Head-Driven Phrase Structure Grammar (HPSG)
Introduction

Grammatikformalismen – Lecture
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UNIVERSITÄT
DES
SAARLANDES

The building blocks of HPSG grammars

In HPSG, sentences, words, phrases, and multisentence discourses are all represented as **signs** = complexes of phonological, syntactic/semantic, and discourse information.

We can (and will) view HPSG grammars in two different ways:

1. From a linguistic perspective
2. From a formal perspective

HPSG grammars from a linguistic perspective

From a linguistic perspective, an HPSG grammar consists of

a) a lexicon
licensing basic words

b) lexical rules
licensing derived words

c) immediate dominance (ID) schemata
licensing constituent structure

d) linear precedence (LP) statements
constraining word order

e) a set of grammatical principles
expressing generalizations about linguistic objects

HPSG feature structures

HPSG is nonderivational, but in some sense, HPSG has several different levels (layers of features)

A feature structure is a directed acyclic graph (DAG), with arcs representing features going between values

Each of these feature values is itself a complex object:

- The **type** *sign* has the **features** PHON and SYNSEM appropriate for it
- The feature SYNSEM has a **value** of type *synsem*
- This type itself has relevant features (LOCAL and NON-LOCAL)

HPSG grammars from a formal perspective

From a formal perspective, an HPSG grammar consists of

- **the signature** as declaration of the domain, and
- **the theory** constraining the domain.

The signature

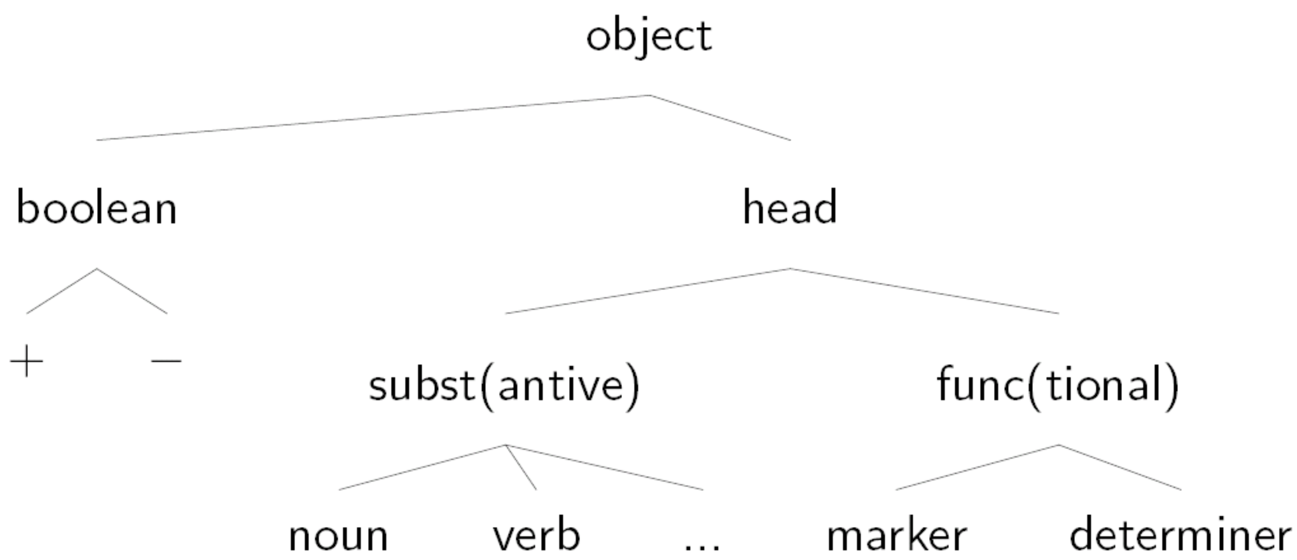
- defines the ontology ('declaration of what exists'):
  - which kind of objects are distinguished, and
  - which properties of which objects are modeled.

- consists of
  - the type (or sort) hierarchy and
  - the appropriateness conditions, defining which type has which appropriate attributes (or features) with which appropriate values.

    Some **atomic** types have no feature appropriate for them

Example excerpt of a signature

Here, we leave out the appropriateness conditions and just show a hierarchy of types



Sort-resolved

Based on the example signature, the following two descriptions are equivalent:

(1) a. *func*

b. *marker* $\vee$ *determiner*

That is, a type (or sort) is really a disjunction of its **maximally specific subtypes**

Models of linguistic objects

- As mentioned, the objects are modelled by feature structures, which are depicted as directed graphs.

- Since these models represent objects in the world (and not knowledge about the world), they are total with respect to the ontology declared in the signature. Technically, one says that these feature structures are
  - *totally well-typed*: Every node has all the attributes appropriate for its type and each attributes has an appropriate value.
  - *sort-resolved*: Every node is of a maximally specific type.

Structure sharing

The main explanatory mechanism in HPSG is that of **structure-sharing**, equating two features as having the exact same value (token-identical)

$$\begin{bmatrix} \textit{word} & \\ \text{PHON} & <\textit{walks}> \\ \text{SYNSEM}|\text{LOC} & \begin{bmatrix} \text{CAT}|\text{SUBCAT} & \left\langle \text{NP}[\textit{nom}]_{\boxed{1}}[\textit{3rd,sing}] \right\rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{laugh'} & \\ \text{LAUGHER} & \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The index of the NP on the SUBCAT list is said to **unify** with the value of LAUGHER

Descriptions

A **description language** and its abbreviating **attribute-value matrix (AVM) notation** is used to talk about sets of objects. Descriptions consists of three building blocks:

- **Type** decriptions single out all objects of a particular type, e.g., *word*
- **Attribute-value pairs** describe objects that have a particular property. The attribute must be appropriate for the particular type of object, and the value can be any kind of description, e.g., $\left[\text{SPOUSE} \left[\text{NAME} \; \textit{mary}\right]\right]$
- **Tags** (structure sharing) to specify **token identity**, e.g. $\boxed{1}$

Descriptions (cont.)

Complex descriptions are obtained by combining descriptions with the help of conjunction ($\wedge$), disjunction ($\vee$) and negation ($\neg$). In the AVM notation, conjunction is implicit.

A **theory** (in the formal sense) is a set of description language statements, often referred to as the constraints.

- The theory singles out a subset of the objects declared in the signature, namely those which are grammatical.
- A linguistic object is admissible with respect to a theory iff it satisfies each of the descriptions in the theory and so does each of its substructures.

Description example

A verb, for example, can specify that its subject be masculine singular (as Russian past tense verbs do):

(2) a. Ya spal.
I$_{masc.sg}$ slept$_{masc.sg}$

b. On spal.
He$_{masc.sg}$ slept$_{masc.sg}$

(3)
$$\begin{bmatrix} \textit{word} \\ \text{SYNSEM}|\text{LOC} \begin{bmatrix} \text{CAT}|\text{HEAD} & \textit{noun} \\ \text{CONTENT} & \begin{bmatrix} \text{INDEX} \begin{bmatrix} \text{NUM} & \textit{sing} \\ \text{GEN} & \textit{masc} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

This doesn't specify the entire (totally well-typed) feature structure, just what needs to be true in the feature structure.

