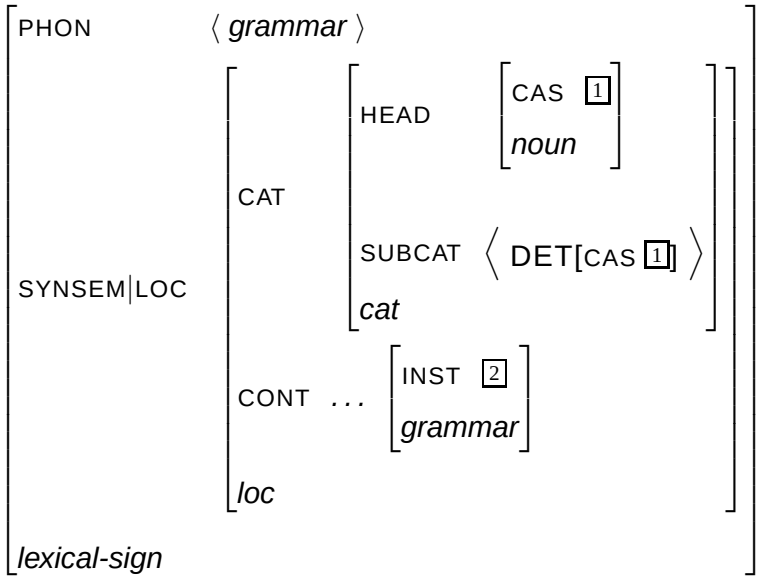
Overall Approach

- Surface-Based
- Monostratal Theory
- Lexicalized (Head-Driven)
- Sign-Based (Saussure, 1915)
- Typed Feature Structures (Lexical Entries, Morphology, Phrases, Principles)
- Multiple Inheritance
  - Phonology
  - Syntax
  - Semantics



Feature Structures

- feature structure
- attribute-value matrix
- feature matrix
- Shieber (1986), Pollard and Sag (1987), Johnson (1988), Carpenter (1992), King (1994)

Def. 1 (Feature Structure—Preliminary Version)
*A feature structure is a set of pairs of the form [*ATTRIBUTE *value].*

ATTRIBUTE *is an element of the set of feature names ATTR.*

The component value *is*

- *atomic (a string)*
- *or again a feature structure.*

Feature Structures – Examples

a simple feature structure:

$$\begin{bmatrix} A1 & W1 \\ A2 & W2 \\ A3 & W3 \end{bmatrix}$$

Feature Structures – Examples

a simple feature structure:

$$\begin{bmatrix} \text{A1} & \textit{W1} \\ \text{A2} & \textit{W2} \\ \text{A3} & \textit{W3} \end{bmatrix}$$

a complex feature structure:

$$\begin{bmatrix} \text{A1} & \textit{W1} \\ \text{A2} & \begin{bmatrix} \text{A21} & \textit{W21} \\ \text{A22} & \begin{bmatrix} \text{A221} & \textit{W221} \\ \text{A222} & \textit{W222} \end{bmatrix} \end{bmatrix} \\ \text{A3} & \textit{W3} \end{bmatrix}$$

An Example

A feature structure that describes a human being:

FIRST-NAME	*max*
SURNAME	*meier*
BIRTHDAY	*10.10.1985*

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Rekursive structurs:

FIRST-NAME	*max*	
SURNAME	*meier*	
BIRTHDAY	*10.10.1985*	
FATHER	FIRST-NAME	*peter*
	SURNAME	*meier*
	BIRTHDAY	*10.05.1960*
	FATHER	*. . .*
	MOTHER	*. . .*
MOTHER	*. . .*	

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Rekursive structurs:

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BIRTHDAY	*10.10.1985*	
FATHER	FIRST-NAME	*peter*
	SURNAME	*meier*
	BIRTHDAY	*10.05.1960*
	FATHER	. . .
	MOTHER	. . .
MOTHER	. . .	

How do we represent the daughters or sons of a human being?

Types

- feature structures are of a certain type
- the type is written in *italics*:

$$\begin{bmatrix} \text{A1} & \textit{W1} \\ \textit{type} & \end{bmatrix}$$

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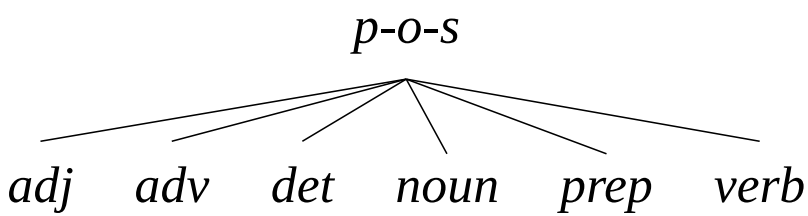
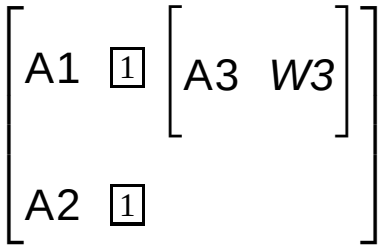
- types are organized in hierarchies
- example: part of speech



Structure Sharing

A1 and A2 are token-identical:



Identity of values is marked by boxes

similar to variables

Structure Sharing

A1 and A2 are token-identical:

$$\begin{bmatrix} \text{A1} & \boxed{1} \begin{bmatrix} \text{A3} & \textit{W3} \end{bmatrix} \\ \text{A2} & \boxed{1} \end{bmatrix}$$

Identity of values is marked by boxes

similar to variables

our agreement example

S $\rightarrow$ NP(Agr), VP(Agr)

rewritten with feature descriptions:

[CAT S] $\rightarrow$ [CAT NP, AGR $\boxed{1}$], [CAT VP, AGR $\boxed{1}$]

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Valence and Grammar Rules: PSG

- huge amount of grammar rules:

VP	→	V	sleep
VP	→	V, NP	love
VP	→	V, PP	talk about
VP	→	V, NP, NP	give X Y
VP	→	V, NP, PP	give Y to X

- verbs have to be used with an appropriate rule
- subcategorization is encoded twice: in rules and in lexical entries

Valence and Grammar Rules: HPSG

- complements are specified as complex categories in the lexical representation of the head
- like Categorial Grammar
- verb subject subcat

  sleep < NP > < >

  love < NP > < NP >

  talk < NP > < PP >

  give < NP > < NP, NP >

  give < NP > < NP, PP >

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- specific rules for head complement combinations:

  V[SUBCAT $\boxed{1}$] $\rightarrow$ V[SUBCAT $\boxed{1} \oplus <\boxed{2}>$] $\boxed{2}$

  N[SUBCAT $\boxed{1}$] $\rightarrow$ N[SUBCAT $\boxed{1} \oplus <\boxed{2}>$] $\boxed{2}$

  A[SUBCAT $\boxed{1}$] $\rightarrow$ A[SUBCAT $\boxed{1} \oplus <\boxed{2}>$] $\boxed{2}$

  P[SUBCAT $\boxed{1}$] $\rightarrow$ P[SUBCAT $\boxed{1} \oplus <\boxed{2}>$] $\boxed{2}$

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  P[SUBCAT $\boxed{1}$] $\rightarrow$ P[SUBCAT $\boxed{1} \oplus <\boxed{2}>$] $\boxed{2}$
- generalized, abstract schema (H = head):

  H[SUBCAT $\boxed{1}$] $\rightarrow$ H[SUBCAT $\boxed{1} \oplus <\boxed{2}>$] $\boxed{2}$

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  – phonological information

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- NP[*nom*] is an abbreviation for a feature description

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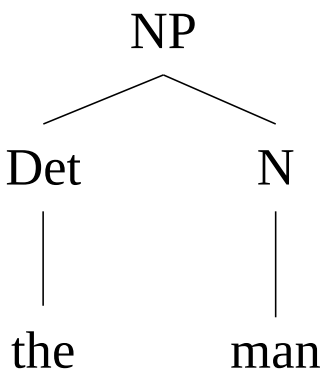
Representation of Grammar Rules (I)

- same description inventory for
  - morphological schemata,
  - lexical entries, and
  - phrasal schemata

  everything is modeled in feature structures
- distinction between immediate dominance and linear precedence
- dominance is encoded in the daughter features of a structure (heads, non-heads)
- precedence is contained implicitly in the PHON value of a sign

Part of the Structure in Feature Structure Representation – PHON Values (I)



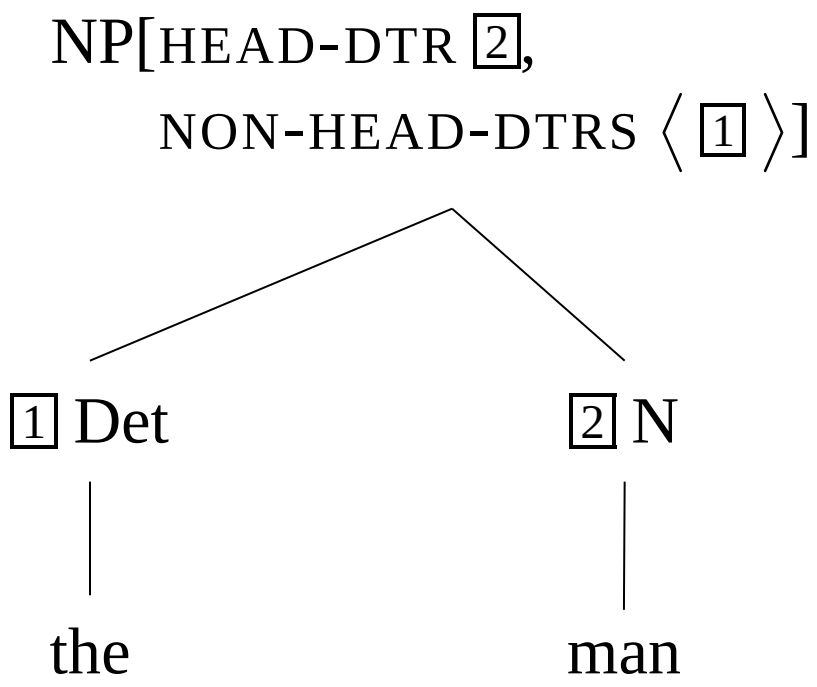
$$\begin{bmatrix} \text{PHON} & \langle\, \textit{the man} \,\rangle \\ \text{HEAD-DTR} & \left[\text{PHON} \langle\, \textit{man} \,\rangle\right] \\ \text{NON-HEAD-DTRS} & \left\langle \left[\text{PHON} \langle\, \textit{the} \,\rangle\right] \right\rangle \end{bmatrix}$$

There is exactly one head daughter (HEAD-DTR).

The head daughter is the daughter that contains the head,
i.e. in a structure with *the* and *picture of Mary* as daughters,
the phrase *picture of Mary* is the head daughter, since *picture* is the head.

NON-HEAD-DTRS is a list of all daughters that do not contain the head.

Tree with DTRS Values (I)



Representation of Grammar Rules (II)

- dominance rule:

Schema 1 (Head Complement Schema (binary branching))

$$\begin{bmatrix} \text{SUBCAT } \boxed{1} \\ \text{HEAD-DTR} \quad \begin{bmatrix} \text{SUBCAT } \boxed{1} \oplus \left\langle \boxed{2} \right\rangle \\ \textit{sign} \end{bmatrix} \\ \text{NON-HEAD-DTRS} \quad \left\langle \boxed{2} \right\rangle \end{bmatrix}$$

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- alternative formulation, similar to $\overline{\text{X}}$ -Schema:

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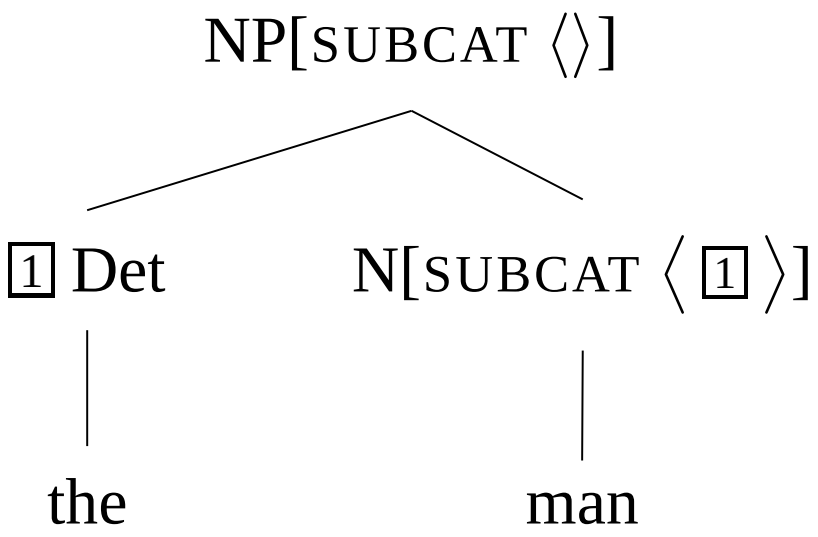
- possible instantiation:

  N[SUBCAT $\boxed{1}$] $\rightarrow$ Det N[SUBCAT $\boxed{1} \oplus <$ Det $>$]

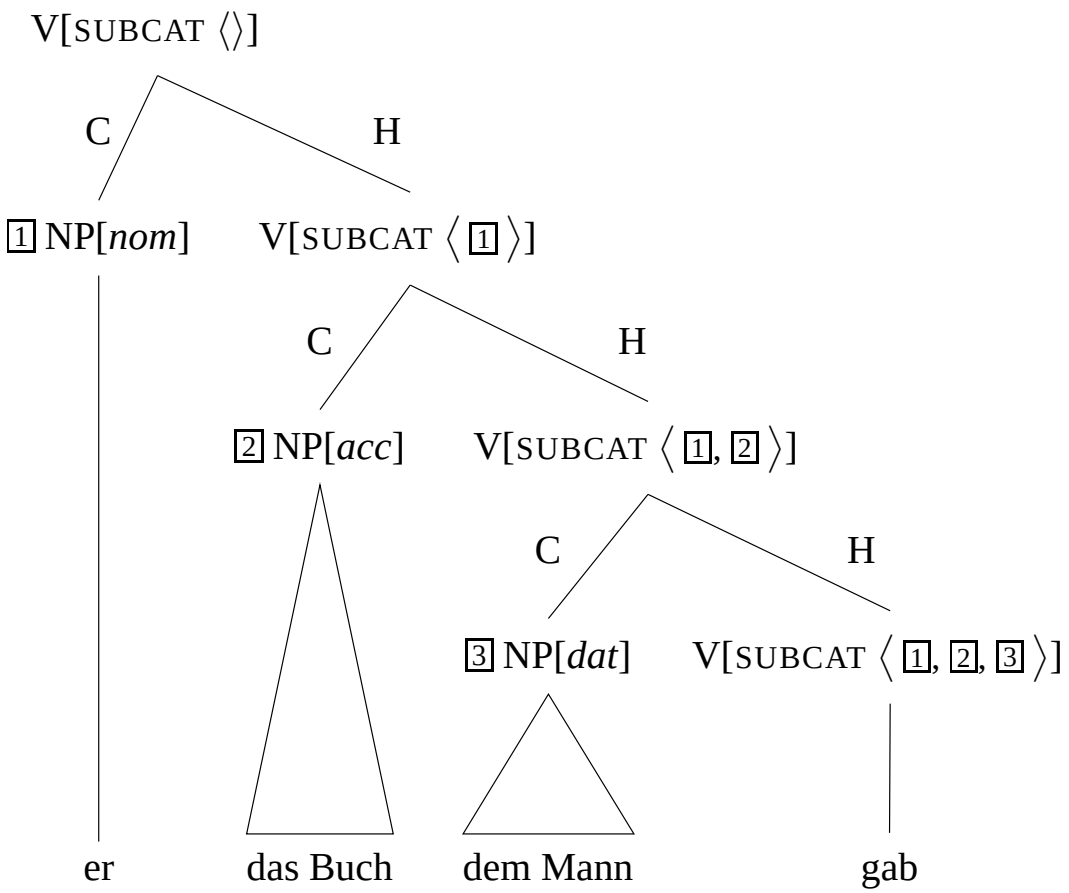
  V[SUBCAT $\boxed{1}$] $\rightarrow$ V[SUBCAT $\boxed{1} \oplus <$ NP[*dat*] $>$] NP[*dat*]

An Example



- Det is selected by *man* (SUBCAT $\left\langle \boxed{1} \right\rangle$).
- The complete NP has an empty valence list (SUBCAT ⟨⟩).

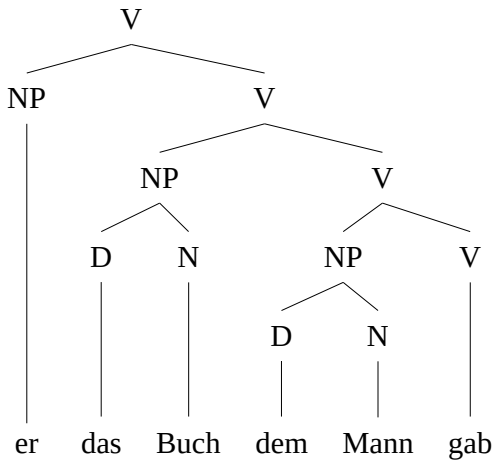
A More Complex Example



Binary Branching Head Complement Structure for ‘He gave the man the book.’

H = Head, C = Complement (= Non-Head)

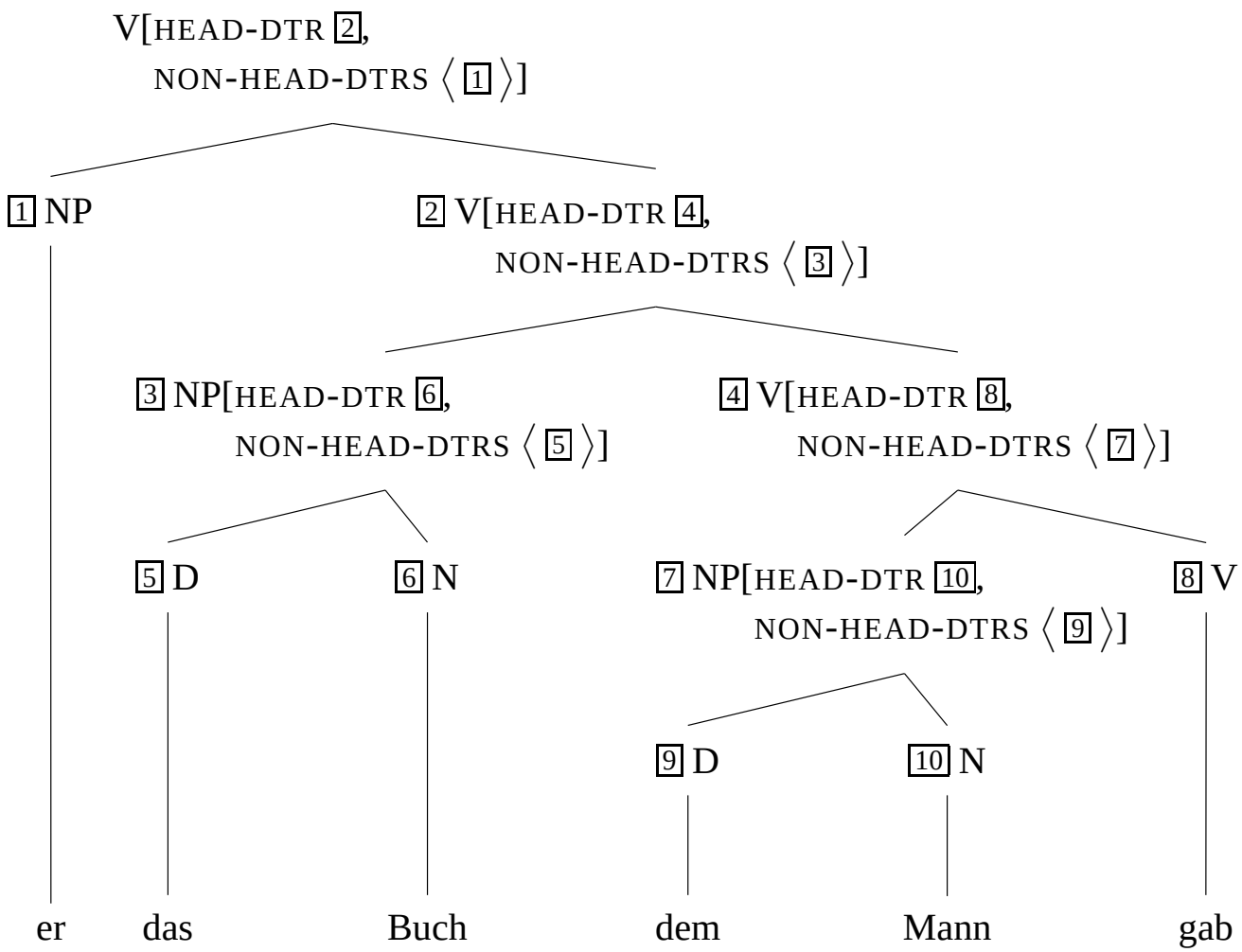
Representation with Feature Structure – PHON Values (II)



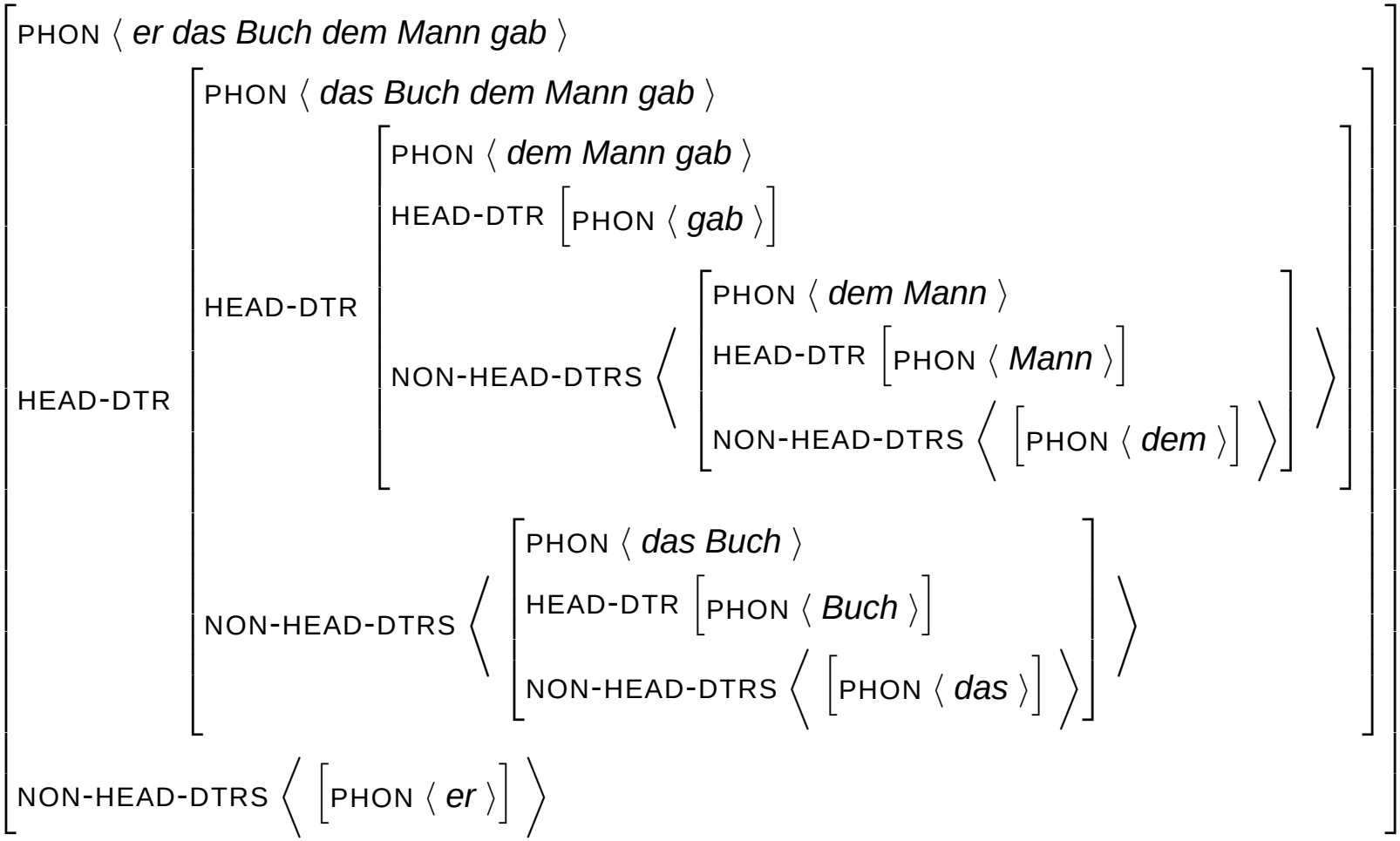
$$\begin{bmatrix} \text{PHON} & \langle\, \textit{dem Mann gab} \,\rangle \\ \text{HEAD-DTR} & \left[\text{PHON} \langle\, \textit{gab} \,\rangle\right] \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{PHON} & \langle\, \textit{dem Mann} \,\rangle \\ \text{HEAD-DTR} & \left[\text{PHON} \langle\, \textit{Mann} \,\rangle\right] \\ \text{NON-HEAD-DTRS} & \left\langle \left[\text{PHON} \langle\, \textit{dem} \,\rangle\right] \right\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

part of the feature structure for *dem Mann gab* (‘the man gave’) as it appears in *er das Buch dem Mann gab* (‘He gave the book to the man.’)

Tree with DTRS Values (II)



Representation with Feature Structure – PHON values (III)



Representation in Feature Structures (Part)

$$\left[\begin{array}{l}
\textsc{phon} \langle \textit{dem Mann, gab} \rangle \\
\textsc{subcat} \boxed{1} \left\langle \text{NP}[\textit{nom}], \text{NP}[\textit{acc}] \right\rangle \\
\textsc{head-dtr} \left[\begin{array}{l} \textsc{phon} \langle \textit{gab} \rangle \\ \textsc{subcat} \boxed{1} \oplus \left\langle \boxed{2} \right\rangle \end{array}\right] \\
\textsc{non-head-dtrs} \left\langle \boxed{2} \left[\begin{array}{l} \textsc{phon} \langle \textit{dem Mann} \rangle \\ \textsc{p-o-s} \textit{ noun} \\ \textsc{subcat} \langle\rangle \\ \textsc{head-dtr} \ldots \\ \textsc{non-head-dtrs} \ldots \\ \textit{head-complement-structure} \end{array}\right] \right\rangle \\
\textit{head-complement-structure}
\end{array}\right]$$

Representation in Feature Structures (Part)

$$\left[\begin{array}{l}
\textsc{phon} \langle \textit{er, das Buch, dem Mann, gab} \rangle \\
\textsc{subcat} \boxed{1} \\
\textsc{head-dtr} \left[\begin{array}{l} \textsc{phon} \langle \textit{das Buch, dem Mann, gab} \rangle \\ \textsc{subcat} \boxed{1} \langle\rangle \oplus \left\langle \boxed{2} \right\rangle \\ \textit{head-complement-structure} \end{array}\right] \\
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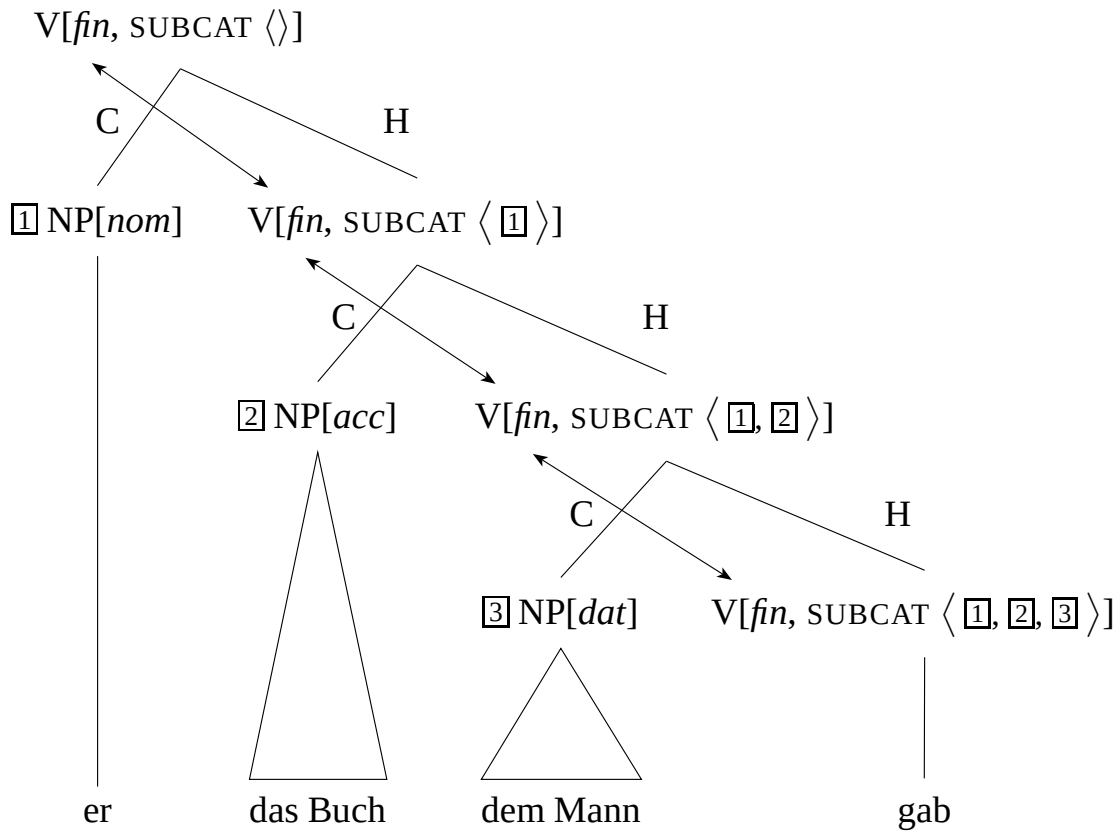
Projection of Head Properties



- head is the finite verb
- finiteness of the verb is marked morphologically (*gab* = *gave*)
- information about finiteness and part of speech is needed at the top node → projection

Representation in Feature Descriptions: the HEAD Value

- possible feature geometry:

$$\begin{bmatrix} \text{PHON} & \textit{list of phonemes} \\ \text{P-O-S} & \textit{p-o-s} \\ \text{VFORM} & \textit{vform} \\ \text{SUBCAT} & \textit{list} \end{bmatrix}$$

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- more structure, grouping information together for projection:

$$\begin{bmatrix} \text{PHON} & \textit{list of phonemes} \\ \text{HEAD} & \begin{bmatrix} \text{P-O-S} & \textit{p-o-s} \\ \text{VFORM} & \textit{vform} \end{bmatrix} \\ \text{SUBCAT} & \textit{list} \end{bmatrix}$$

Different Heads Project Different Features

- VFORM is appropriate only for verbs
- adjectives and nouns project case
- possability: one structure with all features:

$$\begin{bmatrix} \text{P-O-S} & \textit{p-o-s} \\ \text{VFORM} & \textit{vform} \\ \text{CASE} & \textit{case} \end{bmatrix}$$

  for verbs *case* is not filled in

  for nouns *vform* is not filled in

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- better solution: different types of feature structures
  - for verbs

$$\begin{bmatrix} \text{VFORM} & \textit{vform} \\ \textit{verb} & \end{bmatrix}$$

  - for nouns

$$\begin{bmatrix} \text{CASE} & \textit{case} \\ \textit{noun} & \end{bmatrix}$$

A Lexical Entry with Head Features

- a lexical entry consists of:

  gibt (‘gives’ finite form):

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  – head information (part of speech, verb form, . . .)

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  – phonological information
  – head information (part of speech, verb form, . . .)
  – valence information: a list of feature descriptions

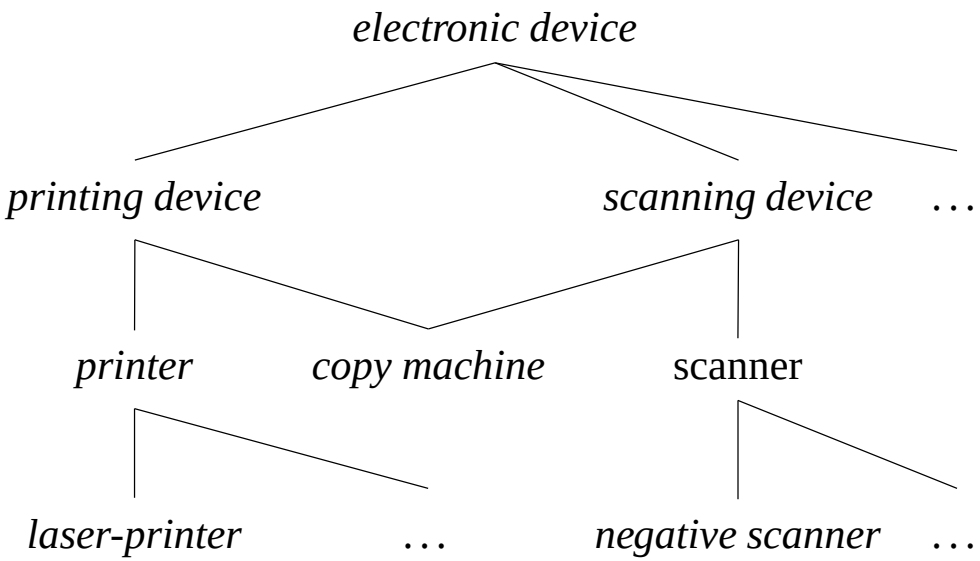
Head Feature Principle (HFP)

- In a headed structure the head features of the mother are token-identical to the head features of the head daughter.

  headed-structure →
  $$\begin{bmatrix} \text{HEAD } \boxed{1} \\ \\ \text{HEAD-DTR} \mid \text{HEAD } \boxed{1} \end{bmatrix}$$

- encoding of principles in the type hierarchy:
  Krieger (1994) and Sag (1997)
- *head-complement-structure* inherits constraints of *headed-structure*

Types: A Non-Linguistic Example for Multiple Inheritance



properties of and constraints on types are inherited from supertypes

possible to capture generalizations: general constraints are stated at high types

more special types inherit this information from their supertypes

nonredundant representation of information

Linguistic Generalizations in the Type Hierarchy

- types are arranged in a hierarchy
- the most general type is at the top
- information about properties of an object of a certain type are specified in the definition of the type
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Linguistic Generalizations in the Type Hierarchy

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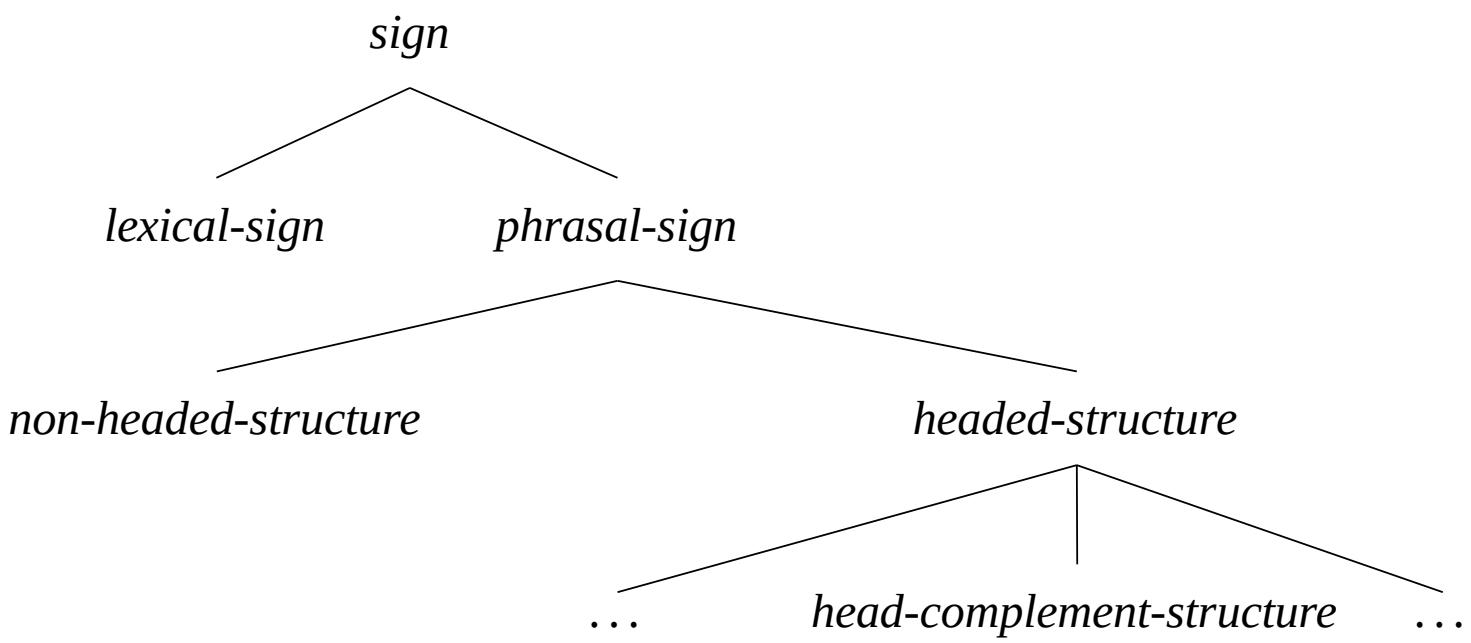
- example: entry in an encyclopedia. references to superconcepts, no repetition of the information that is stated at the superconcept already
- the upper part of a type hierarchy is relevant for all languages (Universal Grammar)
- more specific types may be specific for classes of languages or for one particular language