Subsumption

The description in (3) is said to **subsume** both of the following (partial) feature structures:

(4) a.

$$\begin{bmatrix} \textit{word} & \\ \text{SYNSEM}|\text{LOC} & \begin{bmatrix} \text{CAT}|\text{HEAD} & \textit{noun} \\ \text{CONTENT} & \begin{bmatrix} \text{INDEX} & \begin{bmatrix} \text{PER} & \textit{1st} \\ \text{NUM} & \textit{sing} \\ \text{GEN} & \textit{masc} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

b.

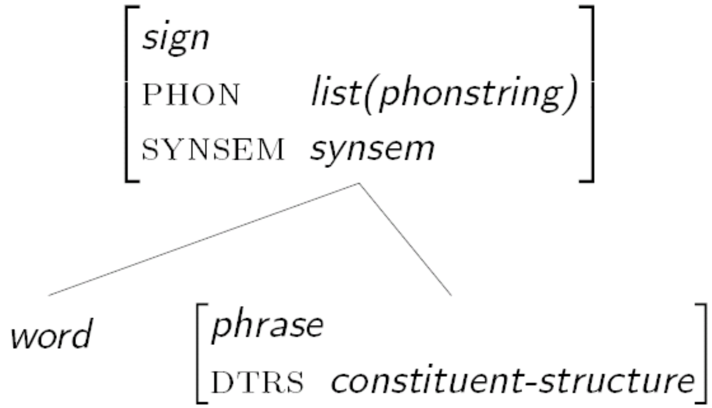
$$\begin{bmatrix} \textit{word} & \\ \text{SYNSEM}|\text{LOC} & \begin{bmatrix} \text{CAT}|\text{HEAD} & \textit{noun} \\ \text{CONTENT} & \begin{bmatrix} \text{INDEX} & \begin{bmatrix} \text{PER} & \textit{3rd} \\ \text{NUM} & \textit{sing} \\ \text{GEN} & \textit{masc} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

HPSG from a linguistic perspective (again)

Now that we have these feature structures, how do we use them for linguistic purposes?

- Specify a signature/ontology which allows us to make linguistically-relevant distinctions and puts appropriate features in the appropriate places
- Specify a theory which constrains that signature for a particular language
  - Lexicon specifies each word and the different properties that it has There can also be relations (so-called lexical rules) between words in the lexicon
  - Phrasal rules, or principles allow words to combine into phrases

An ontology of linguistic objects



synsem	
LOCAL	*local*
NON-LOCAL	*non-local*

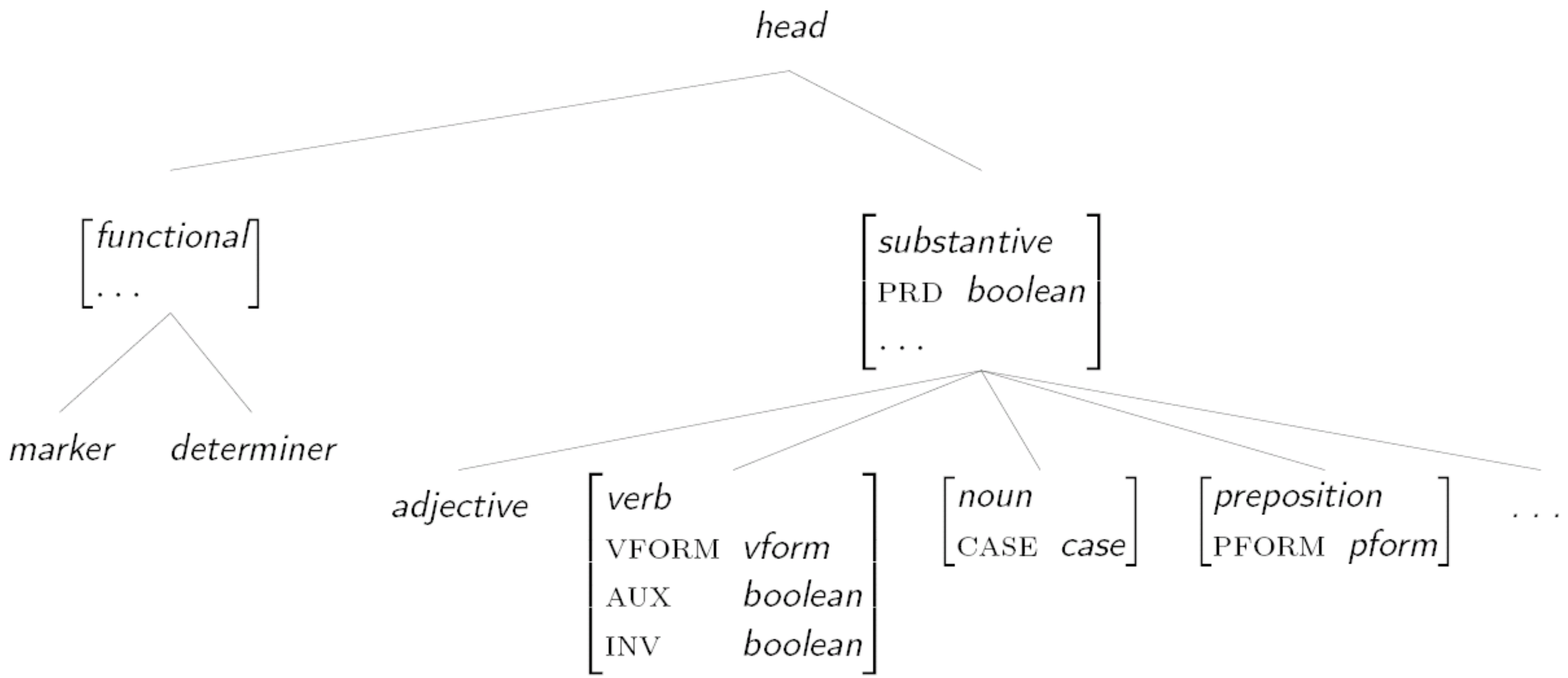
local	
CATEGORY	*category*
CONTENT	*content*
CONTEXT	*context*

category	
HEAD	*head*
SUBCAT	*list(synsem)*
...	

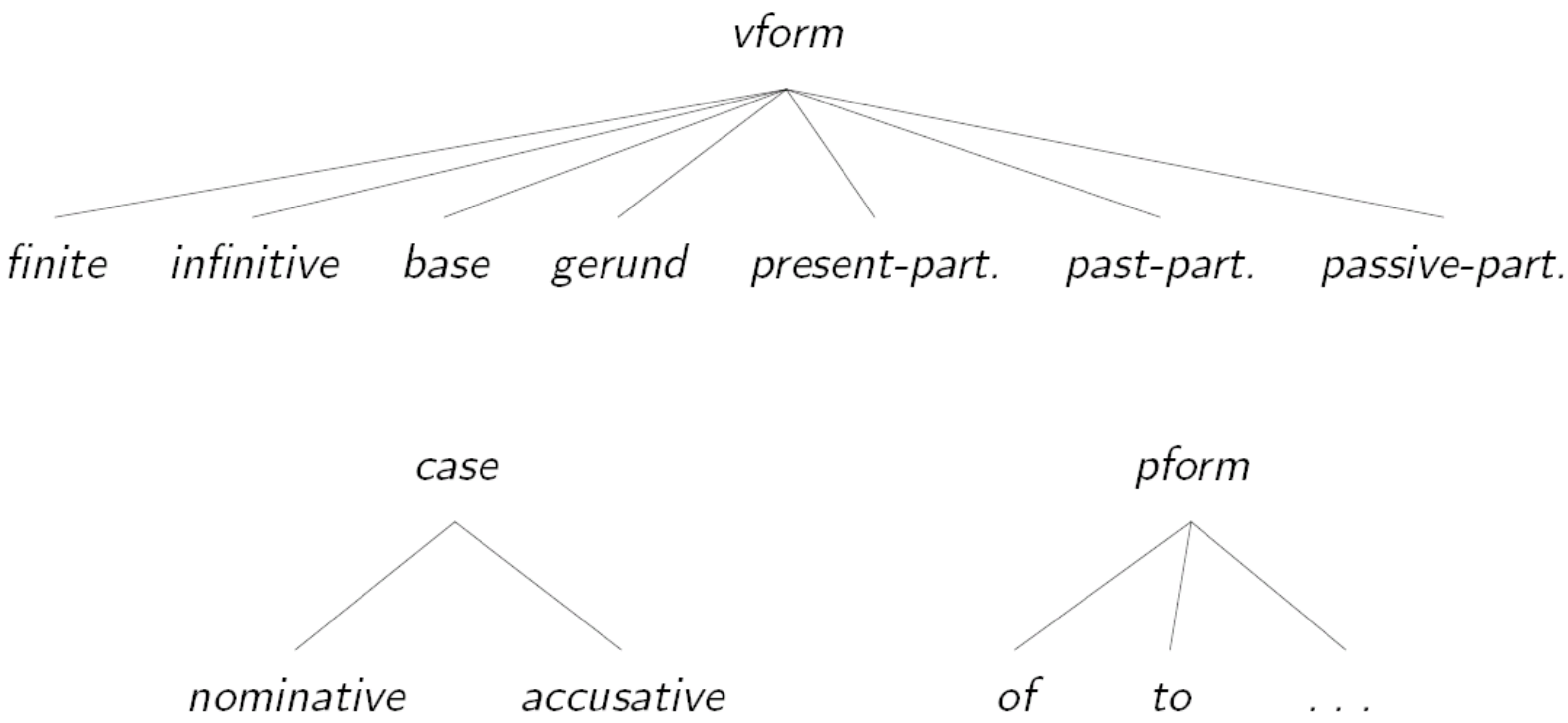
Why the complicated structure?

- LOCAL & NONLOCAL: Most linguistic constructions can be handled locally, but non-local constructions (e.g., extraction) require different mechanisms
- CATEGORY, CONTENT, and CONTEXT: roughly, these correspond to syntactic, semantic, and pragmatic notions, all of which are locally determined
- HEAD and SUBCAT: a words syntactic information comes in two parts: its own lexical information (part of speech, etc.) and information about its arguments

Part-of-speech (head information)



Properties of particular part-of-speech



Motivating VFORM

(5) a. Peter will *win* the race. (base form)
b. * Peter will *won* the race.
c. * Peter will *to win* the race.

(6) a. Peter has *won* the race. (past participle)
b. * Peter has *win* the race.
c. Peter has *to win* the race.
(→ different verb)

(7) a. Peter seems *to win* the race. (*to*-infinitive)
b. * Peter seems *win* the race.
c. * Peter seems *won* the race.

Motivating CASE

(8) a. *He* left. (nom)
b. * *Him* left.

(9) a. She sees *him*. (acc)
b. * She sees *he*.

Motivating SUBCAT

(10) a. I *laugh*. (<NP>)
b. I *saw* him. (<NP NP>)
c. I *give* her the book. (<NP NP NP>)
d. I *said* that she left. (<NP S[that]>)

Cannot always be derived from semantics:

(11) a. Paul ate a steak. (<NP>)
b. Paul ate. (<NP NP>)

(12) a. Paul devoured a steak. (<NP>)
b. * Paul devoured (<NP NP>)

What SUBCAT does

The SUBCAT list can be thought of as akin to a word's valency requirements

- Items on the SUBCAT list are ordered by obliqueness—akin to LFG—not necessarily by linear order

- The SUBCAT Principle, described below, will describe a way for a word to combine with its arguments
  - That is, we will still need a way to go from the SUBCAT specification to some sort of tree structure

Locality of SUBCAT

SUBCAT selects a list of SYNSEM values, not SIGN values.

- If you work through the ontology, this means that a word does not have access to the DTRS list of items on its own SUBCAT list
- Intuitively, this means that a word cannot dictate properties of the daughters of its daughters.

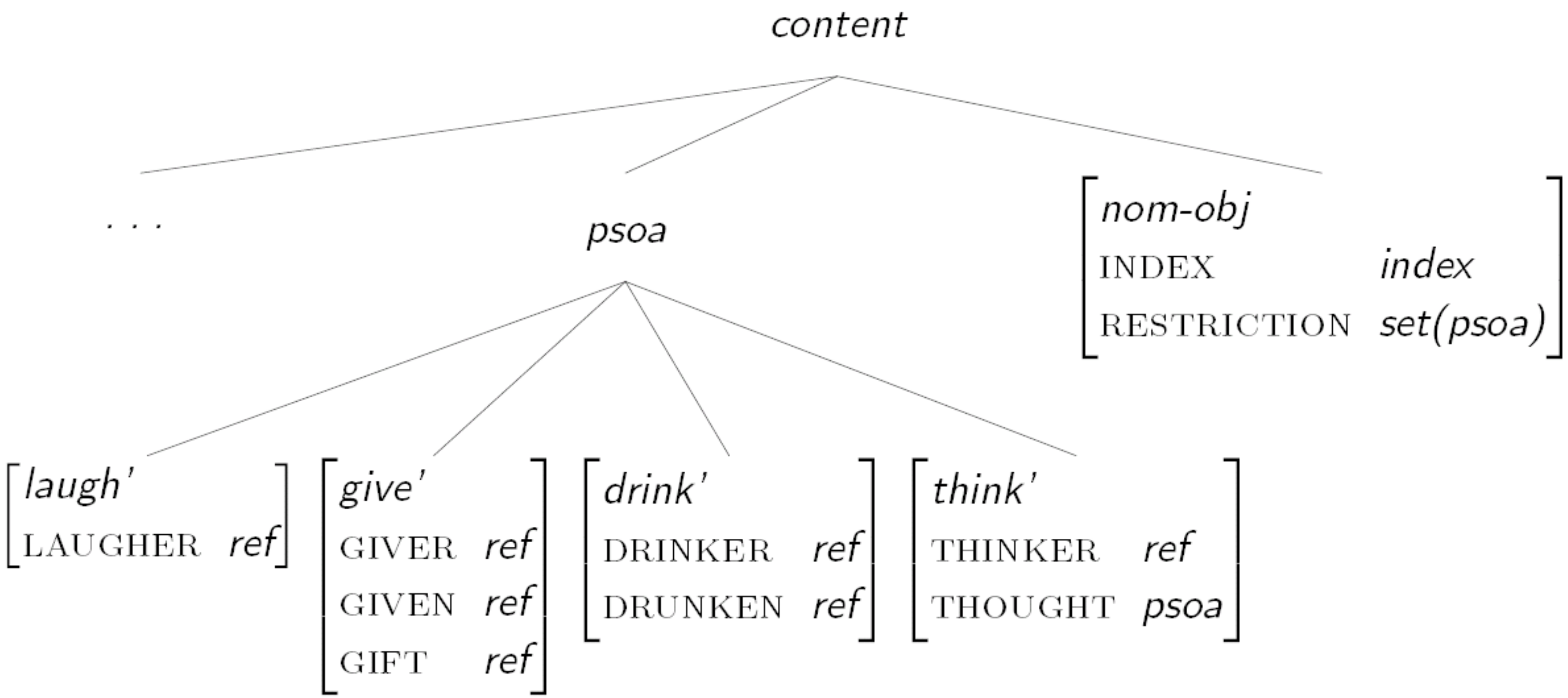
⇒ Constructions are thus restricted to local relations