Type Hierarchy for *sign*



all subtypes of *headed-structure* inherit the constraints

Constraints on the Type *head-complement-structure*

head-complement-structure $\rightarrow$

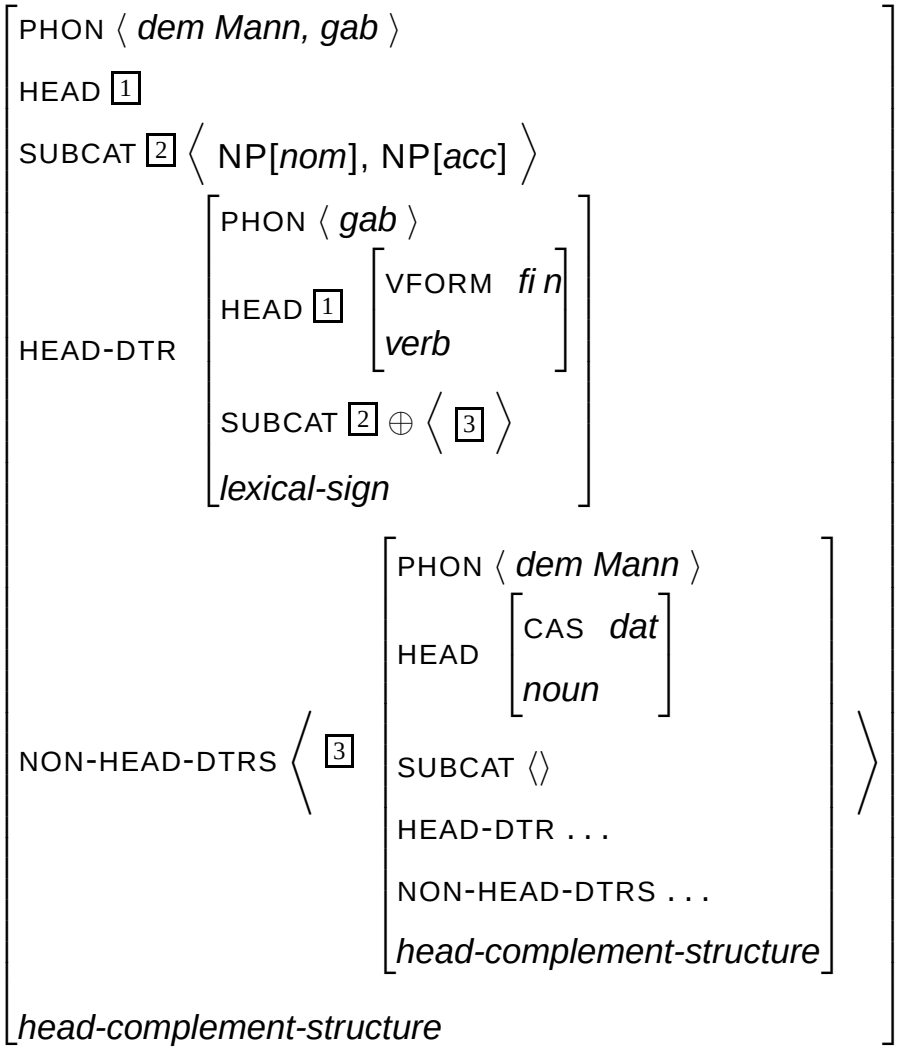
$$\left[\begin{array}{ll} \text{SUBCAT } \boxed{1} & \\ \text{HEAD-DTR} & \left[\begin{array}{l} \text{SUBCAT } \boxed{1} \oplus \left\langle \boxed{2} \right\rangle \\ \textit{sign} \end{array}\right] \\ \text{NON-HEAD-DTRS} & \left\langle \boxed{2} \right\rangle \end{array}\right]$$

Head Complement Schema + Head Feature Principle

$$\begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{SUBCAT} & \boxed{2} \\ \text{HEAD-DTR} & \begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{SUBCAT} & \boxed{2} \oplus \langle \boxed{3} \rangle \end{bmatrix} \\ \text{NON-HEAD-DTRS} & \langle \boxed{3} \rangle \end{bmatrix}$$

Type *head-complement-structure* with information inherited from *headed-structure*

Head Complement Structure with Head Information Shared



Outline

- Phrase Structure Grammars and Features
- The Formalism
- Valence and Grammar Rules
- Complementation
- **Semantics**
- Adjunction
- Nonlocal Dependencies
- Relative Clauses

Semantics

- Pollard and Sag (1987) and Ginzburg and Sag (2001) assume Situation Semantics (Barwise and Perry, 1983; Cooper, Mukai and Perry, 1990; Devlin, 1992)

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- some recent publications use Minimal Recursion Semantics (Copestake, Flickinger and Sag, 1997)
- I will use Situation Semantics.

Individuals, Circumstances and Situations

- persistent things that belong to the causal order of the world, objects that we can track perceptually and affect by acting upon them: individuals (*Karl*, *the woman*, *the fear*, *the promise*)

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- known facts: relations and properties (properties = relations with arity one)
  - zero: *rain*
  - one: *die*
  - two: *love*
  - three: *give*
  - four: *buy*

Individuals, Circumstances and Situations

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  - zero: *rain*
  - one: *die*
  - two: *love*
  - three: *give*
  - four: *buy*
- semantic roles: Fillmore (1968, 1977), Kunze (1991)
  AGENT, PATIENT, EXPERIENCER, SOURCE, GOAL, THEME, LOCATION, TRANS-OBJ, INSTRUMENT, MEANS, and PROPOSITION
- roles are needed in order to capture generalizations: linking

Parameterized State of Affairs

- State of Affairs: *state of affairs* (*soa*)
- Verb: $\ll beat, agent : X, patient : Y; 1 \gg$
- Adjective: $\ll red, theme : X; 1 \gg$
- Noun: $\ll man, instance : X; 1 \gg$

- parameterized state of affairs (*psoa*)
- Verb

  (7) The man beats the dog.

  $\ll beat, agent : X, patient : Y; 1 \gg$
  $X | \ll man, instance : X; 1 \gg,$
  $Y | \ll dog, instance : Y; 1 \gg$

- Adjective

  (8) The girl is smart.

  $\ll smart, theme : X; 1 \gg$
  $X | \ll girl, instance : X; 1 \gg$

Circumstances and Feature Structure Representations

$\ll beat, agent : X, patient : Y; 1 \gg$

$$\begin{bmatrix} \text{AGENT} & X \\ \text{PATIENT} & Y \\ beat & \end{bmatrix}$$

$\ll man, instance : X; 1 \gg$

$$\begin{bmatrix} \text{INST} & X \\ man & \end{bmatrix}$$

$\ll woman, instance : X; 0 \gg$

$$\begin{bmatrix} \text{ARG} & \begin{bmatrix} \text{INST} & X \\ woman & \end{bmatrix} \\ neg & \end{bmatrix}$$

Representation in Feature Descriptions: the CONT value

- possible feature geometry (CONT = CONTENT):

$$\begin{bmatrix} \text{PHON} & \textit{list of phonemes} \\ \text{HEAD} & \textit{head} \\ \text{SUBCAT} & \textit{list} \\ \text{CONT} & \textit{cont} \end{bmatrix}$$

- more structure, separation of syntactic and semantic information (CAT = CATEGORY)

$$\begin{bmatrix} \text{PHON} & \textit{list of phonemes} \\ \text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{head} \\ \text{SUBCAT} & \textit{list} \\ & \textit{cat} \end{bmatrix} \\ \text{CONT} & \textit{cont} \end{bmatrix}$$

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- $\rightarrow$ sharing of syntactic information can be expressed easily
- example: symmetric coordination: the CAT values of conjuncts are identical

(9) a. the man and the woman

b. He knows and loves this record.

c. He is stupid and arrogant.

The Semantic Contribution of Nominal Objects

- Index (like discourse referents in DRT (Kamp and Reyle, 1993))
- Restrictions

$$\begin{bmatrix} \text{PHON} & \langle \textit{book} \rangle \\ \text{CAT} & \begin{bmatrix} \text{HEAD} & [\textit{noun}] \\ \text{SUBCAT} & \langle \text{DET} \rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{neu} \end{bmatrix} \\ \text{RESTR} & \left\{ \begin{bmatrix} \text{INST} & \boxed{1} \\ \textit{book} & \end{bmatrix} \right\} \end{bmatrix} \end{bmatrix}$$

- person, number, and gender are important for resolving references:

(10) a. The woman$_i$ bought a table$_j$. She$_i$ likes it$_j$.

b. Die Frau$_i$ hat einen Tisch$_j$ gekauft. Sie$_i$ mag ihn$_j$.

Abbreviations

$$\mathrm{NP}_{[3,sg,fem]} \quad \begin{bmatrix} \mathrm{CAT} & \begin{bmatrix} \mathrm{HEAD} & [noun] \\ \mathrm{SUBCAT} & \langle\rangle \end{bmatrix} \\ \mathrm{CONT}|\mathrm{IND} & \begin{bmatrix} \mathrm{PER} & 3 \\ \mathrm{NUM} & sg \\ \mathrm{GEN} & fem \end{bmatrix} \end{bmatrix}$$

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$$\mathrm{NP}_{\boxed{1}} \quad \begin{bmatrix} \mathrm{CAT} & \begin{bmatrix} \mathrm{HEAD} & [noun] \\ \mathrm{SUBCAT} & \langle\rangle \end{bmatrix} \\ \mathrm{CONT} & \begin{bmatrix} \mathrm{IND} & \boxed{1} \end{bmatrix} \end{bmatrix}$$

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$\mathrm{NP}_{\boxed{1}}$ $\begin{bmatrix} \mathrm{CAT} & \begin{bmatrix} \mathrm{HEAD} & [noun] \\ \mathrm{SUBCAT} & \langle\rangle \end{bmatrix} \\ \mathrm{CONT} & \begin{bmatrix} \mathrm{IND} & \boxed{1} \end{bmatrix} \end{bmatrix}$

$\overline{\mathrm{N}}$: $\boxed{1}$ $\begin{bmatrix} \mathrm{CAT} & \begin{bmatrix} \mathrm{HEAD} & [noun] \\ \mathrm{SUBCAT} & \langle\, \mathrm{DET} \,\rangle \end{bmatrix} \\ \mathrm{CONT} & \boxed{1} \end{bmatrix}$

The Feature Structure Representation of Circumstances

$\ll beat, agent : X, patient : Y; 1 \gg$
$X \mid \ll man, instance : X; 1 \gg,$
$Y \mid \ll dog, instance : Y; 1 \gg$

$$\begin{bmatrix} \text{AGENT} & \boxed{1} \\ \text{PATIENT} & \boxed{2} \\ \textit{beat} & \end{bmatrix}$$

$$\begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{mas} \end{bmatrix} \\ \text{RESTR} & \left\{ \begin{bmatrix} \text{INST} & \boxed{1} \\ \textit{man} & \end{bmatrix} \right\} \end{bmatrix}$$

$$\begin{bmatrix} \text{IND} & \boxed{2} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{neu} \end{bmatrix} \\ \text{RESTR} & \left\{ \begin{bmatrix} \text{INST} & \boxed{2} \\ \textit{dog} & \end{bmatrix} \right\} \end{bmatrix}$$

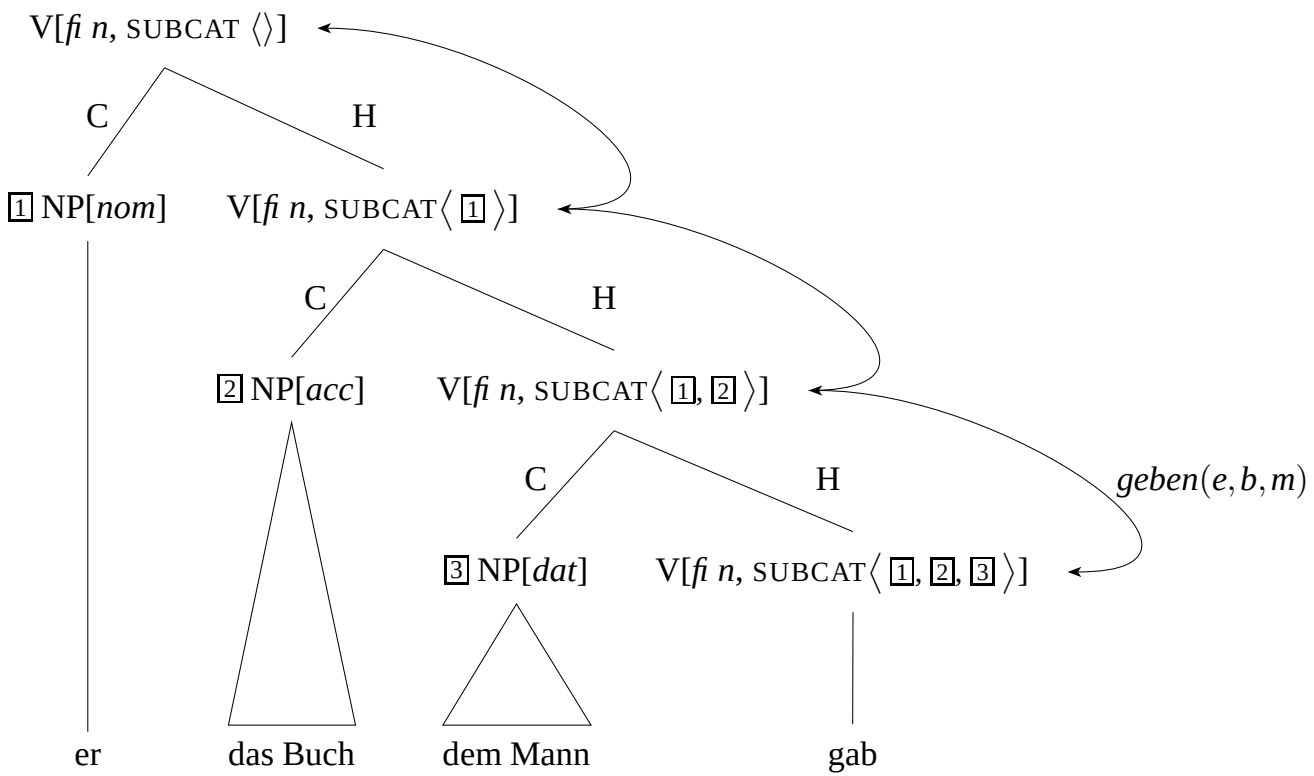
Representation in Feature Descriptions and Linking

- linking between valence and semantic contribution
- type-based
- various valance/linking patterns

gibt (finite Form):

$$\begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{VFORM} & \textit{fin} \\ & \textit{verb} \end{bmatrix} \\ \text{SUBCAT} & \langle \text{NP}[\textit{nom}]\boxed{1}, \text{NP}[\textit{acc}]\boxed{2}, \text{NP}[\textit{dat}]\boxed{3} \rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{AGENT} & \boxed{1} \\ \text{THEME} & \boxed{2} \\ \text{GOAL} & \boxed{3} \\ & \textit{geben} \end{bmatrix} \end{bmatrix}$$

Projection of the Semantic Contribution of the Head



Semantics Principle (preliminary version)

In headed structures the content of the mother is identical to the content of the head daughter.

Head Complement Schema + HFP + SemP

$$\left[\begin{array}{l} \text{CAT} \left[\begin{array}{l} \text{HEAD} \quad \boxed{1} \\ \text{SUBCAT} \quad \boxed{2} \end{array}\right] \\ \text{CONT} \ \boxed{3} \\ \text{HEAD-DTR} \left[\begin{array}{l} \text{CAT} \quad \left[\begin{array}{l} \text{HEAD} \quad \boxed{1} \\ \text{SUBCAT} \quad \boxed{2} \oplus \left\langle \boxed{4} \right\rangle \end{array}\right] \\ \text{CONT} \ \boxed{3} \end{array}\right] \\ \text{NON-HEAD-DTRS} \left\langle \boxed{4} \right\rangle \end{array}\right]$$

type *head-complement-structure* with information that is inherited from *headed-structure* and Semantics Principle

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Complements vs. Adjuncts

Examples for adjuncts:

adjectives	a *smart* woman
relative clauses	the man, *who Kim loves*,
	the man, *who loves Kim*,
Adverbs	Karl snores *loudly*.

- adjuncts do not fill a semantic role

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	the man, *who loves Kim*,
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- adjuncts do not fill a semantic role
- adjuncts are optional
- adjuncts can be iterated (11a), complements cannot (11b)

(11) a. a smart beautiful woman

b. * The man the man sleeps.