CONTENT information

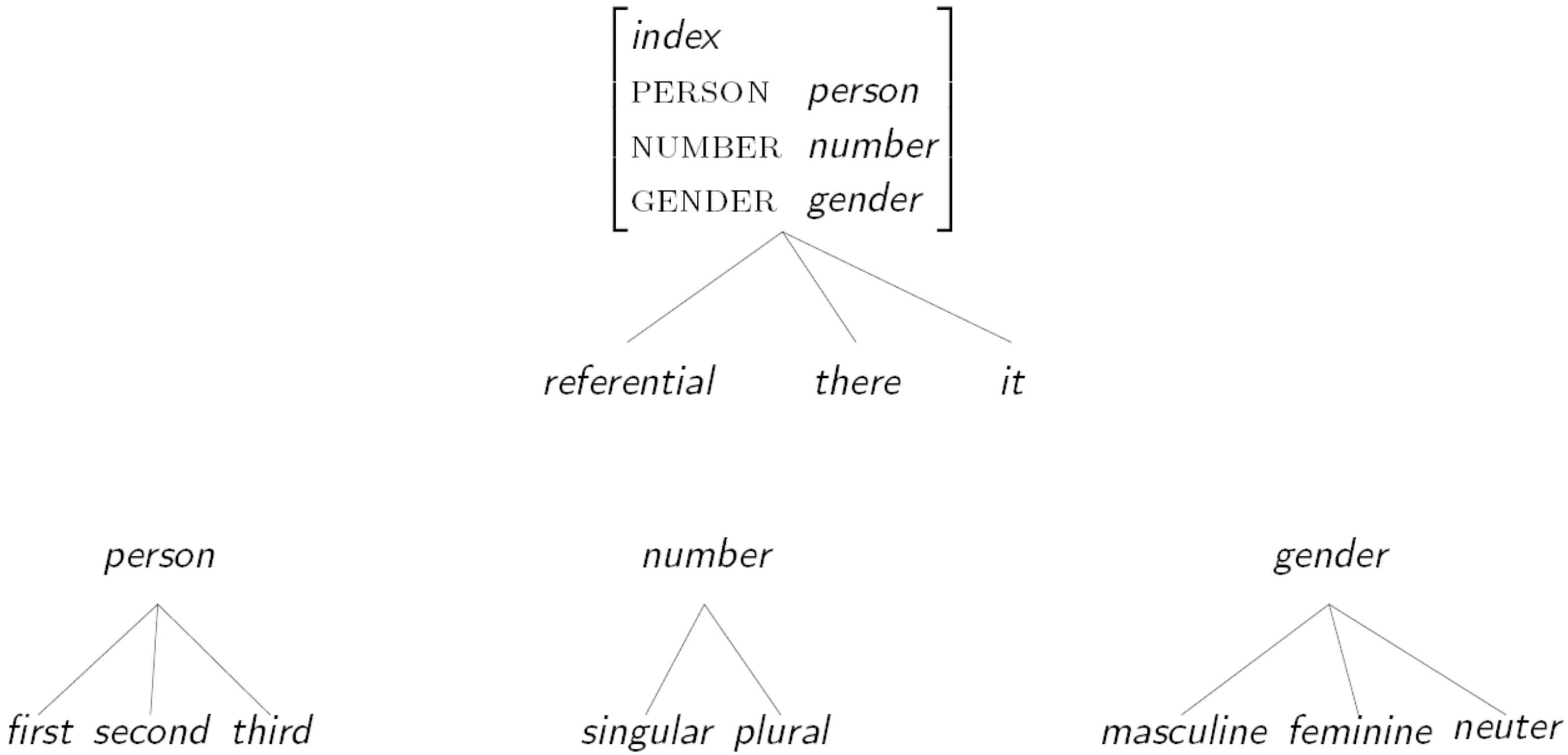
The CONTENT feature specifies different semantic information

- A feature appropriate for *nominal-object* objects (a subtype of *content* objects) is INDEX
- Agreement features can be stated through the INDEX feature
- Note that CASE was put somewhere else (within HEAD), so CASE agreement is treated differently than person, number, and gender agreement (at least in English)

Semantic representations

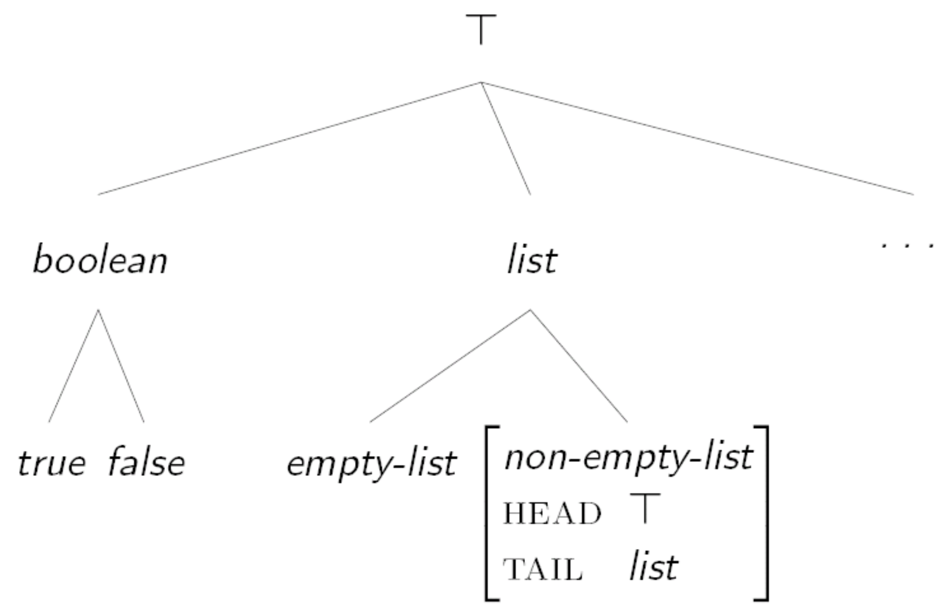


Indices


index
PERSON person
NUMBER number
GENDER gender
referential
there
it
person
first
second
third
number
singular
plural
gender
masculine
feminine
neuter

Auxiliary data structures

Before we move on to some linguistic examples, a few other objects need to be defined



Abbreviations for describing lists

empty-list	is abbreviated as	*e-list*, $<>$
non-empty-list	is abbreviated as	*ne-list*
$\begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{TAIL} & \boxed{2} \end{bmatrix}$	is abbreviated as	$\left\langle \boxed{1} \mid \boxed{2} \right\rangle$
$\left\langle \ldots \boxed{1} \mid \langle\rangle \right\rangle$	is abbreviated as	$\left\langle \ldots \boxed{1} \right\rangle$
$\begin{bmatrix} \text{HEAD} & \boxed{1} \\ \text{TAIL} & \begin{bmatrix} \text{HEAD} & \boxed{2} \\ \text{TAIL} & \boxed{3} \end{bmatrix} \end{bmatrix}$	is abbreviated as	$\left\langle \boxed{1} , \boxed{2} \mid \boxed{3} \right\rangle$

Attention: $\left\langle \top \right\rangle$ and $\left\langle \boxed{1} \right\rangle$ describe all lists of length **one**!