Adjunction

- adjunct selects head via MODIFIED (MOD)

  (12) the red book

$$\begin{bmatrix} \text{PHON} & \langle \textit{red} \rangle \\ \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{MOD} & \overline{\text{N}} \\ \textit{adj} & \end{bmatrix} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \end{bmatrix}$$

- adjectives select an almost saturated (SUBCAT $\left\langle \text{DET} \right\rangle$) nominal projection
- elements that do not modify other elements have the MOD value *none*

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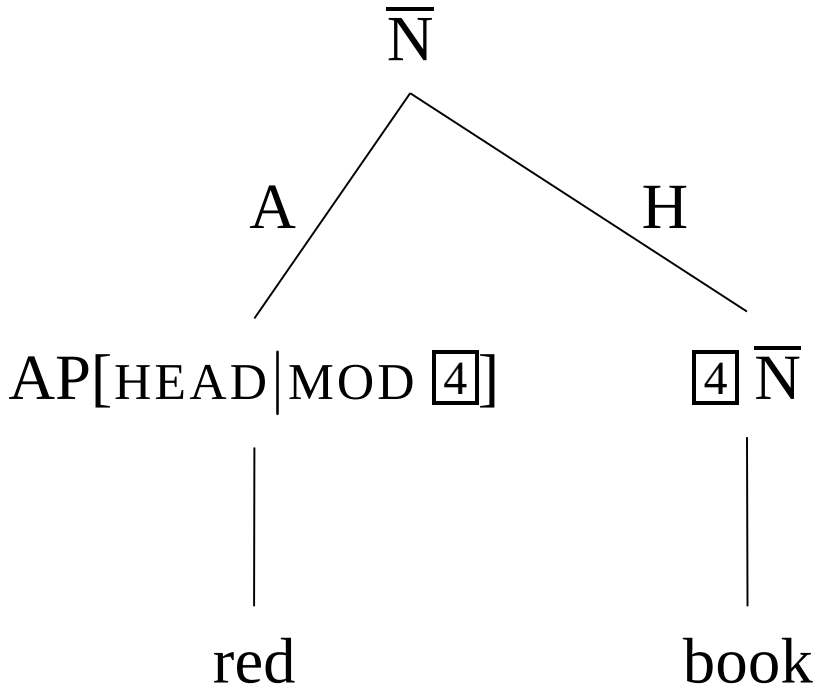
- adjectives select an almost saturated (SUBCAT $\left\langle \text{DET} \right\rangle$) nominal projection
- elements that do not modify other elements have the MOD value *none*
- alternative:
  head contains description of all possible adjuncts (Pollard and Sag, 1987)
  problematic because of iteratability (Pollard and Sag, 1994)

Head Adjunct Structure (Selection)



H = Head, A = Adjunct (= Non-Head)

Schema 2 (Head Adjunct Schema (preliminary version))

head-adjunct-structure →

$$\begin{bmatrix} \text{HEAD-DTR} & \boxed{1} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD}\,|\,\text{MOD} & \boxed{1} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

- the value of the selection feature of the adjunct (1) gets identified with the head daughter

Schema 2 (Head Adjunct Schema (preliminary version))

head-adjunct-structure →

$$\begin{bmatrix} \text{HEAD-DTR} & \boxed{1} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD}\,|\,\text{MOD} & \boxed{1} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

- the value of the selection feature of the adjunct (1) gets identified with the head daughter
- the adjunct must be saturated (SUBCAT $\langle\rangle$):

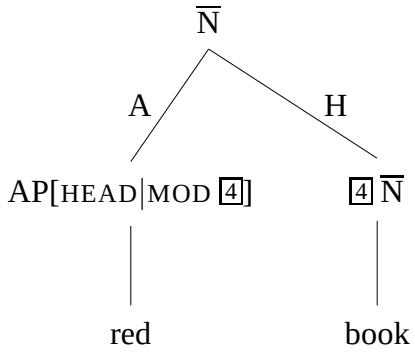
(13) a. the sausage in the cupboard

b. * the sausage in

Why is MOD a Head Feature?

- like adjectives, prepositional phrases can modify
- adjuncts must be saturated in order to be able to modify
- the feature that selects the head to be modified has to be present at the maximal projection of the adjunct
- P + NP = PP
  PP modifies $\overline{\text{N}}$
- MOD has to be present in the lexicon (P) and at a phrasal level (PP)
  project it explicitely or put it in a place that is projected anyway
  $\rightarrow$ head feature

The Semantic Contribution in Head Adjunct Structures



- From where does the semantic representation at the mother node come?
- the meaning of *book* is fixed: book(X)
- possibility: projection of meaning representation of both daughters
- *red* (red(X)) + *book* (book(Y)) = red(X) & book(X)

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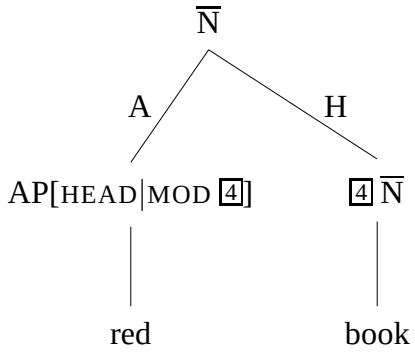


- From where does the semantic representation at the mother node come?
- the meaning of *book* is fixed: book(X)
- possibility: projection of meaning representation of both daughters
- *red* (red(X)) + *book* (book(Y)) = red(X) & book(X)
- but:

  (14) the alleged murderer

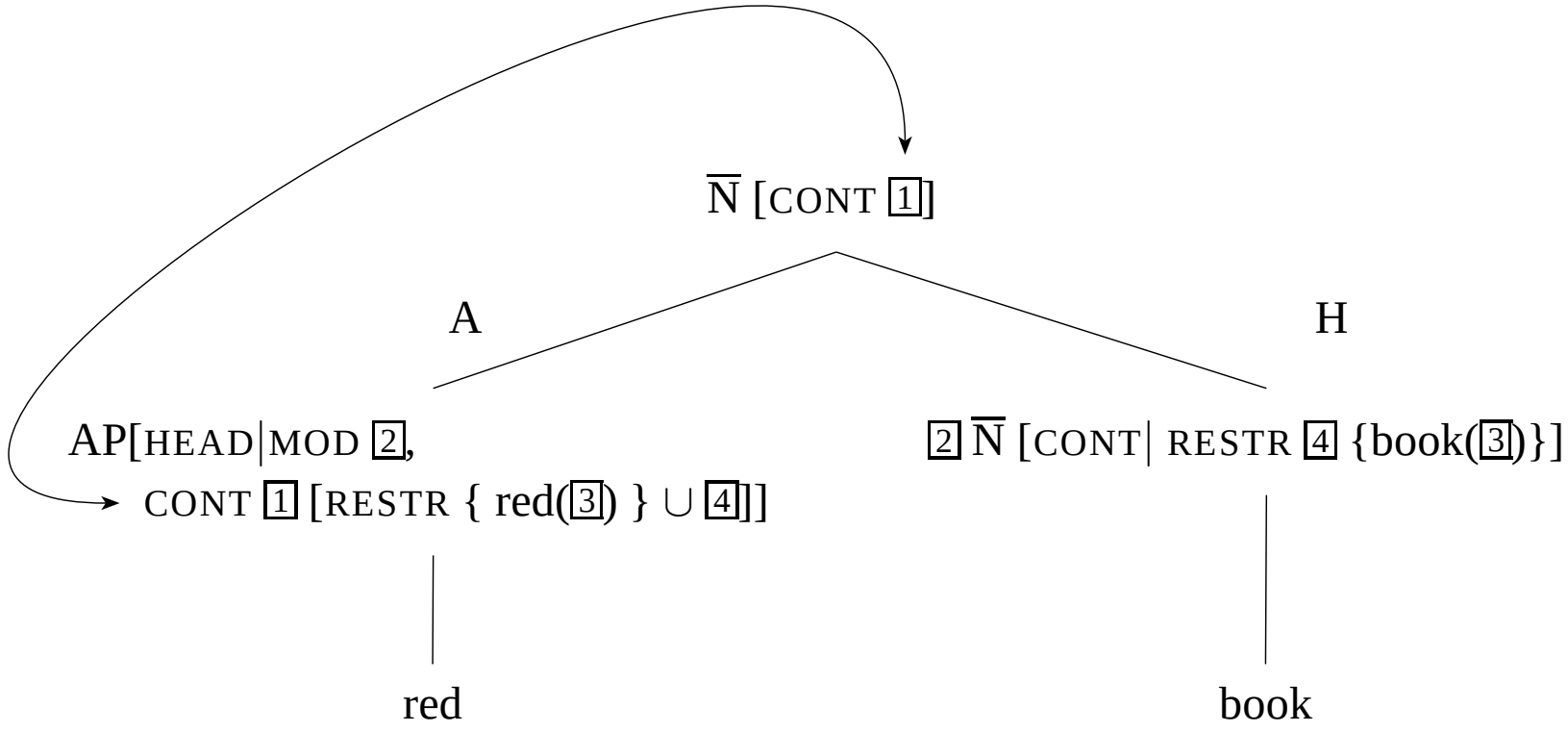
  alleged (alleged(X)) + *murderer* (murderer(Y)) $\neq$ alleged(X) & murderer(X)

- alternative: representation of the meaning at the adjunct:

  The meaning of the mother node is encoded in the lexical entry for *red* and *alleged*.

  The meaning of the modified head is integrated into the meaning of the modifier.

Head Adjunct Structures (Selection and Semantics)



- the head adjunct schema identifies the head with the MOD value of the adjunct daughter (2)
- modifier has the meaning of the complete expression under CONT: { red(3) } ∪ 4
- semantic contribution of the phrase is projected from the modifier (1)

Entry of the Adjective with Semantic Contribution

$$\begin{bmatrix}
\text{PHON} & \langle \textit{red} \rangle \\
\text{CAT} & \begin{bmatrix}
\text{HEAD} & \begin{bmatrix} \text{MOD} & \overline{\text{N}}\text{:} \begin{bmatrix} \text{IND} & \boxed{1} \\ \text{RESTR} & \boxed{2} \end{bmatrix} \\ & \textit{adj} \end{bmatrix} \\
\text{SUBCAT} & \langle\rangle
\end{bmatrix} \\
\text{CONT} & \begin{bmatrix}
\text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \end{bmatrix} \\
\text{RESTR} & \left\{ \begin{bmatrix} \text{THEME} & \boxed{1} \\ \textit{red} \end{bmatrix} \right\} \cup \boxed{2}
\end{bmatrix}
\end{bmatrix}$$

- adjective selects noun to be modifi ed via MOD →
  adjective can access CONT value of the noun (index and restrictions) →
  adjective may include restrictions (2) into its own semantic contribution
  identifi cation of indices (1) ensures that adjective and noun refer to the same discourse referent
- semantic contribution of the complete structure is projected from the adjunct

The Result of the Combination

$$\begin{bmatrix}
\text{PHON} & \langle \textit{red book} \rangle \\
\text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{noun} \end{bmatrix} \\ \text{SUBCAT} & \left\langle \text{DET} \right\rangle \end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{neu} \end{bmatrix} \\ \text{RESTR} & \left\{ \begin{bmatrix} \text{THEME} & \boxed{1} \\ \textit{red} & \end{bmatrix}, \begin{bmatrix} \text{INST} & \boxed{1} \\ \textit{book} & \end{bmatrix} \right\} \end{bmatrix}
\end{bmatrix}$$

meaning of *red book* is not represented in *book* but in the adjective → projection of the semantic contribution form the adjunct

Projection of the Meaning in Head Adjunct Structures

head-adjunct-structure →

$$\begin{bmatrix} \text{CONT} & \boxed{1} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{CONT} & \boxed{1} \end{bmatrix} \right\rangle \end{bmatrix}$$

The Complete Head Adjunct Schema

Schema 3 (Head Adjunct Schema)

head-adjunct-structure →

$$\begin{bmatrix} \text{CONT} & \boxed{1} \\ \text{HEAD-DTR} & \boxed{2} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD}\vert\text{MOD} & \boxed{2} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{CONT} & \boxed{1} \end{bmatrix} \right\rangle \end{bmatrix}$$

The Semantics Principle

In headed structures which are not head adjunct structures, the semantic contribution of the mother is identical to the semantic contribution of the head daughter.

head-non-adjunct-structure → $\begin{bmatrix} \text{CONT} & \boxed{1} \\ \text{HEAD-DTR}\,|\,\text{CONT} & \boxed{1} \end{bmatrix}$

In head adjunct structures, the semantic contribution of the mother is identical to the semantic contribution of the adjunct daughter.

head-adjunct-structure → $\begin{bmatrix} \text{CONT} & \boxed{1} \\ \text{NON-HEAD-DTRS} & \left\langle \left[\text{CONT} \; \boxed{1} \right] \right\rangle \end{bmatrix}$

Headed structures (*headed-structure*) are subtypes of either *head-non-adjunct-structure* or *head-adjunct-structure*.

Valence in Head Adjunct Structures

book has the same valence like *red book*: a determiner is missing

adjunction does not change valence

valence information at the mother node is identical to the valence information of the head daughter

formal:

$$\begin{bmatrix} \text{CAT}|\text{SUBCAT } \boxed{1} \\ \text{HEAD-DTR}|\text{CAT}|\text{SUBCAT } \boxed{1} \\ \textit{head-non-complement-structure} \end{bmatrix}$$

In structures of type *head-non-complement-structure*, no argument gets saturated. The subcat value of the mother is identical to the subcat value of the head daughter.

Valence in Head Adjunct Structures

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In structures of type *head-non-complement-structure*, no argument gets saturated. The subcat value of the mother is identical to the subcat value of the head daughter.

Remark:
head-non-complement-structure and *head-complement-structure* have a complementary distribution in the type hierarchy.

I. e., all structures of type *headed-structure* that are not of type *head-complement-structure* are of type *head-non-complement-structure*.

Subcat Principle

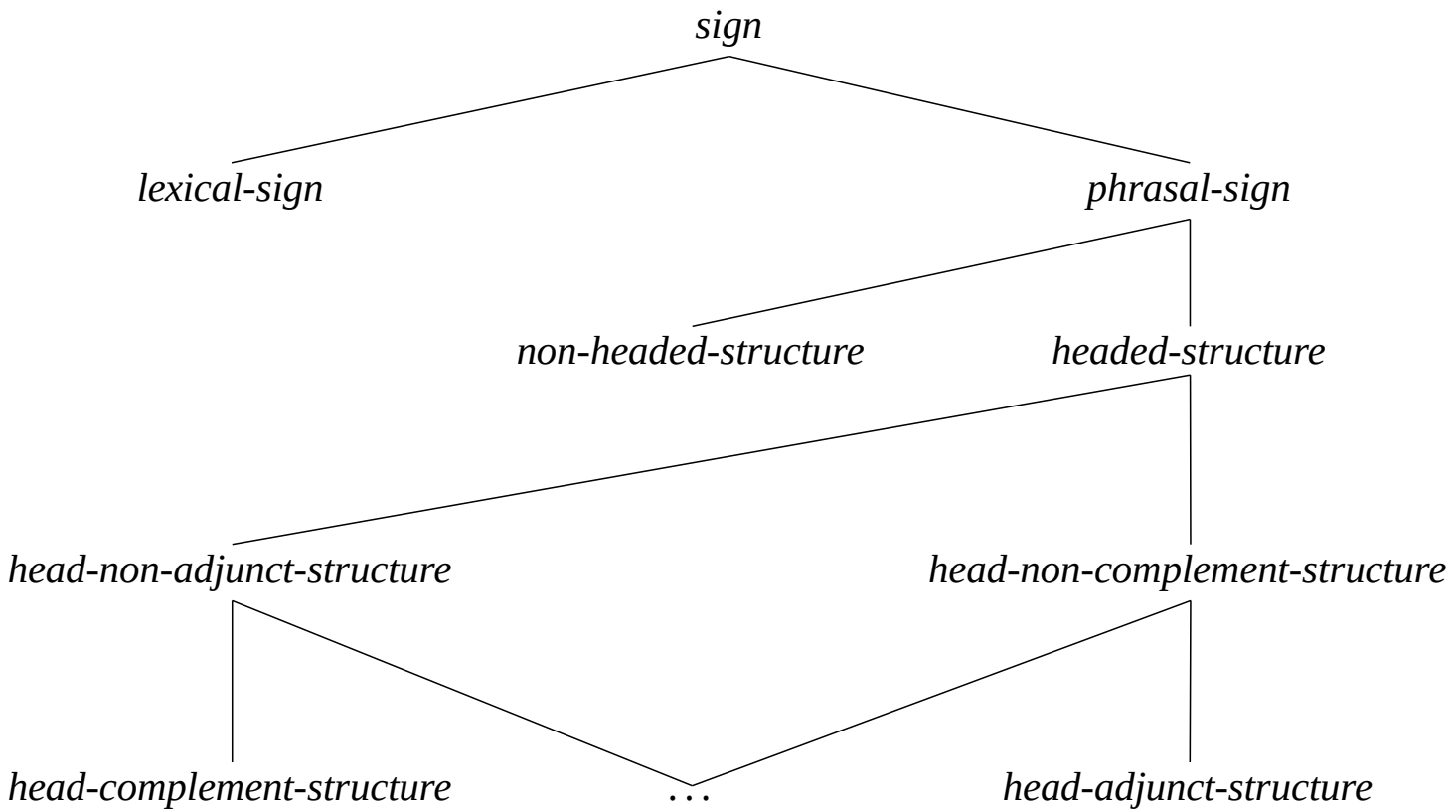
In headed structures the subcat list of the mother is the subcat list of the head daughter minus the complements that were realized as complement daughters.

$$\textit{head-complement-structure} \rightarrow \begin{bmatrix} \text{CAT}|\text{SUBCAT } \boxed{1} \\ \text{HEAD-DTR}|\text{CAT}|\text{SUBCAT } \boxed{1} \oplus \boxed{2} \\ \text{NON-HEAD-DTRS } \boxed{2}\ \textit{ne-list} \end{bmatrix}$$

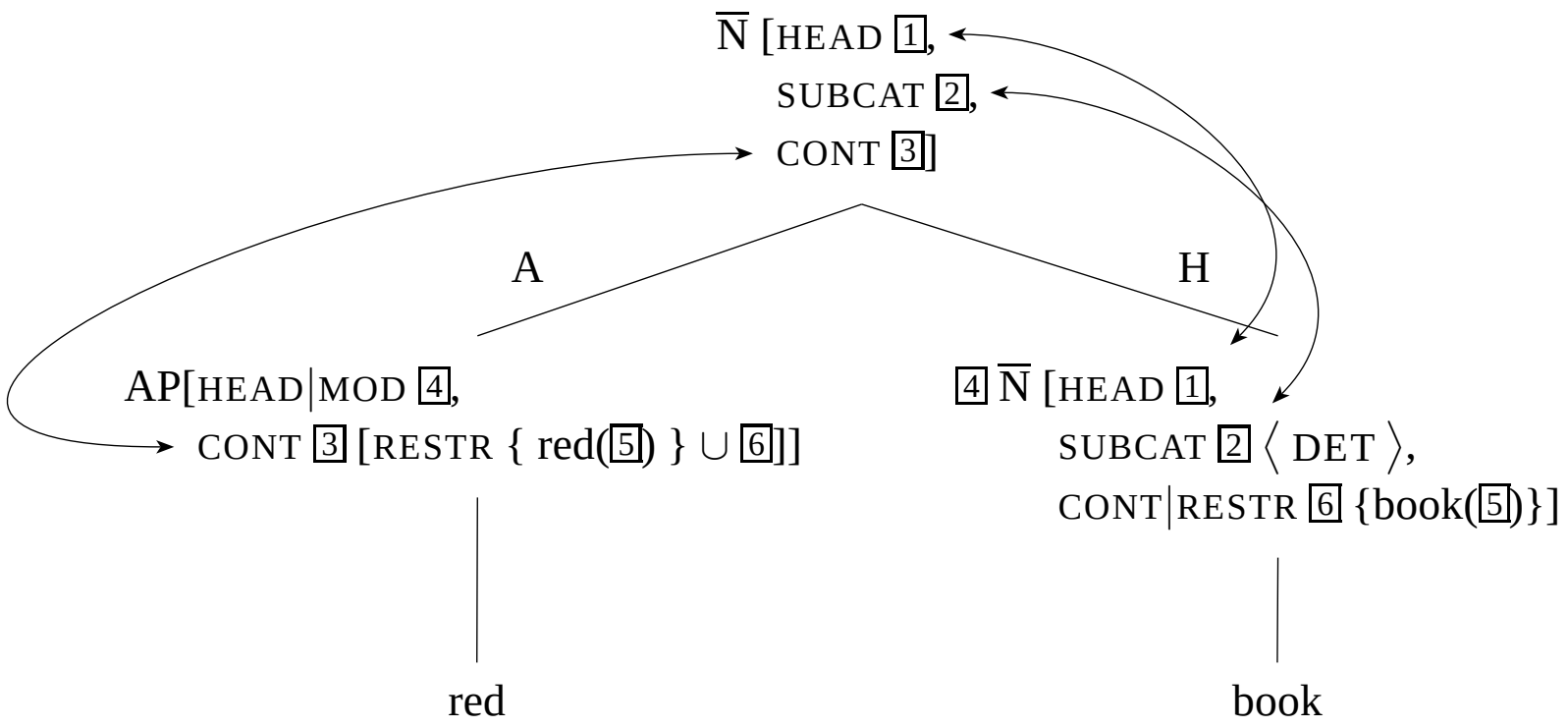
$$\textit{head-non-complement-structure} \rightarrow \begin{bmatrix} \text{CAT}|\text{SUBCAT } \boxed{1} \\ \text{HEAD-DTR}|\text{CAT}|\text{SUBCAT } \boxed{1} \end{bmatrix}$$

Structures with head (*headed-structure*) are subtypes of either *head-complement-structure* or *head-non-complement-structure*.