Abbreviations of common AVMs

Pollard and Sag (1994) use some abbreviations to describe *synsem* objects:

Abbreviation	Abbreviated AVM
$\text{NP}_{\boxed{1}}$	$\begin{bmatrix} \textit{synsem} & \\ \text{LOCAL} & \begin{bmatrix} \text{CATEGORY} & \begin{bmatrix} \text{HEAD} & \textit{noun} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{CONTENT}\mid\text{INDEX} & \boxed{1} \end{bmatrix} \end{bmatrix}$
$\text{S}{:}\boxed{1}$	$\begin{bmatrix} \textit{synsem} & \\ \text{LOCAL} & \begin{bmatrix} \text{CATEGORY} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{CONTENT} & \boxed{1} \end{bmatrix} \end{bmatrix}$
$\text{VP}{:}\boxed{1}$	$\begin{bmatrix} \textit{synsem} & \\ \text{LOCAL} & \begin{bmatrix} \text{CATEGORY} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{SUBCAT} & \left\langle \textit{synsem} \right\rangle \end{bmatrix} \\ \text{CONTENT} & \boxed{1} \end{bmatrix} \end{bmatrix}$

The Lexicon

The basic lexicon is defined by the *Word Principle* as part of the theory. It defines which of the ontologically possible words are grammatical:

$$\textit{word} \rightarrow \text{lexical-entry}_1 \vee \text{lexical-entry}_2 \vee \ldots$$

with each of the lexical entries being descriptions, such as e.g.:

$$\begin{bmatrix} \textit{word} & \\ \text{PHON} & <\textit{laughs}> \\ \text{SYNSEM}|\text{LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{verb} & \\ \text{VFORM} & \textit{fin} \end{bmatrix} \\ \text{SUBCAT} & \left\langle \text{NP}[\textit{nom}]_{\boxed{1}}[\textit{3rd,sing}] \right\rangle \end{bmatrix} \\ \text{CONTENT} & \begin{bmatrix} \textit{laugh'} & \\ \text{LAUGHER} & \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

An example lexicon

$$
\textit{word} \longrightarrow \begin{bmatrix} \text{PHON} & \langle \textit{gives} \rangle \\ \text{S}|\text{L} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{verb} & \\ \text{VFORM} & \textit{fin} \end{bmatrix} \\ \text{SUBCAT} & \left\langle \text{NP}[\textit{nom}]_{\boxed{1}}[\textit{sing}],\ \text{NP}[\textit{acc}]_{\boxed{2}},\ \text{PP}[\textit{to}]_{\boxed{3}} \right\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \textit{give}' & \\ \text{GIVER} & \boxed{1} \\ \text{GIFT} & \boxed{2} \\ \text{GIVEN} & \boxed{3} \end{bmatrix} \end{bmatrix} \end{bmatrix}
$$

$$
\mathrm{V}\left[\begin{array}{ll}
\textsc{phon} & \langle \textit{drinks} \rangle \\
\textsc{s}|\textsc{l} & \left[\begin{array}{ll}
\textsc{cat} & \left[\begin{array}{ll}
\textsc{head} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{verb}} \\ \textsc{vform} & \textit{fin} \end{array}\right] \\
\textsc{subcat} & \left\langle \mathrm{NP}[\textit{nom}]_{\boxed{1}[\textit{3rd,sing}]},\ \mathrm{NP}[\textit{acc}]_{\boxed{2}} \right\rangle
\end{array}\right] \\
\textsc{cont} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{drink}'} \\ \textsc{drinker} & \boxed{1} \\ \textsc{drunken} & \boxed{2} \end{array}\right]
\end{array}\right]
\end{array}\right]
$$

$$
\mathrm{V}\left[\begin{array}{ll}
\textsc{phon} & \langle \textit{drink} \rangle \\
\textsc{s}|\textsc{l} & \left[\begin{array}{ll}
\textsc{cat} & \left[\begin{array}{ll}
\textsc{head} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{verb}} \\ \textsc{vform} & \textit{fin} \end{array}\right] \\
\textsc{subcat} & \left\langle \mathrm{NP}[\textit{nom}]_{\boxed{1}[\textit{plur}]},\ \mathrm{NP}[\textit{acc}]_{\boxed{2}} \right\rangle
\end{array}\right] \\
\textsc{cont} & \left[\begin{array}{ll} \multicolumn{2}{l}{\textit{drink}'} \\ \textsc{drinker} & \boxed{1} \\ \textsc{drunken} & \boxed{2} \end{array}\right]
\end{array}\right]
\end{array}\right]
$$

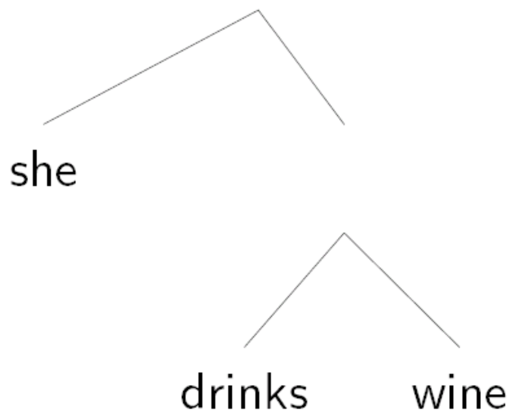
$$\vee \begin{bmatrix} \text{PHON} & <\textit{she}> \\ \text{SYNSEM}|\text{LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{noun} & \\ \text{CASE} & \textit{nom} \end{bmatrix} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{INDEX} & \begin{bmatrix} \text{PER} & \textit{third} \\ \text{NUM} & \textit{sing} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\vee \begin{bmatrix} \text{PHON} & <\textit{wine}> \\ \text{SYNSEM}|\text{LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{noun} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{INDEX} & \begin{bmatrix} \text{PER} & \textit{third} \\ \text{NUM} & \textit{sing} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\bigvee \begin{bmatrix} \text{PHON} & \langle \textit{to} \rangle \\ \text{S}|\text{L} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{preposition} \\ \text{PFORM} \;\; \textit{to} \end{bmatrix} \\ \text{SUBCAT} & \left\langle \text{NP}[\textit{acc}]_{\boxed{1}} \right\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{INDEX} & \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\bigvee \begin{bmatrix} \text{PHON} & \langle \textit{think} \rangle \\ \text{S}|\text{L} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{verb} \\ \text{VFORM} \;\; \textit{fin} \end{bmatrix} \\ \text{SUBCAT} & \left\langle \text{NP}[\textit{nom}]_{\boxed{1}[\textit{plur}]}, \text{S}[\textit{fin}]:\boxed{2} \right\rangle \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \textit{think'} & \\ \text{THINKER} & \boxed{1} \\ \text{THOUGHT} & \boxed{2} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

A very first sketch of an example



Types of phrases

In order to put words from our lexicon into a sentence, we have to define what makes an acceptable sentence structure

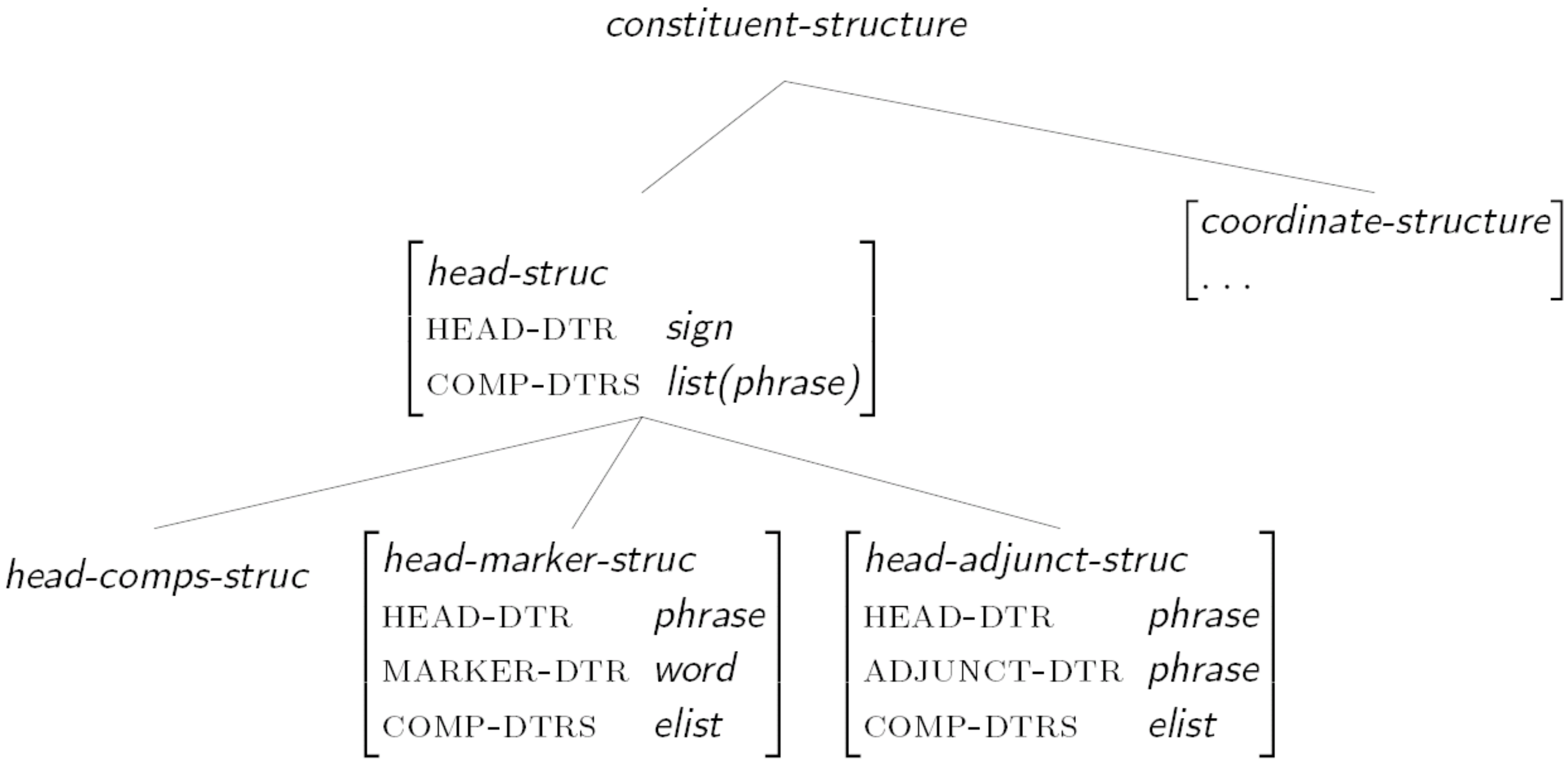
- Each *phrase* has a DTRS attribute (*words* do not have this attribute), which has a *constituent-structure* value

- This DTRS value loosely corresponds to what we normally view in a tree as daughters

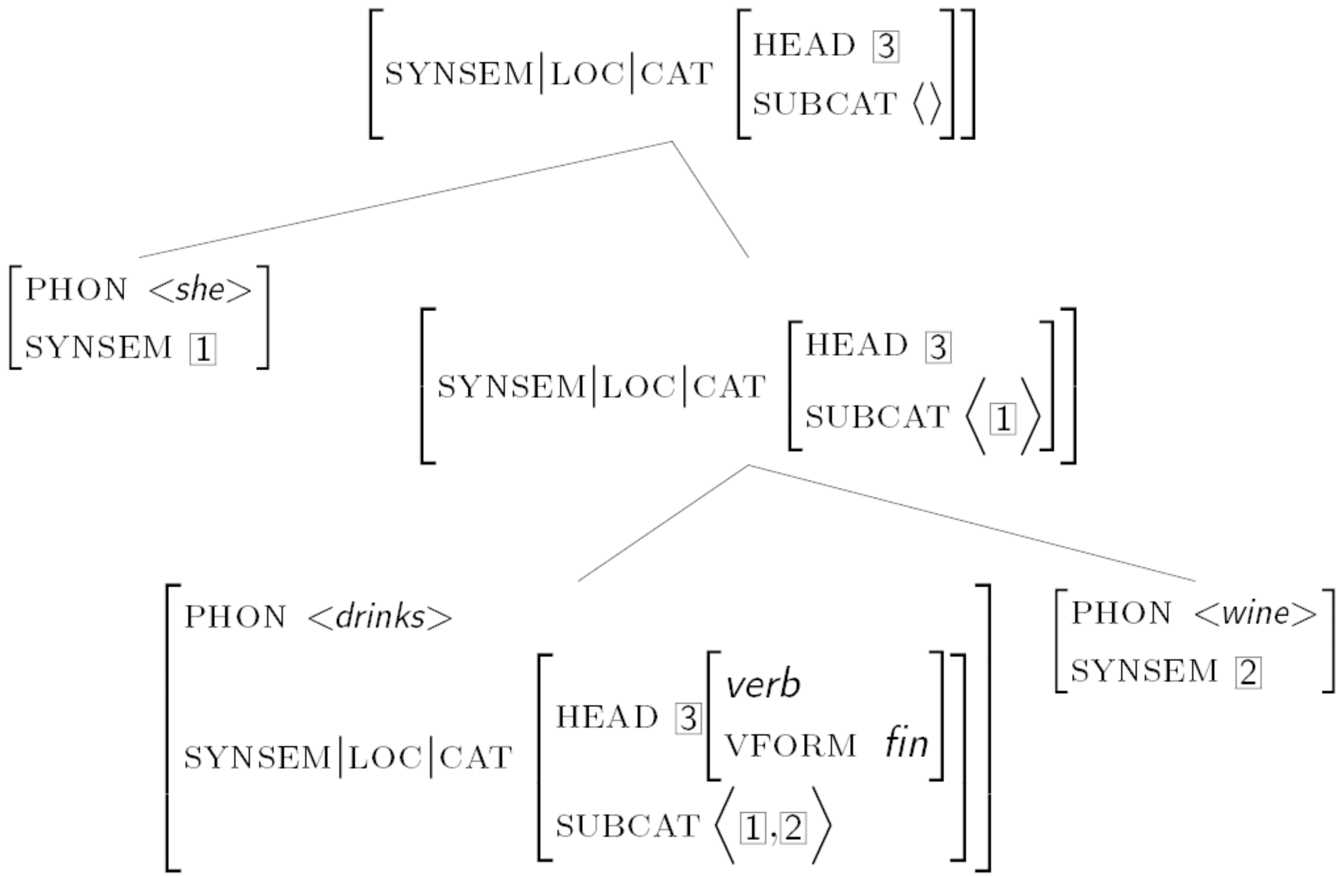
  Additionally, tree branches" contain grammatical role information (adjunct, complement, etc.)