Type Hierarchy for *sign*



Head Adjunct Structure (Selection, Semantics, HFP, . . .)



The Locality of Selection

- with the present feature geometry, a head can access phonological form and internal structure of complements
- head may say: I want something that has a daughter with a PHON value *man*
- this possability should be excluded → modification in the feature geometry
- all features that can be selected are grouped together
- both syntactic and semantic information can be selected

The Locality of Selection: The Data Structure

- data structure of headed phrasal signs which we have now:

$$\begin{bmatrix} \text{PHON} & \textit{list of phonemes} \\ \text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{head} \\ \text{SUBCAT} & \textit{list} \\ & \textit{cat} \end{bmatrix} \\ \text{CONT} & \textit{cont} \\ \text{HEAD-DTR} & \textit{sign} \\ \text{NON-HEAD-DTRS} & \textit{list of signs} \end{bmatrix}$$

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- new data structure with syntactic and semantic information under SYNTAX-SEMATICS (SYNSEM):

$$\begin{bmatrix} \text{PHON} & \textit{list of phonemes} \\ \text{SYNTAX-SEMANTICS} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{head} \\ \text{SUBCAT} & \textit{list of synsem-objects} \\ & \textit{cat} \end{bmatrix} \\ \text{CONT} & \textit{cont} \\ & \textit{synsem} \end{bmatrix} \\ \text{HEAD-DTR} & \textit{sign} \\ \text{NON-HEAD-DTRS} & \textit{list of signs} \end{bmatrix}$$

- only marked area is selected → no daughters or PHON
- elements in subcat-lists are *synsem* objects

Outline

- Phrase Structure Grammars and Features
- The Formalism
- Valence and Grammar Rules
- Complementation
- Semantics
- Adjunction
- **Nonlocal Dependencies**
- Relative Clauses

Nonlocal Dependencies

- topicalization

  (15) a. Bagels$_i$, [I like _$_i$].

  _$_i$ stands for the gap or trace
  Bagels$_i$ is the filler

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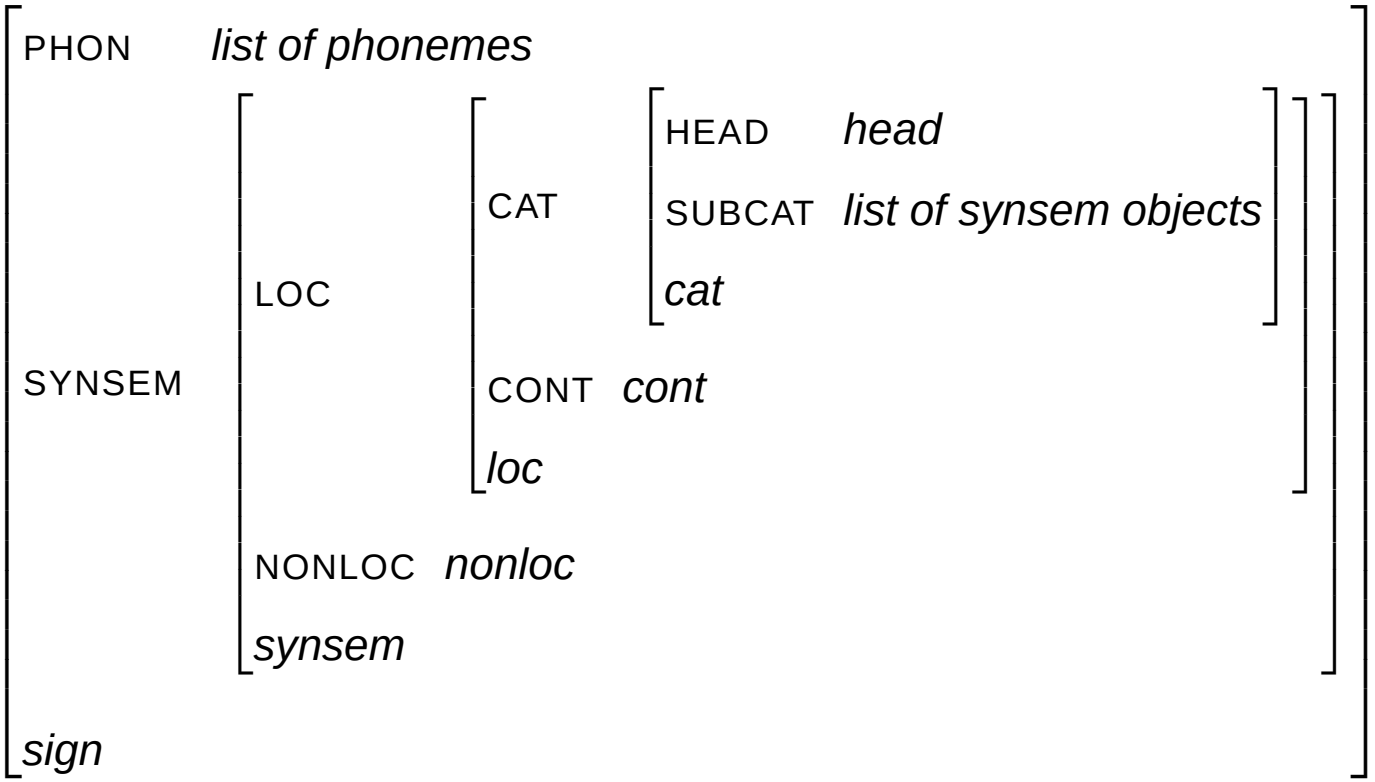
- *wh* questions

  (18) Who$_i$ did Kim claim _$_i$ left?

Data Structure: Grouping into Local/Non-Local Information

- grouping of the information into such that is locally relevant (LOCAL) and such that plays a role in nonlocal dependencies (NONLOCAL)



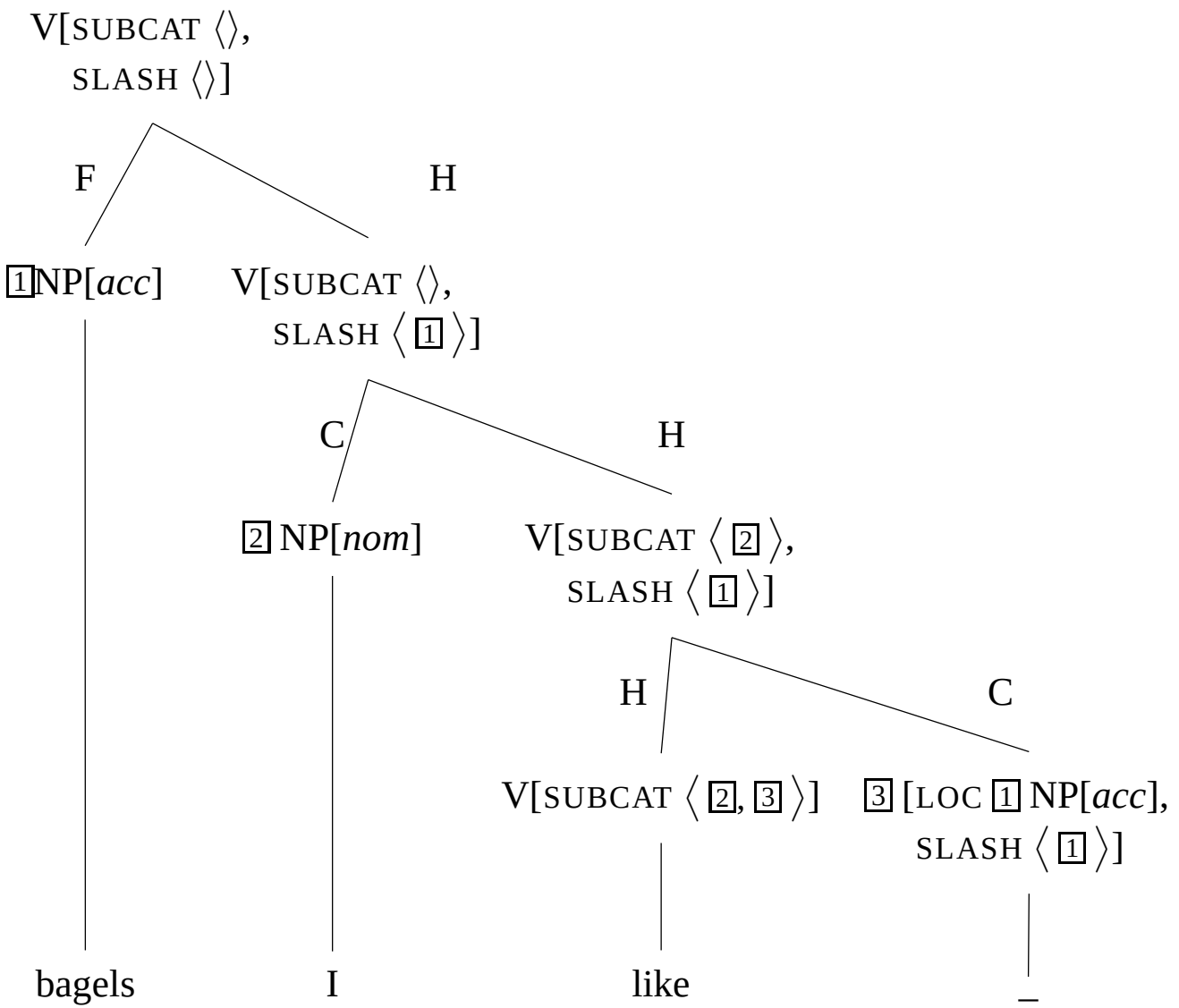
Data Strucutre for Nonlocal Information

- NONLOC value is structured further:

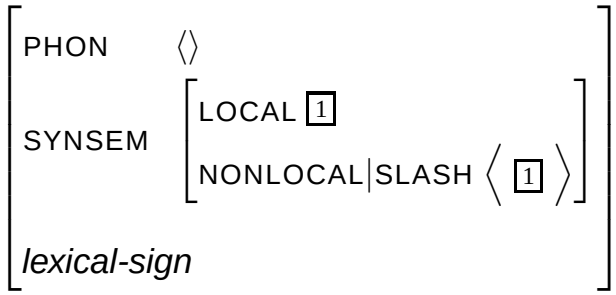
$$\begin{bmatrix} \text{QUE} & [\textit{list of npros}] \\ \text{REL} & [\textit{list of indices}] \\ \text{SLASH} & [\textit{list of local structures}] \\ \textit{nonloc} & \end{bmatrix}$$

- QUE: list of indices of question words (interrogative clauses)
- REL: list of indices of relative pronouns (relative clauses)
- SLASH: list of *local* objects (topicalization)
- The name SLASH is historical (GPSG).
- We will only consider SLASH and REL.

Percolation of Nonlocal Information



The Lexical Entry for the Trace



- no phonological contribution
- whatever is expected locally (1) is put into the SLASH list

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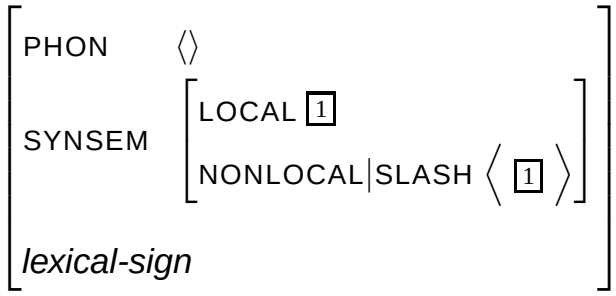
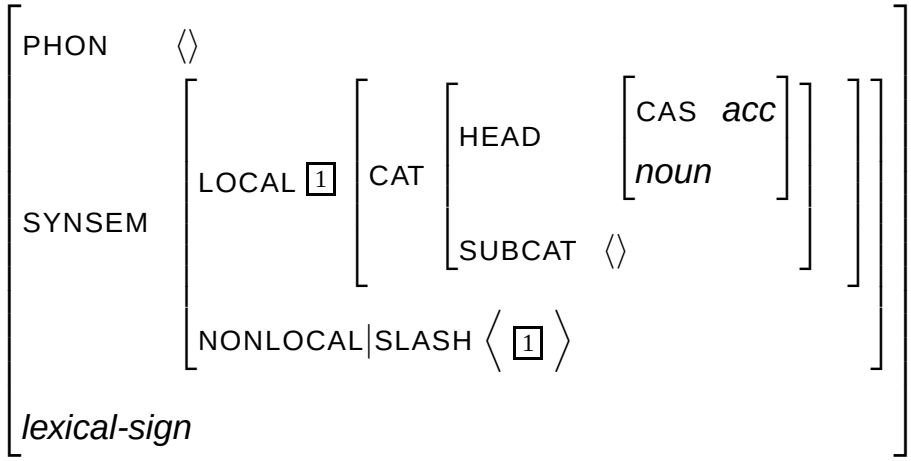


- no phonological contribution
- whatever is expected locally (1) is put into the SLASH list
- trace instantiated for complement of *like* = NP[*acc*]:



Schema 4 (Head Filler Schema)

head-filler-structure →

$$\left[\begin{array}{l} \text{NONLOC}|\text{SLASH}\ \langle\rangle \\ \text{HEAD-DTR}|\text{SYNSEM}\ \left[\begin{array}{l} \text{LOCAL}\ \left[\begin{array}{l} \text{CAT}\ \left[\begin{array}{l} \text{HEAD}\ \left[\begin{array}{l} \text{VFORM}\ \textit{fin} \\ \textit{verb} \end{array}\right] \\ \text{SUBCAT}\ \langle\rangle \end{array}\right] \end{array}\right] \\ \text{NONLOC}|\text{SLASH}\ \left\langle \boxed{1} \right\rangle \end{array}\right] \\ \text{NON-HEAD-DTRS}\ \left\langle \left[\begin{array}{l} \text{SYNSEM}\ \left[\begin{array}{l} \text{LOCAL}\ \boxed{1} \\ \text{NONLOC}|\text{SLASH}\ \langle\rangle \end{array}\right] \end{array}\right] \right\rangle \end{array}\right]$$

- the head daughter is a finite clause

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$$\begin{bmatrix} \text{NONLOC}|\text{SLASH} \langle\rangle & \\ \text{HEAD-DTR}|\text{SYNSEM} & \begin{bmatrix} \text{LOCAL} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{VFORM} & \textit{fin} \\ & \textit{verb} \end{bmatrix} \\ \text{SUBCAT} \langle\rangle & \end{bmatrix} \end{bmatrix} \\ \text{NONLOC}|\text{SLASH} \left\langle \boxed{1} \right\rangle & \end{bmatrix} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \text{SYNSEM} & \begin{bmatrix} \text{LOCAL} \boxed{1} \\ \text{NONLOC}|\text{SLASH} \langle\rangle \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix}$$

- the head daughter is a finite clause with a missing constituent ($\boxed{1}$)

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- the head daughter is a finite clause with a missing constituent ($\boxed{1}$)
- the non head daughter is the filler, i.e., corresponds to the missing constituent

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- the head daughter is a finite clause with a missing constituent ($\boxed{1}$)
- the non head daughter is the filler, i.e., corresponds to the missing constituent
- the gap is filled, the mother does not have any gaps → SLASH is empty

Important Points about the Analysis

- percolation of nonlocal information
- structure sharing $\rightarrow$
  information simultaneously present at each node
- nodes in the middle of a nonlocal dependency can access it
  there are languages where elements inflect depending on whether a nonlocal depnedency passes the node they head

More Complex Examples: *tough* Movement

(19) a. John$_i$ is easy to please $\__i$.

b. * John is easy to please John.