- By distinguishing different kinds of *constituent-structures*, we define what kinds of phrases exist in a language

An ontology of phrases



Sketch of an example for head-complement structures



Universal Principles

But how exactly did that last example work?

- *drinks* has head information specifying that it is a verb and so forth, and it also has subcategorization information specifying that it needs a subjects and an object.
  - The head information gets percolated up (The HEAD Principle)
  - The subcategorization information gets "checked off" as you move up in the tree (The SUBCAT Principle)

Such principles are treated as linguistic universals in HPSG.

Head-Feature Principle:

- In prose: The HEAD feature of any headed phrase is structure-shared with the HEAD value of the head daughter.
- Specified as a **constraint**:

$$\begin{bmatrix} \textit{phrase} & \\ \text{DTRS} & \textit{headed-structure} \end{bmatrix} \rightarrow \begin{bmatrix} \text{SYNSEM}|\text{LOC}|\text{CAT}|\text{HEAD} & \boxed{1} \\ \text{DTRS}|\text{HEAD-DTR}|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{HEAD} & \boxed{1} \end{bmatrix}$$

Subcat Principle:

In a headed phrase, the SUBCAT value of the head daughter is the concatenation of the phrase's SUBCAT list with the list (in order of increasing obliqueness of SYNSEM values of the complement daughters.

$$\left[\text{DTRS} \;\; \textit{headed-structure}\right] \longrightarrow \begin{bmatrix} \text{SYNSEM}|\text{LOC}|\text{CAT}|\text{SUBCAT} \; \boxed{1} \\ \text{DTRS} \begin{bmatrix} \text{HEAD-DTR}|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{SUBCAT} \; \boxed{1} \oplus \boxed{2} \\ \text{COMP-DTRS} \; \textit{synsem2sign}\left(\boxed{2}\right) \end{bmatrix} \end{bmatrix}$$

with $\oplus$ standing for list concatenation, i.e., *append*, defined as follows

$$\begin{array}{lcl} \textit{e-list} \oplus \boxed{1} & := & \boxed{1}. \\ \begin{bmatrix} \text{FIRST} & \boxed{1} \\ \text{REST} & \boxed{2} \end{bmatrix} \oplus \boxed{3} & := & \begin{bmatrix} \text{FIRST} & \boxed{1} \\ \text{REST} & \boxed{2} \oplus \boxed{3} \end{bmatrix}. \end{array}$$

Fallout from these Principles

- Note that agreement is handled neatly, simply by the fact that the SYNSEM values of a word's daughters are token-identical to the word's SUBCAT items.

One question remains before we can get the structure we have above:

- How exactly do we decide on a syntactic structure?
- i.e., Why is it that the object was checked off low and the subject was checked off at a higher point?

Answer: because of the ID schemata used

Immediate Dominance (ID) Schemata

- There is an inventory of valid ID schemata in a language
- Every headed phrase must satisfy exactly one of the ID schemata
  - Which ID schema is used depends on the type of the DTRS attribute
  - this goes back to the ontology of phrases we saw earlier

Immediate Dominance Principle (for English):

$$\begin{bmatrix} \textit{phrase} & \\ \text{DTRS} & \textit{headed-struc} \end{bmatrix} \rightarrow \begin{bmatrix} \text{SYNSEM|LOC|CAT} & \begin{bmatrix} \text{HEAD} & \left(\begin{bmatrix} \textit{verb} & \\ \text{INV} & - \end{bmatrix} \lor \neg\ \textit{verb} \right) \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{DTRS} & \begin{bmatrix} \textit{head-comps-struc} & \\ \text{HEAD-DTR} & \textit{phrase} \\ \text{COMP-DTRS} & \langle \textit{sign} \rangle \end{bmatrix} \end{bmatrix} \qquad \text{(Head-Subject)}$$

$$\lor \begin{bmatrix} \text{SYNSEM|LOC|CAT} & \begin{bmatrix} \text{HEAD} & \left(\begin{bmatrix} \textit{verb} & \\ \text{INV} & - \end{bmatrix} \lor \neg\ \textit{verb} \right) \\ \text{SUBCAT} & \langle \textit{synsem} \rangle \end{bmatrix} \\ \text{DTRS} & \begin{bmatrix} \textit{head-comps-struc} & \\ \text{HEAD-DTR} & \textit{word} \end{bmatrix} \end{bmatrix} \qquad \text{(Head-Complement)}$$

$$\lor \begin{bmatrix} \text{SYNSEM|LOC|CAT} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{verb} & \\ \text{INV} & + \end{bmatrix} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{DTRS} & \begin{bmatrix} \textit{head-comps-struc} & \\ \text{HEAD-DTR} & \textit{word} \end{bmatrix} \end{bmatrix} \qquad \text{(Head-Subject-Complement)}$$

$\lor$ . . . continued on next page

Immediate Dominance Principle (for English):

$$\begin{bmatrix} \textit{phrase} \\ \text{DTRS} \;\; \textit{headed-struc} \end{bmatrix} \rightarrow \;\; \begin{array}{l} \vdots \\ \vdots \\ \vdots \\ \vee \begin{bmatrix} \text{DTRS} & \begin{bmatrix} \textit{head-marker-struc} \\ \text{MARKER-DTR|SYNSEM|LOC|CAT|HEAD} \;\; \textit{marker} \end{bmatrix} \end{bmatrix} \;\; \text{(Head-Marker)} \\ \vee \begin{bmatrix} \text{DTRS} & \begin{bmatrix} \textit{head-adjunct-struc} \\ \text{ADJ-DTR|SYNSEM|LOC|CAT|HEAD|MOD} \;\; \boxed{1} \\ \text{HEAD-DTR|SYNSEM} \;\; \boxed{1} \end{bmatrix} \end{bmatrix} \;\; \text{(Head-Adjunct)} \end{array}$$

So, in the example of *She drinks wine*, the DTRS value over *drinks wine* is a *head-comps-struc*, while the DTRS over the whole sentence is a *head-subj-struc*