- *to please* is a VP with a missing object (*We try [to please John].*)

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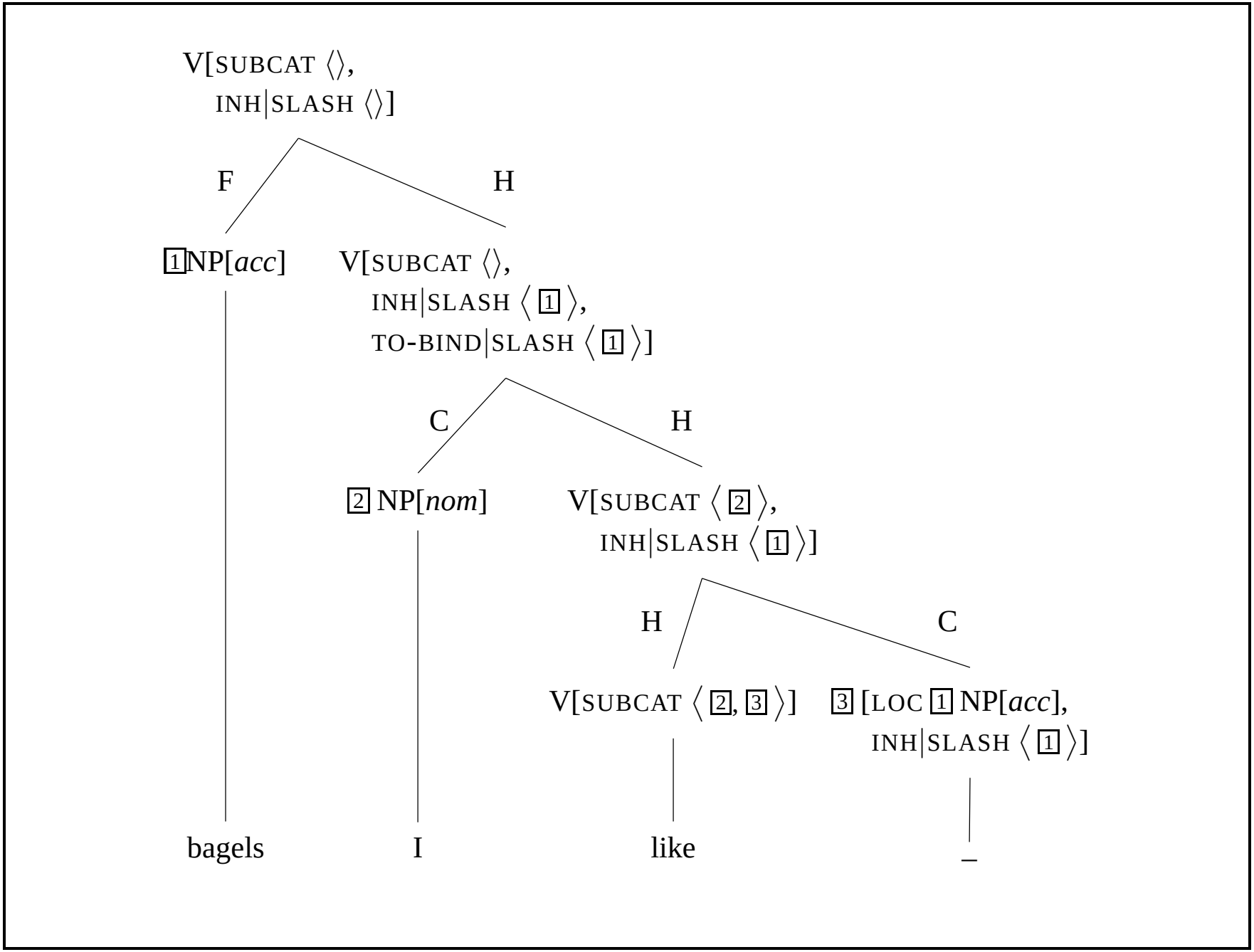
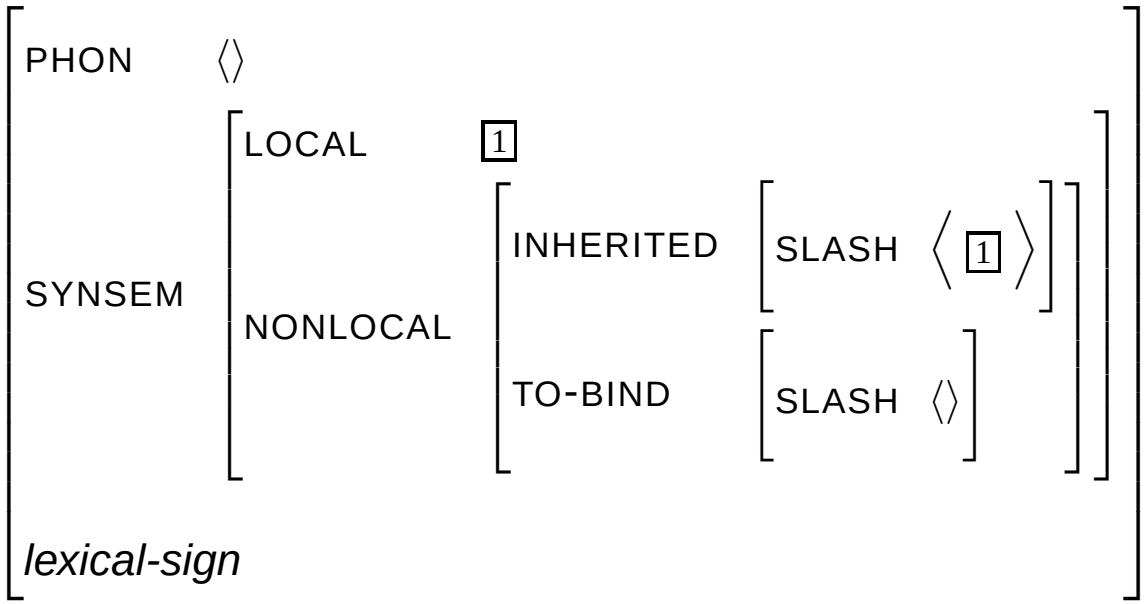
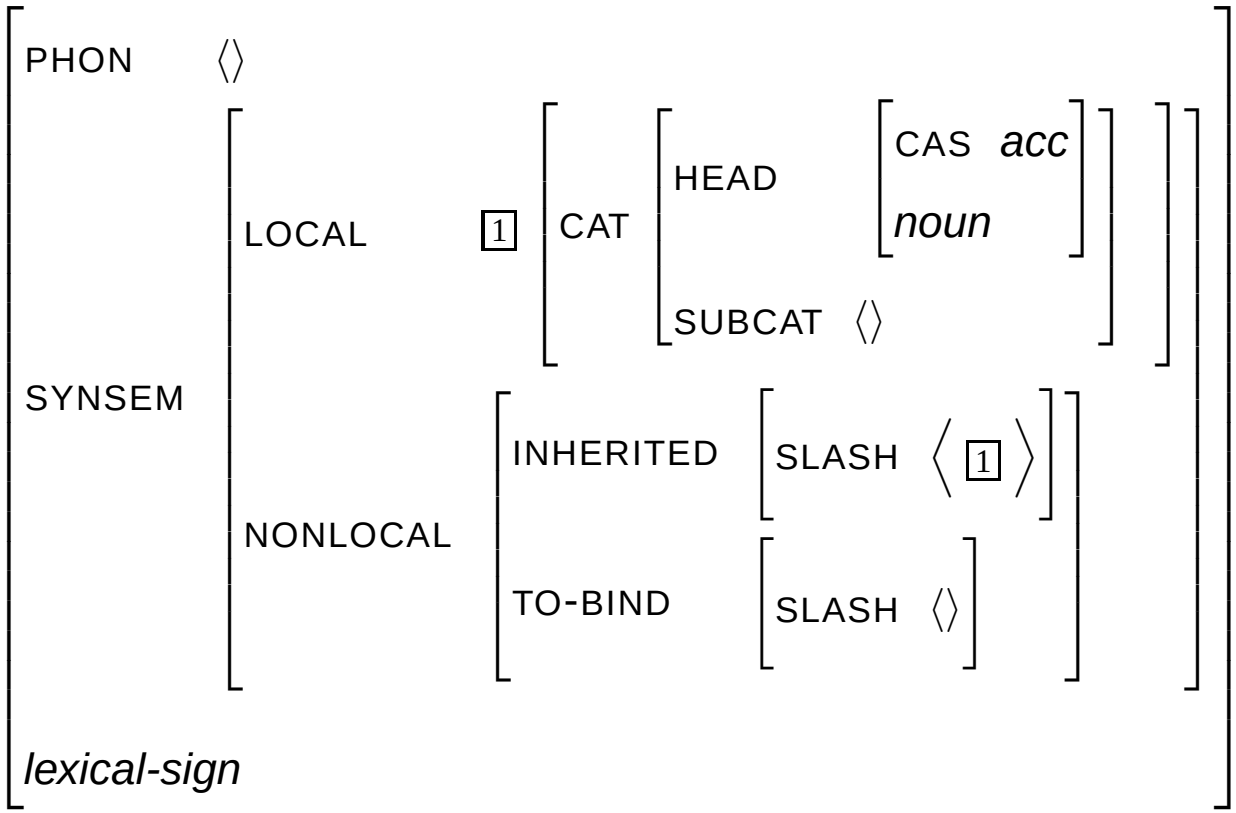
- *easy* lexically binds off the gap in the VP


V[SUBCAT ⟨⟩,
INH|SLASH ⟨⟩]
F
H
1 NP[acc]
V[SUBCAT ⟨⟩,
INH|SLASH ⟨ 1 ⟩,
TO-BIND|SLASH ⟨ 1 ⟩]
C
H
2 NP[nom]
V[SUBCAT ⟨ 2 ⟩,
INH|SLASH ⟨ 1 ⟩]
H
C
V[SUBCAT ⟨ 2, 3 ⟩]
3 [LOC 1 NP[acc],
INH|SLASH ⟨ 1 ⟩]
bagels
I
like
_

The Lexical Entry for the Trace (Revised)



Trace Instantiated for Complement of *like*



Nonlocal Feature Principle

For each nonlocal feature, the INHERITED value of the mother is the concatenation of the INHERITED values on the daughters minus the TO-BIND value on the head daughter.

Schema 5 (Head Filler Schema)

head-fi ller-structure →

$$\left[\begin{array}{l}\text{HEAD-DTR}\,|\,\text{SYNSEM} \left[\begin{array}{l}\text{LOCAL} \left[\begin{array}{l}\text{CAT} \left[\begin{array}{l}\text{HEAD} \left[\begin{array}{l}\text{VFORM}\ \textit{fin}\\ \textit{verb}\end{array}\right]\\ \text{SUBCAT}\ \langle\rangle\end{array}\right]\end{array}\right]\\ \text{NONLOC} \left[\begin{array}{l}\text{INHER}\,|\,\text{SLASH}\ \left\langle \ldots, \boxed{1}, \ldots \right\rangle\\ \text{TO-BIND}\,|\,\text{SLASH}\ \left\langle \boxed{1} \right\rangle\end{array}\right]\end{array}\right]\\ \text{NON-HEAD-DTRS}\ \left\langle \left[\begin{array}{l}\text{SYNSEM} \left[\begin{array}{l}\text{LOCAL}\ \boxed{1}\\ \text{NONLOC}\ \text{INHER}\,|\,\text{SLASH}\ \langle\rangle\end{array}\right]\end{array}\right] \right\rangle\end{array}\right]$$

Problems with Traces

Linguistic:

- coordination
  _ and _

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Linguistic:

- coordination
  _ and _
- linearization (depending on assumptions made in the grammar)

(20) Dem Mann$_i$ hilft eine Frau _$_i$. vs. Dem Mann$_i$ hilft _$_i$ eine Frau.
the man$_{dat}$ helps a woman$_{nom}$ the man$_{dat}$ helps a woman$_{nom}$

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- restriction to non heads

(21) a. [Der kluge Mann]$_i$ hat _$_i$ geschlafen.
the smart man has slept
'The smart man slept.'

b. * [Mann]$_i$ hat der kluge _$_i$ geschlafen.

Problems with Traces

Linguistic:

- coordination
  _ and _
- linearization (depending on assumptions made in the grammar)

  (20) Dem Mann$_i$ hilft eine Frau _$_i$. vs. Dem Mann$_i$ hilft _$_i$ eine Frau.
  the man$_{dat}$ helps a woman$_{nom}$ the man$_{dat}$ helps a woman$_{nom}$

- restriction to non heads

  (21) a. [Der kluge Mann]$_i$ hat _$_i$ geschlafen.
  the smart man has slept
  'The smart man slept.'

  b. * [Mann]$_i$ hat der kluge _$_i$ geschlafen.

Computational:

- depending on the parser:
  hypotheses of empty elements that are never used

  (22) the _ man

Introduction of Nonlocal Dependencies

- trace
- unary projection
- lexical rule
- underspecified lexical entries and relational constraints

Grammar Transformation

Bar-Hillel, Perles and Shamir (1961):

$\overline{\text{v}} \rightarrow$ v, np		$\overline{\text{v}} \rightarrow$ v, np
np $\rightarrow \varepsilon$	$\Rightarrow$	$\overline{\text{v}} \rightarrow$ v
$\overline{\text{v}} \rightarrow \overline{\text{v}}$, adv		$\overline{\text{v}} \rightarrow \overline{\text{v}}$, adv
adv $\rightarrow \varepsilon$		$\overline{\text{v}} \rightarrow \overline{\text{v}}$

Grammar Transformation

Bar-Hillel, Perles and Shamir (1961):

$\overline{\text{v}} \rightarrow$ v, np		$\overline{\text{v}} \rightarrow$ v, np
np $\rightarrow \varepsilon$	$\Rightarrow$	$\overline{\text{v}} \rightarrow$ v
$\overline{\text{v}} \rightarrow \overline{\text{v}}$, adv		$\overline{\text{v}} \rightarrow \overline{\text{v}}$, adv
adv $\rightarrow \varepsilon$		$\overline{\text{v}} \rightarrow \overline{\text{v}}$

H[SUBCAT X] $\rightarrow$ H[SUBCAT X $\oplus \left\langle \text{Y} \right\rangle$], Y

Y $\rightarrow \varepsilon$

$\Rightarrow$

H[SUBCAT X] $\rightarrow$ H[SUBCAT X $\oplus \left\langle \text{Y} \right\rangle$], Y

H[SUBCAT X] $\rightarrow$ H[SUBCAT X $\oplus \left\langle \text{Y} \right\rangle$]

Schema 6 (SLASH Introduction Schema for Complements)

head-comp-slash-structure →

$$\left[\begin{array}{ll} \text{SYNSEM} & \left[\begin{array}{ll} \text{LOC}|\text{CAT} & \left[\text{SUBCAT } \boxed{1}\right] \\ \text{NONLOC} & \left[\text{INHER}|\text{SLASH } \left\langle \boxed{2} \right\rangle \oplus \boxed{3}\right] \end{array}\right] \\ \text{HEAD-DTR} & \left[\begin{array}{ll} \text{SYNSEM} & \left[\begin{array}{ll} \text{LOC}|\text{CAT} & \left[\text{SUBCAT } \boxed{1} \oplus \left\langle \boxed{4} \right\rangle\right] \\ \text{NONLOC} & \left[\text{INHER}|\text{SLASH } \boxed{3}\right] \end{array}\right] \end{array}\right] \end{array}\right]$$

$\boxed{4}$ stands for:

$$\left[\begin{array}{ll} \text{LOC} & \boxed{2} \\ \text{NONLOC} & \left[\text{INHER}|\text{SLASH } \left\langle \boxed{2} \right\rangle\right] \\ \textit{synsem} & \end{array}\right]$$

$\boxed{6}$ is the SYNSEM value of a trace

Lexicon Transformation

$\overline{\text{v}} \rightarrow$ v-ditrans, np, np, np	v-ditrans $\rightarrow$ give
$\overline{\text{v}} \rightarrow$ v-trans, np, np	v-trans $\rightarrow$ love
$\overline{\text{v}} \rightarrow$ v-intrans, np	v-intrans $\rightarrow$ sleep
$\overline{\text{v}} \rightarrow$ v-subjless	
np $\rightarrow \varepsilon$	

$\Rightarrow$

$\overline{\text{v}} \rightarrow$ v-ditrans, np, np, np	v-ditrans $\rightarrow$ give
$\overline{\text{v}} \rightarrow$ v-trans, np, np	v-trans $\rightarrow$ love $\vee$ give
$\overline{\text{v}} \rightarrow$ v-intrans, np	v-intrans $\rightarrow$ sleep $\vee$ love $\vee$ give
$\overline{\text{v}} \rightarrow$ v-subjless	v-subjless $\rightarrow$ sleep $\vee$ love $\vee$ give

Lexicon Transformation

V[SUBCAT $\langle$ NP$_1$, NP$_2$, NP$_3$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_1$, NP$_2$ $\rangle$] $\rightarrow$ love
V[SUBCAT $\langle$ NP$_1$ $\rangle$] $\rightarrow$ sleep

$\Rightarrow$

V[SUBCAT $\langle$ NP$_1$, NP$_2$, NP$_3$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_1$, NP$_2$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_1$, NP$_3$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_2$, NP$_3$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_1$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_2$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle$ NP$_3$ $\rangle$] $\rightarrow$ give
V[SUBCAT $\langle\rangle$] $\rightarrow$ give

V[SUBCAT $\langle$ NP$_1$, NP$_2$ $\rangle$] $\rightarrow$ love
V[SUBCAT $\langle$ NP$_1$ $\rangle$] $\rightarrow$ love
V[SUBCAT $\langle$ NP$_2$ $\rangle$] $\rightarrow$ love
V[SUBCAT $\langle\rangle$] $\rightarrow$ love

V[SUBCAT $\langle$ NP$_1$ $\rangle$] $\rightarrow$ sleep
V[SUBCAT $\langle\rangle$] $\rightarrow$ sleep

The SLASH Introduction Lexical Rule

$$\left[\begin{array}{l} \textsc{synsem} \left[\begin{array}{ll} \textsc{loc} & \left[\textsc{cat}|\textsc{subcat}\ \boxed{1} \oplus \left\langle \boxed{2} \right\rangle \oplus \boxed{3}\right] \\ \textsc{nonloc} & \left[\textsc{inher}|\textsc{slash}\ \boxed{4}\right] \end{array}\right] \\ \textit{lexical-sign} \end{array}\right] \rightarrow$$

$$\left[\begin{array}{l} \textsc{synsem} \left[\begin{array}{ll} \textsc{loc} & \left[\textsc{cat}|\textsc{subcat}\ \boxed{1} \oplus \boxed{3}\right] \\ \textsc{nonloc} & \left[\textsc{inher}|\textsc{slash}\ \boxed{4} \oplus \left\langle \boxed{5} \right\rangle\right] \end{array}\right] \\ \textit{lexical-sign} \end{array}\right]$$

$\boxed{2}$ stands for:

$$\left[\begin{array}{ll} \textsc{loc} & \boxed{5} \\ \textsc{nonloc} & \left[\textsc{inher}|\textsc{slash}\ \left\langle \boxed{5} \right\rangle\right] \\ \multicolumn{2}{l}{\textit{synsem}} \end{array}\right]$$

Lexicon Underspecification

Bouma, Malouf and Sag (2001)

- two lists:
  - Argument Structure
  - Dependents

Outline

- Phrase Structure Grammars and Features
- The Formalism
- Valence and Grammar Rules
- Complementation
- Semantics
- Adjunction
- Nonlocal Dependencies
- **Relative Clauses**

Relative Clauses: Structure (I)

- Relative phrase followed by a finite clause with the verb in last postion from which the relative phrase is extracted

(23) a. der Mann, [*der*] Maria küßt
the man who$_{nom}$ Maria kisses
'the man who is kissing Maria'

b. der Mann, [*den*] Maria küßt
the man who$_{acc}$ Maria kisses
'the man Maria is kissing'

c. der Mann, [*dem*] Maria zuhöhrt
the man who$_{dat}$ Maria listens.to
'the man Maria is listening to'

- Relative phrase may be subject, (Akk/Dat/PP) object, adjunct or VP complement

Relative Clauses: Structure (II)

- Relative phrase may be subject, (Akk/Dat/PP) object, adjunct or VP complement
- Relative phrase may be complex (VP, PP, NP $\rightarrow$ relative word is possesive)

(24) a. der Mann, [von *dem*] Maria geküßt wird
the man by who$_{dat}$ Maria kissed is
'the man by whom Maria is kissed'

b. die Stadt, [in *der*] Karl arbeitet
the town in which Karl works

c. Änderungen, [*deren* Tragweite] mir nicht bewußt war.
modifications the consequences me not conscious was
'modifications the consequences of which I was not conscious of'

d. ein Umstand, [*den* zu berücksichtigen] meist vergessen wird.
a fact that to consider usually forget is
'a fact that is usually neglected'

- Relative word agrees with antecedent in number and gender
- case is determined by the head inside of the relative clause

Two Kinds of Relative Clauses

- two kinds of relative clauses
  - modify a noun (with antecedent)

    (25) der Mann, der schläft
    the man who sleeps

  - appear as a direct argument or adjunct of a possibly non-verbal head (without antecedent = free relative clause)

    (26) Wer schläft, sündigt nicht.
    who sleeps sins not
    'He who sleeps does not sin.'

- I will argue that free relative clauses have to be analyzed as 'relative clauses'.
  We will deal with relative clauses with antecedent first.

Extraction of the Relative Phrase

The relative phrase is extracted from a finite clause:

(27) a. der Mann, [von dessen Schwester]$_i$ Maria [ein Bild _$_i$] gemalt hat,
the man of whose sister Maria a picture drawn has
'the man a picture of whose sister Maria has drawn'

b. * der Mann, Maria ein Bild von dessen Schwester gemalt hat,
the man Maria a picture of whose sister painted has

c. * der Mann, ein Bild von dessen Schwester Maria gemalt hat,
the man a picture of whose sister Maria painted has

(28) das Thema, [über das]$_i$ er Peter gebeten hat, [$_{\mathrm{VP}}$ [einen Vortrag _$_i$] zu halten],
the topic about which he Peter asked has a talk to give

(29) Wollen wir mal da hingehen, wo$_i$ Jochen gesagt hat, [daß es _$_i$ so gut schmeckt]?
want we there towards.go where Jochen said has that it so good tastes

An analysis as linearization variant inside of a head domain is impossible.

Clearly a nonlocal dependency.

It is the same kind of phenomenon as topicalization in English and fronting in German.

Percolation of the Index Information

- antecedent noun and relative pronoun have to agree in gender and number and are coreferential → coindexing
- the coindexing cannot be established locally since relative phrase may be complex:

(30) a. der Mann$_i$, [von *dem*$_i$] Maria geküßt wird
the man by who$_{dat}$ Maria kissed is
'the man by whom Maria is kissed'

b. die Stadt$_i$, [in *der*$_i$] Karl arbeitet
the town in which Karl works

c. Änderungen$_i$, [*deren*$_i$ Tragweite] mir nicht bewußt war.
modifications the consequences me not conscious was
'modifications the consequences of which I was not conscious of'

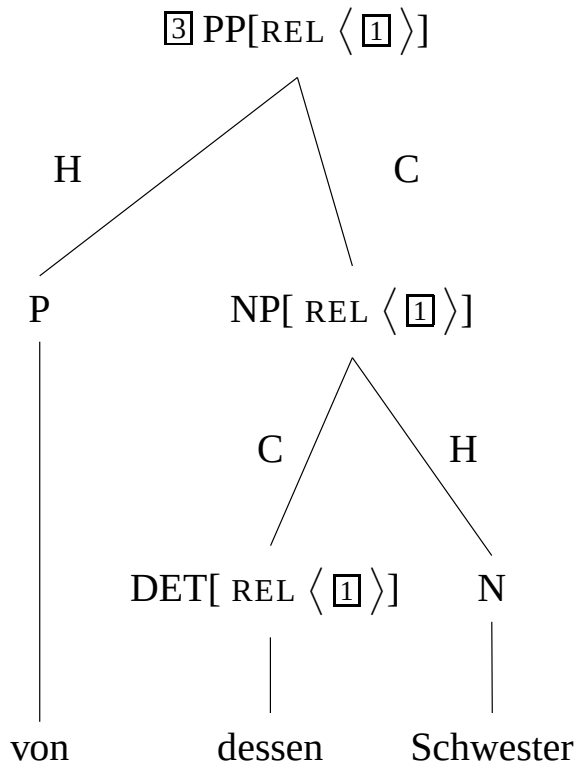
d. ein Umstand$_i$, [*den*$_i$ zu berücksichtigen] meist vergessen wird.
a fact that to consider usually forget is
'a fact that is usually neglected'

Lexical Entry for the Relative Pronoun *dem*

$$\begin{bmatrix}
\text{PHON} & \langle\, \textit{dem} \,\rangle \\
\text{SYNSEM} & \begin{bmatrix}
\text{LOC} & \begin{bmatrix}
\text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{CAS} & \textit{dat} \\ \textit{noun} & \end{bmatrix} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\
\text{CONT} & \begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{mas} \vee \textit{neu} \end{bmatrix} \end{bmatrix}
\end{bmatrix} \\
\text{NONLOC} & \begin{bmatrix}
\text{INHER} & \begin{bmatrix} \text{REL} & \langle\, \boxed{1} \,\rangle \\ \text{SLASH} & \langle\rangle \end{bmatrix} \\
\text{TO-BIND} & \begin{bmatrix} \text{REL} & \langle\rangle \\ \text{SLASH} & \langle\rangle \end{bmatrix}
\end{bmatrix}
\end{bmatrix} \\
\textit{lexical-sign} &
\end{bmatrix}$$

introduces index into nonloc features under REL

Flow of Information—Percolation of the REL-Value



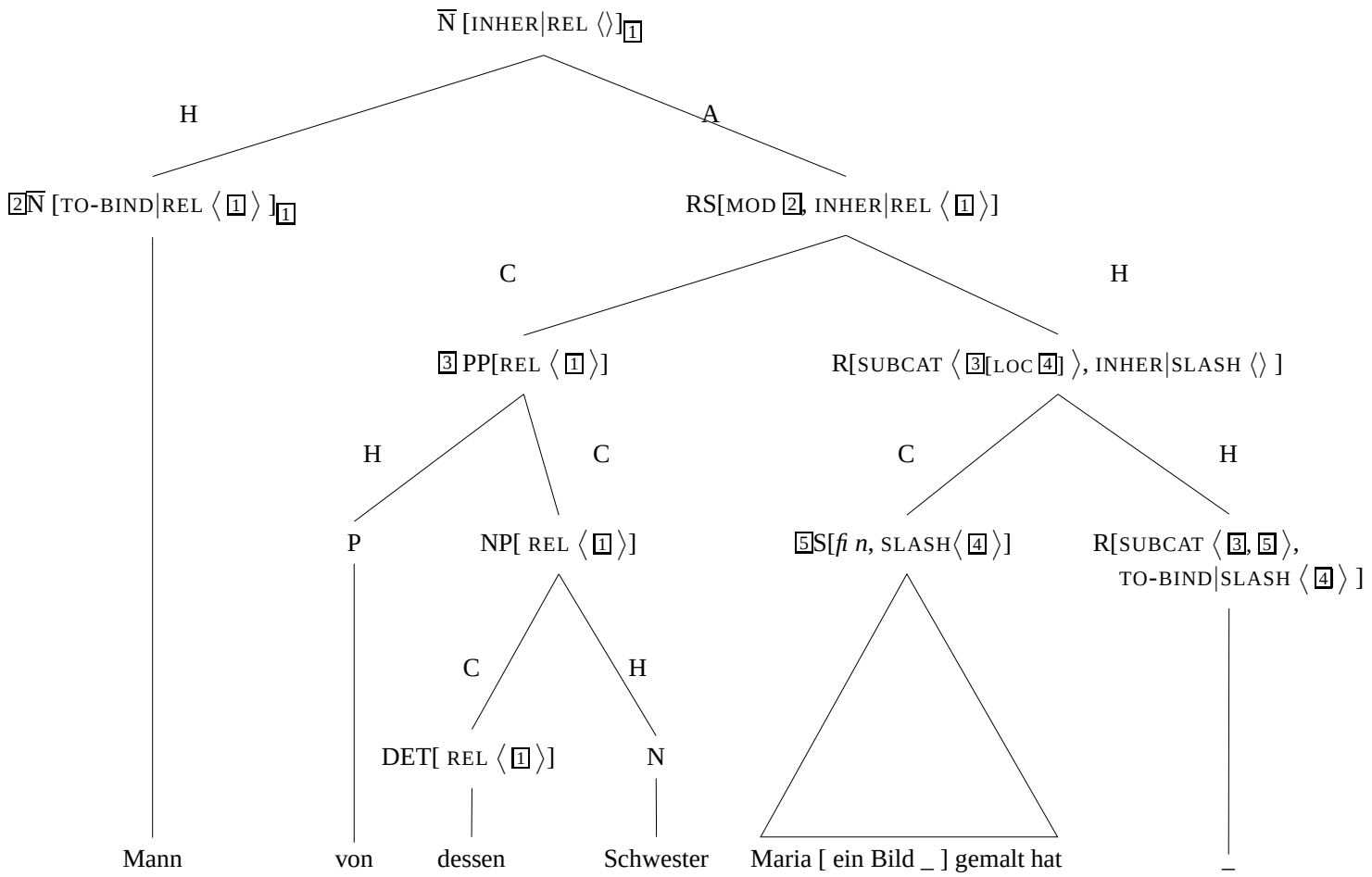
Properties of Relative Clauses

- They are modifiers and behave like adjectives or PPs.

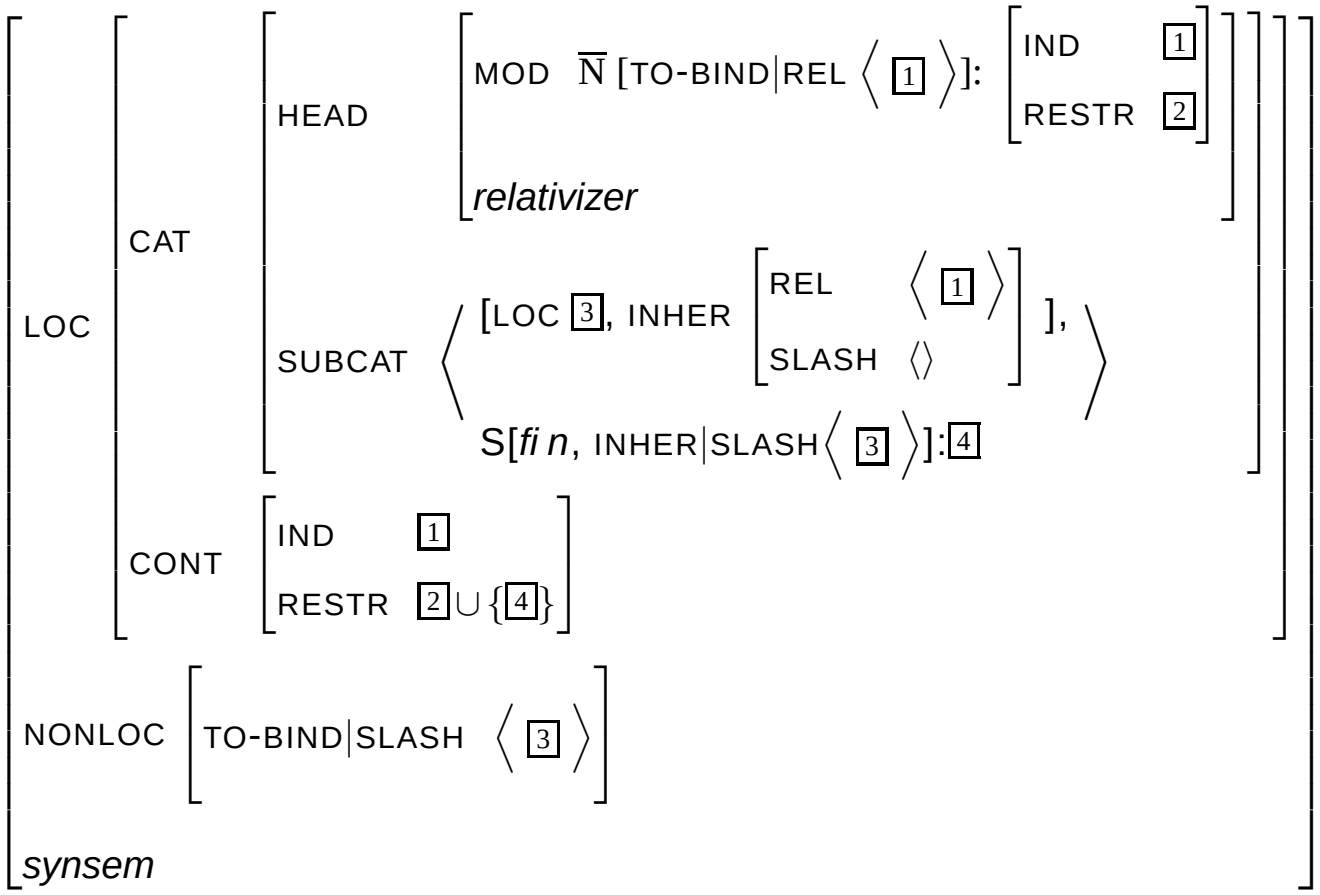
  (31) a. die Frau, die schläft
  b. die schöne Frau
  c. die Frau im Cafe

- select $\overline{\text{N}}$ via MOD feature
- integrate semantic contribution of the noun
- $\rightarrow$ behave differnt from normal finite clauses
- two possibilities
  - phonologically empty head that takes the relative phrase and the finite clause as complements and acts as modifier
  - rule that combines relative phrase and finite clause and yields the modifier

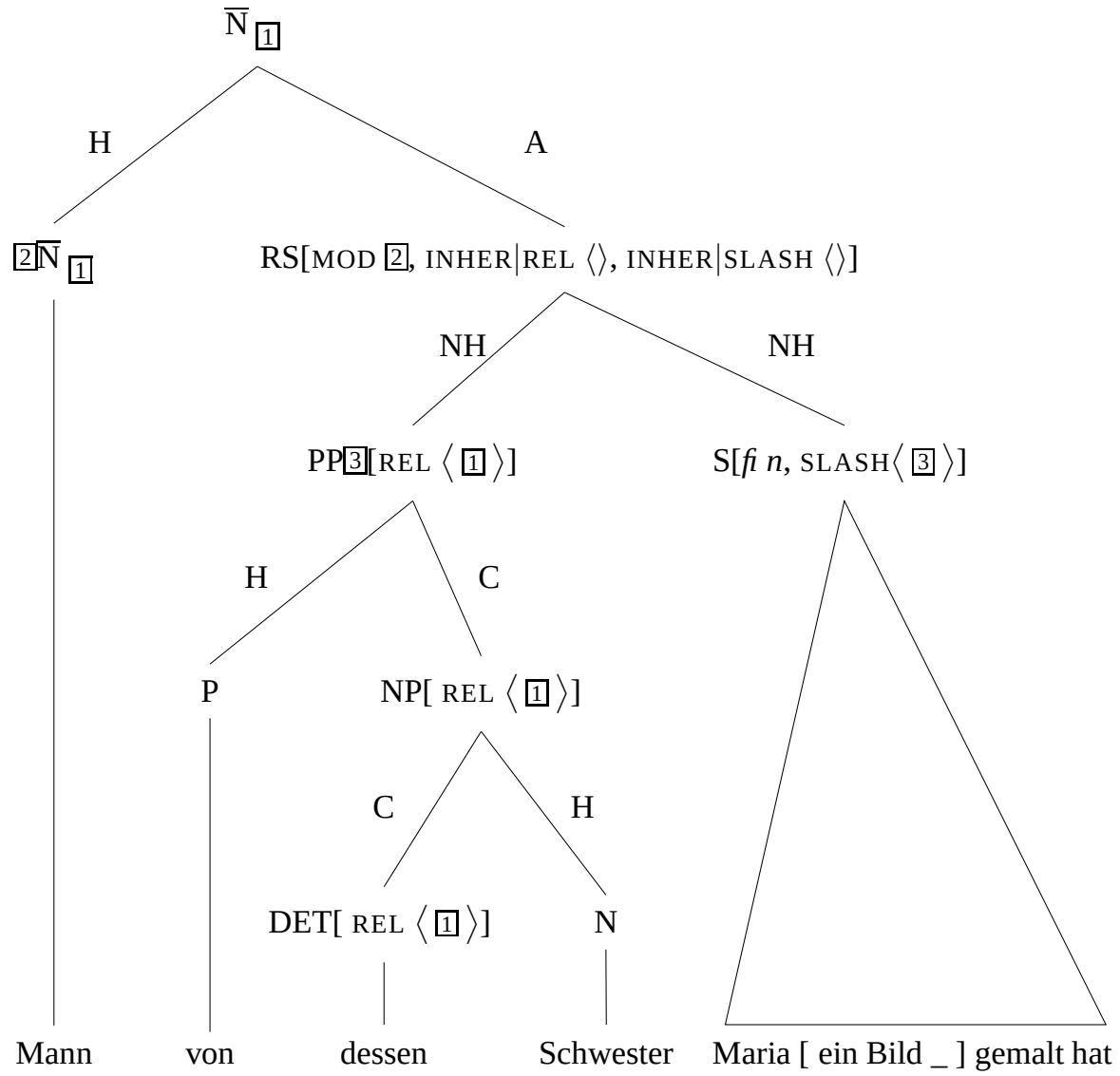
Extraction, REL-Percolation and Binding-Off: The Empty Relativizer



Lexical Entry for the Empty Relativizer

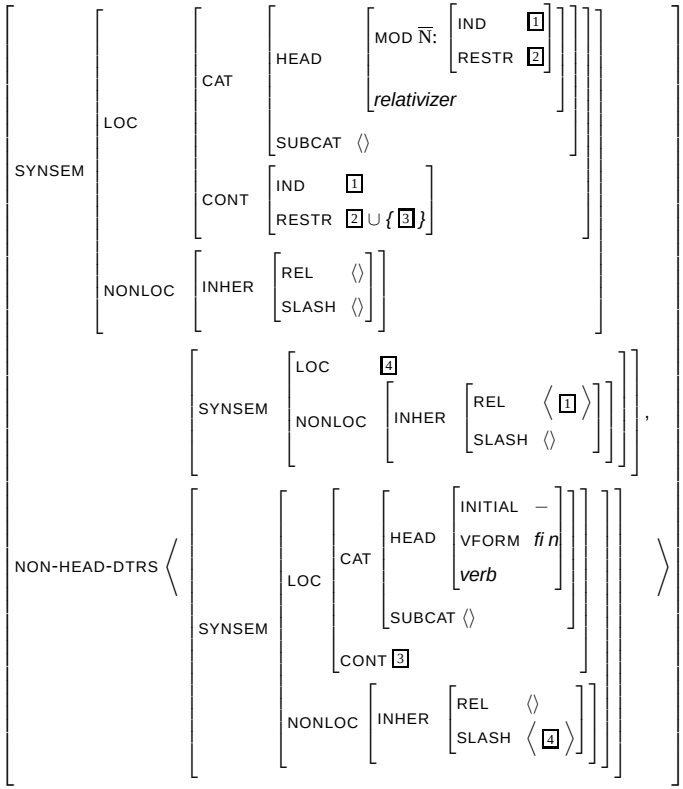


Extraction, REL-Percolation and Binding-Off: Relative Clause Schema



Schema 7 (Relative Clause Schema)

relativizer-structure →



- *relative-clause-structure* is not a subtype of *headed-structure*
- valence principle, semantics principle and nonloc principle do not hold for such structures

Free Relative Clauses (I)

- FRC as subject

(32) [*Wer*] schläft, sündigt nicht.
who sleeps sins not

‘He who sleeps does not sin.’

Free Relative Clauses (I)

- FRC as subject

(32) [*Wer*] schläft, sündigt nicht.
who sleeps sins not
'He who sleeps does not sin.'

accusative object

(33) Sie hat, [*was*] sie geschenkt bekommen hat, sofort in den Schrank
she has what she given got has instantly in the cupboard
gestellt. (Bausewein, 1990)
put
'She put what she was given into the cupboard instantly.'

Free Relative Clauses (II)

Dativ-Objekt

(34) a. [*Wem*] er vertraut, hilft er auch. (Engel, 1977)
who he trusts helps he too
'He helps those he trusts.'

Free Relative Clauses (II)

Dativ-Objekt

(34) a. [*Wem*] er vertraut, hilft er auch. (Engel, 1977)
who he trusts helps he too
'He helps those he trusts.'

genitive object

(35) a. Jeder versichert sich, [*wessen*] er kann. (Heringer, 1973)
everybody ensures self who he can

b. Er wurde angeklagt, [*wessen*] er sich schuldig gemacht hat. (Engel, 1988)
he was sued which he self guilty made has

Free Relative Clauses (II)

Dativ-Objekt

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everybody ensures self who he can

b. Er wurde angeklagt, [*wessen*] er sich schuldig gemacht hat. (Engel, 1988)
he was sued which he self guilty made has

prepositional object

(36) Ihr könnt beginnen, [mit *wem*] ihr (beginnen) wollt. (Bausewein, 1990)
you can begin with who you begin want
'You can begin with whoever you like.'

Three Possible Analyses (I)

(37) [*Wer*] schläft, sündigt nicht.
who sleeps sins not
'He who sleeps does not sin.'

1. Grammar Rule that is analogous to the relative clause rule, but projecting a certain phrase instead of a RC

   RC rule:

   (38) RC $\rightarrow$ XP_i, S/XP

   XP_i is the relative phrase that is extracted from the finite clause

   $_i$ stands for the referential index

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   rule for the direct projection of an NP:

   (39) NP $\rightarrow$ NP, S/NP

   Jackendoff (1977), Bresnan and Grimshaw (1978) suggested such rules for English, Hinrichs and Nakazawa (2002) for German

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   Jackendoff (1977), Bresnan and Grimshaw (1978) suggested such rules for English, Hinrichs and Nakazawa (2002) for German

   Generalization:

   (40) XP$_i$ $\rightarrow$ XP$_i$, S/XP

Three Possible Analyses (II)

2. Avgustinova (1996, 1997): verb directly selects the relative clause

   (41) $[_{RS}$ Wer schläft], sündigt nicht.

   lexical rule produces alternative lexical entry for *sündigt*

Three Possible Analyses (II)

2. Avgustinova (1996, 1997): verb directly selects the relative clause

   (41) [$_{RS}$ Wer schläft], sündigt nicht.

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- Rooryck (1994) and Åfarli (1994) suggest analyzing FR as CPs in English and Norwegian

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3. empty head (42): relative clause modifies an empty element

   (42) XP $\rightarrow$ $\_{}_{XP}$ RS

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   Alternative: unary rule

   (43) XP $\rightarrow$ RS

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What arguments do we have in favour of the possabilities?

- FRs behave like their relative phrase $\rightarrow$ 1

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What arguments do we have in favour of the possabilities?

- FRs behave like their relative phrase $\rightarrow$ 1
- FRs behave like sentences $\rightarrow$ 2

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   Alternative: unary rule

   (43) XP $\rightarrow$ RS

What arguments do we have in favour of the possabilities?

- FRs behave like their relative phrase $\rightarrow$ 1
- FRs behave like sentences $\rightarrow$ 2
- FRs have both properties $\rightarrow$ 3

Agreement and Coordination (I)

Oppenrieder (1991) claims:
FRs behave like sentences and not like NPS

(44) Wer erster wird und wer den letzten Platz belegt, bekommt /* bekommen einen
who first becomes and who the last place takes gets /* get a
Preis.
prize
'Both the winner and the loser get prizes.'

(45) Karl und Maria *bekommt / bekommen einen Preis.

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'Both the winner and the loser get prizes.'

(45) Karl und Maria *bekommt / bekommen einen Preis.

But: coordination of NPs may also be singular

(46) a. Viel Wein und Schnaps wurde getrunken.
much wine and schnapps was$_{sg}$ drunk

b. Bei mir geht prinzipiell jeder Montag und jeder Donnerstag. (Verb*mobil*)
at me goes$_{sg}$ in principal every Monday and every Thursday
'In principal every Monday and every Thursday is okay for me.'

(47) Wer erster wird und wer den letzten Platz belegt müssen sich umarmen. (Alexander Grosu, p.c. 2002)

Coordination with NPs

- no fully worked out theory of coordination
- symmetrical coordination is unproblematic
- coordination data can be taken into account as weak evidence
- (48) is unproblematic if FRC correspond to phrases with properties of their relative phrase:

(48) Das Motiv ist klar: Haß auf den technischen Fortschritt und seine Repräsentanten,
auf [$_{NP}$ [$_{NP}$ Naturwissenschaftler],
[$_{NP}$ Computerexperten],
[$_{NP}$ Vertreter der Holzindustrie] oder
[$_{NP}$ [$_{RS}$ wen immer er für die Zerstörung der Natur verantwortlich machte]]]. (taz, 08.11.97)

- Jackendoff's approach and the approach with empty head or unary projection is compatible with the data
- lexical rule is not

Linearisation Properties: Ordering in the Mittelfeld

- FR behave like their relative phrase

  complement FRs can be serialized in the Mittelfeld

(49) a. Sie hat, was sie geschenkt bekommen hat, sofort in den Schrank
she has what she given got has instantly in the cupboard
gestellt. (Bausewein, 1990)
put

'She put what she was given into the cupboard instantly.'

b. Schon heute muß, wer harte Informationen oder lockere Unterhaltung haben will, blechen, portionenweise, (c't, 10/96)
'It is already the case that you have to cough up, bit by bit, both for hard facts and entertainment of a less serious nature.'

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  'It is already the case that you have to cough up, bit by bit, both for hard facts and entertainment of a less serious nature.'

- placement of other complement clauses in the Mittelfeld is marked:

  (50) a. Ich habe geglaubt, daß Peter das interessiert.
  I have believed that Peter that interests

  'I believed that Peter was interested in that.'

  b. ?? Ich habe, daß Peter das interessiert, geglaubt.
  I have that Peter that interests believed

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- cannot be explained with lexical rule-based approaches

Linearisation Properties: Placement in the Nachfeld

- Gross and van Riemsdijk (1981): freie RS verhalten sich bei Extraposition wie Sätze

(51) a. Der Hans hat das Geld zurückgegeben, das er gestohlen hat.
the Hans has the money returned that he stolen has
'Hans has returned the money that he has stolen.'

b. * Der Hans hat zurückgegeben das Geld, das er gestohlen hat.

c. Der Hans hat zurückgegeben, was er gestohlen hat.

- NP extraposition is possible but marked

Linearisation Properties: Placement in the Nachfeld

- Gross and van Riemsdijk (1981): freie RS verhalten sich bei Extraposition wie Sätze

  (51) a. Der Hans hat das Geld zurückgegeben, das er gestohlen hat.
  the Hans has the money returned that he stolen has
  'Hans has returned the money that he has stolen.'

  b. * Der Hans hat zurückgegeben das Geld, das er gestohlen hat.

  c. Der Hans hat zurückgegeben, was er gestohlen hat.

- NP extraposition is possible but marked
- cannot be explained with Jackendoffs analysis (NP $\rightarrow$ NP S/NP):
  was er gestohlen hat is NP,

  (52) Der Hans hat zurückgegeben, [$_{\text{NP}}$ [$_{\text{NP}}$ was] [$_{\text{S/NP}}$ er gestohlen hat]].

  NP extraposition: (52b) should be as grammatical as (52c)

Conclusion of the Data Section

	XP → XP, S/XP	Lexical Rule	XP → RS
linearisation in the Mittelfeld	yes	no	yes
linearisation in the Nachfeld	no	yes	yes

The Analysis

- it remains the analysis, where a RC is projected to a category, that corresponds to the relative phrase
- two possibilities
  - empty head:

    (53) XP $\rightarrow$ $\_{}_{\mathrm{XP}}$ RS

    corresponds to the intuition that the RC modifies something empty

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    the empty heads cannot appear unmodified $\rightarrow$ unpleasent solution:
    empty heads are subcategorized for their adjunct
- the only option is the unary projection

The Analysis in HPSG

(56) [$_{NP}$ [$_{RC}$ Wer schläft]], sündigt nicht.
who sleeps sins not

‘He who sleeps does not sin.’

semantic contribution of the FRC:

$$\begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{mas} \end{bmatrix} \\ \text{RESTR} & \left\{ \begin{bmatrix} \text{THEMA} & \boxed{1} \\ \textit{schlafen} \end{bmatrix} \right\} \\ \textit{nom-obj} \end{bmatrix}$$

semantic contribution of the relative clause:

$$\begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{MOD} & \overline{\text{N}}\text{:} \begin{bmatrix} \text{IND} & \boxed{1} \\ \text{RESTR} & \boxed{2} \end{bmatrix} \\ & \textit{relativizer} \end{bmatrix} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{IND} & \boxed{1} \begin{bmatrix} \text{PER} & \textit{3} \\ \text{NUM} & \textit{sg} \\ \text{GEN} & \textit{mas} \end{bmatrix} \\ \text{RESTR} & \boxed{2} \cup \left\{ \begin{bmatrix} \text{THEMA} & \boxed{1} \\ \textit{schlafen} \end{bmatrix} \right\} \end{bmatrix} \\ \textit{loc} & \end{bmatrix}$$

- The semantic contribution of the modified noun ($\boxed{2}$) is instantiated as {}.

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- The semantic contribution of the modified noun ($\boxed{2}$) is instantiated as {}.
- We get the contribution that we want for the FRC.

Projection of the Properties of the Relative Phrase

- information about the relative phrase must be accessible in the description of a relative clause
- three options
  - information in the daughters of the relative clause
  - the information could be projected by a nonlocal dependency
  - special feature for relative clauses
    (value identical to the head value of the relative phrase)

Accessing the Daughter of the Relative Clause

- would violate the Locality Principle (Pollard and Sag, 1987, p. 142–143) which forbids a head to access information under the path DTRS.

Accessing the Daughter of the Relative Clause

- would violate the Locality Principle (Pollard and Sag, 1987, p. 142–143) which forbids a head to access information under the path DTRS.
- This is not just a design issue:

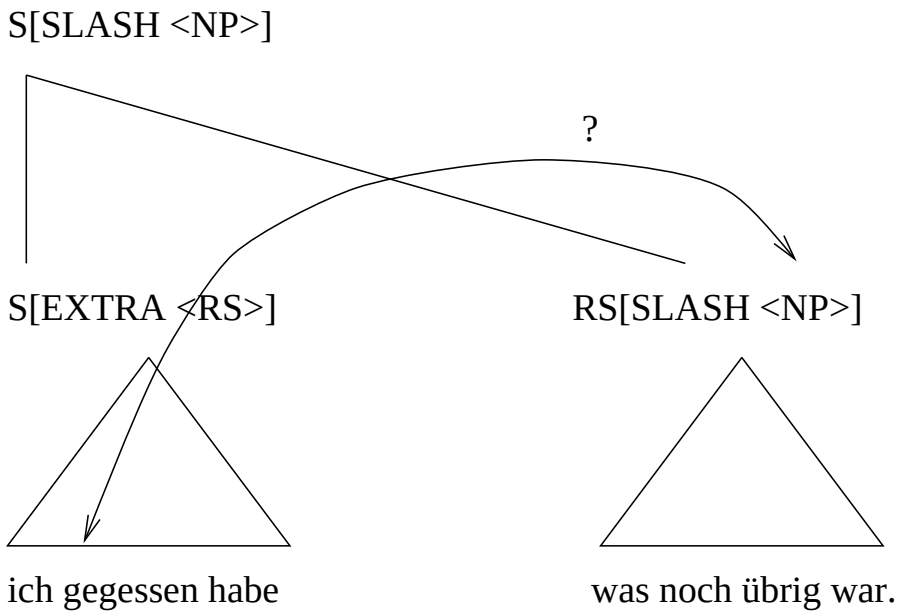
  (57) [[Wer erster wird] und [wer letzter wird]] müssen sich umarmen.
  who first becomes and who last becomes must self embrace

  Two relative clauses are coordinated, i.e., we cannot say something like: Look at the first daughter.

- In order to find the relative phrases in (57) we had to dig around in structures.

Projecting the Nonlocal-Information about the Relative Phrase

- Relative Clauses are finite clauses with one element extracted.
- The relative phrase binds off a gap in a finite clause.
- We could decide to not bind the gap off.
- not compatible with the treatment of extraposition as a nonlocal dependency, as was suggested by Keller (1995) and Bouma (1996):

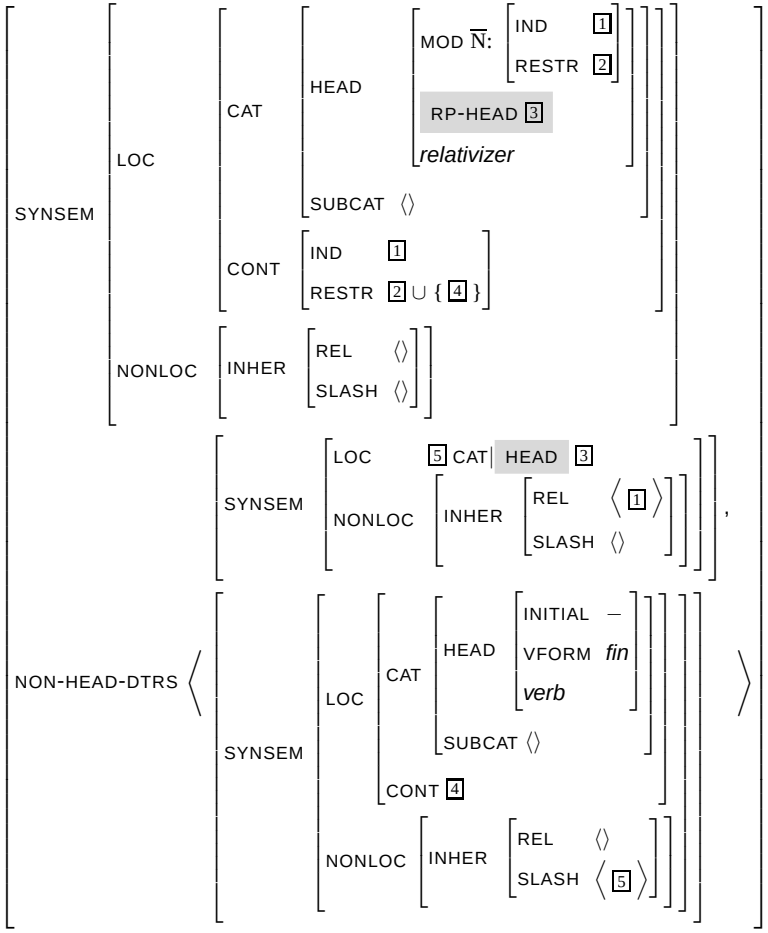


ALternative: Explicit Projection

- explicit projection of the properties of the relative phrase
- only head features have to be projected since FRC stand for maximal NPs, PPs or whatever
- feature RP-HEAD for all relative clauses that contains the head features of the relative phrase
- special rule that accesses this feature and projects the appropriate phrase

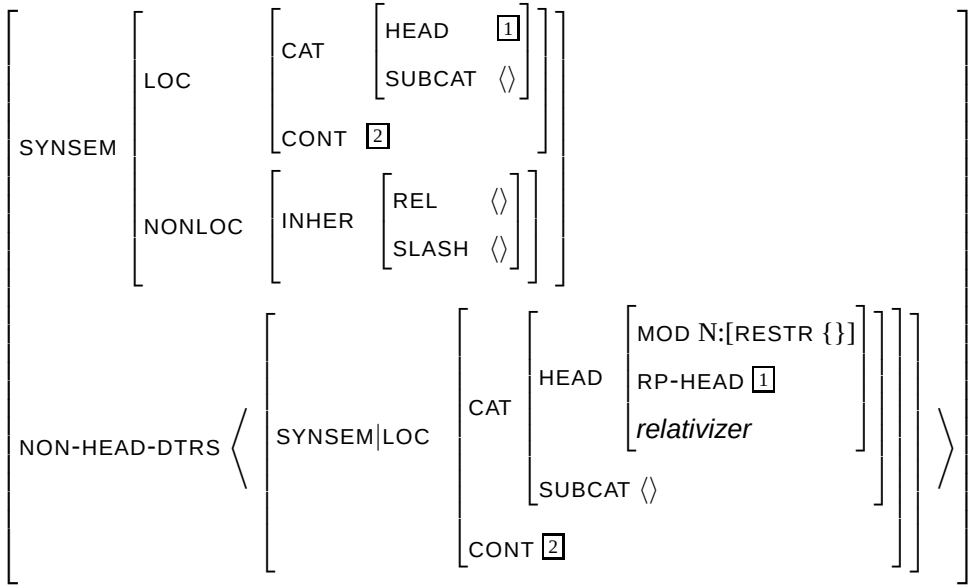
Schema 8 (Relative Clause Schema (final version))

relativizer-structure →



The Schema for FRCs

relativizer-projection-structure →



- The properties of the relative phrase (1) get projected.
- The resulting projection is maximal (SUBCAT ⟨⟩).
- The RESTR set in the MOD value of the relative clause is instantiated as {}.
  This corresponds to the intuition that an empty element is modified.
- The semantic contribution of the relative clause is taken over.

Conclusion

- unary schema
- part of an implemented fragment

Demo

(58) a. Wer schläft, sündigt nicht.

b. Wen er liebt, lädt er ein.

c. Wem er vertraut, hilft er auch. (Engel, 1977)

(59) a. Wem der Termin paßt, kann kommen.

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