Towards Head Adjunct Structures

Lexical entry of an attributive adjective

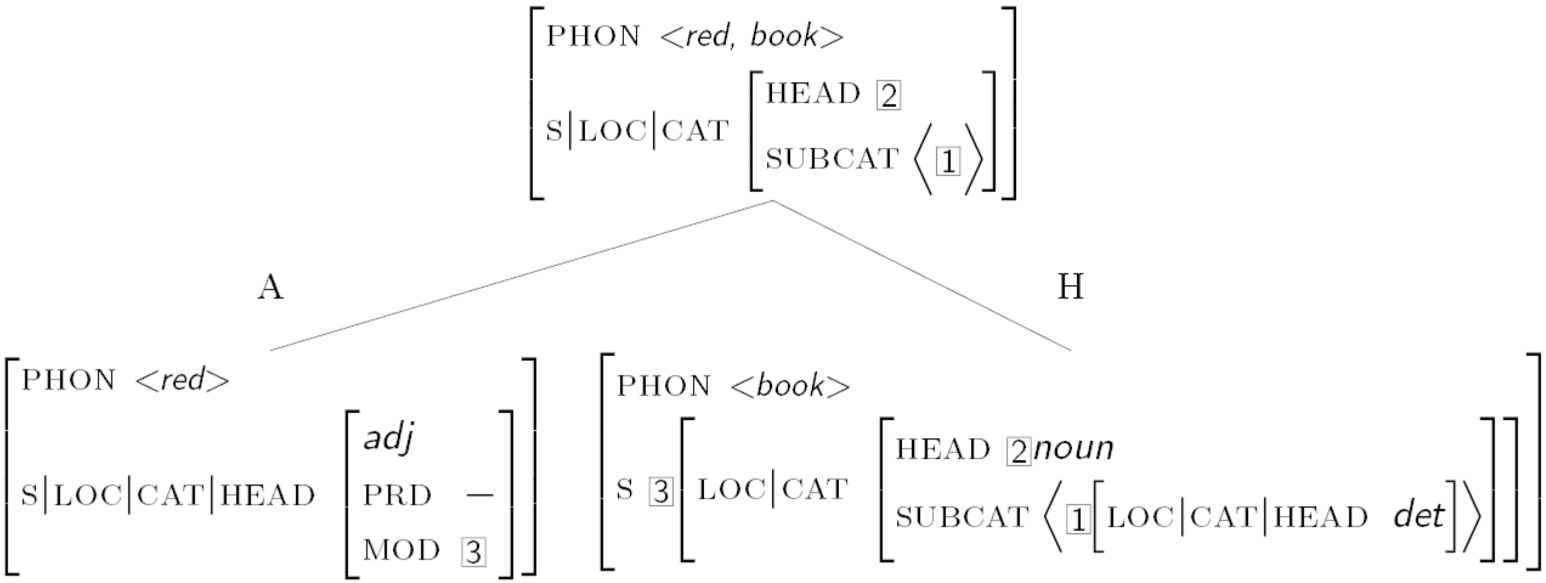
```
[word
 PHON    <red>
 SYNSEM  [synsem
          LOCAL [local
                 CATEGORY [cat
                           HEAD [adj
                                 PRD  −
                                 MOD  [synsem
                                       LOCAL [local
                                              CATEGORY [cat
                                                        HEAD    noun
                                                        SUBCAT  ⟨ [synsem
                                                                   LOCAL [local
                                                                          CATEGORY [cat
                                                                                    HEAD det]]] ⟩ ]
                                              CONTENT  [nom-obj
                                                        INDEX [1] index
                                                        RESTR [2] list]]]]]
                 CONTENT  [nom-obj
                           INDEX [1]
                           RESTR ⟨ [red-rel
                                    ARG1 [1]] | [2] ⟩ ]]]]
```

Lexical entry of an attributive adjective

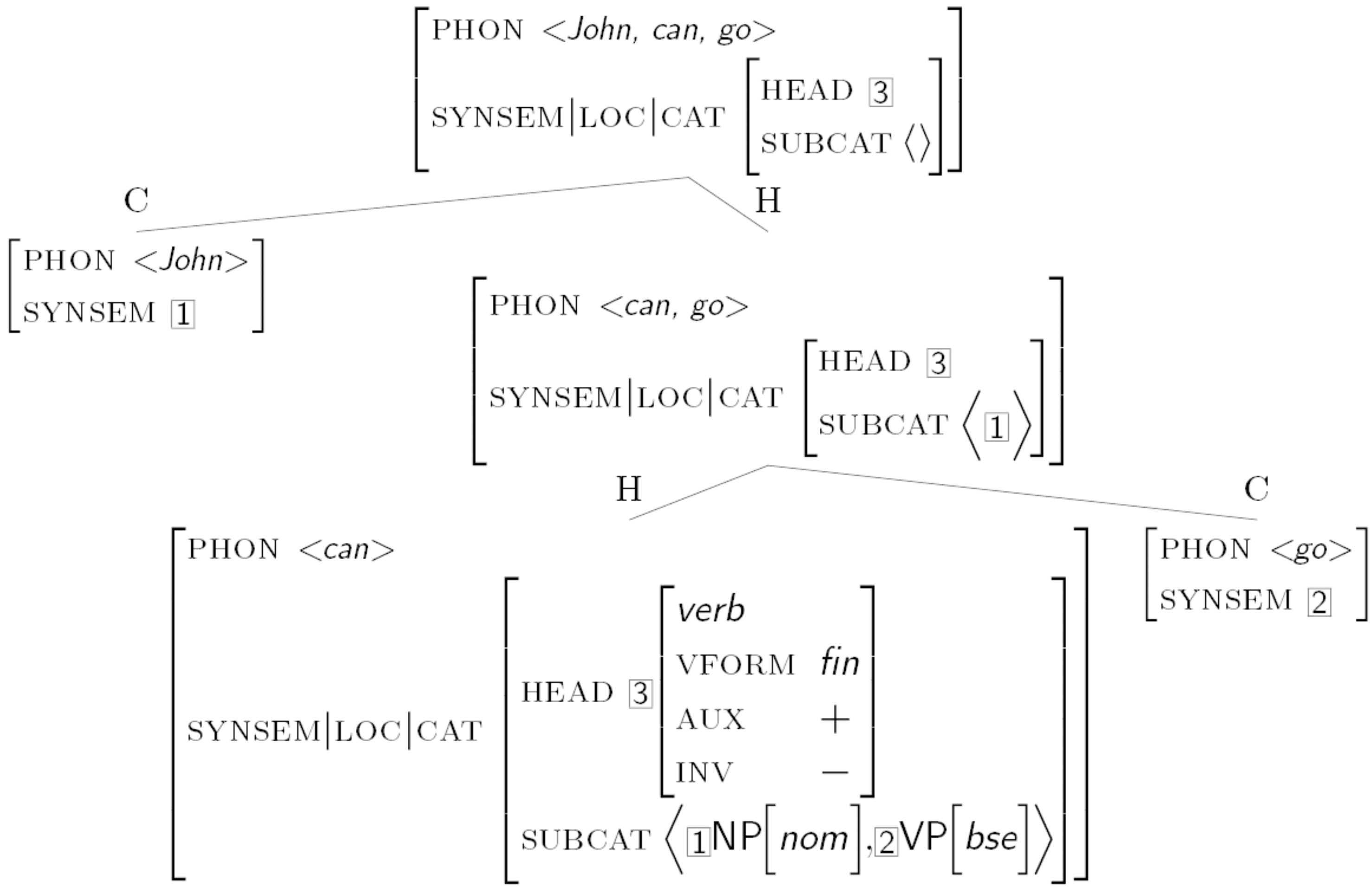
Version without redundant specifications

$$\begin{bmatrix} \textit{word} & \\ \text{PHON} & \langle \textit{red} \rangle \\ \text{SYNSEM|LOC} & \begin{bmatrix} \text{CAT|HEAD} & \begin{bmatrix} \textit{adj} & \\ \text{PRD} & - \\ \text{MOD|LOC} & \begin{bmatrix} \text{CAT} & \begin{bmatrix} \text{HEAD} & \textit{noun} \\ \text{SUBCAT} & \left\langle \begin{bmatrix} \text{LOC|CAT|HEAD} & \textit{det} \end{bmatrix} \right\rangle \end{bmatrix} \\ \text{CONTENT} & \begin{bmatrix} \text{INDEX} & \boxed{1}\,\textit{index} \\ \text{RESTR} & \boxed{2}\,\textit{list} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \text{CONT} & \begin{bmatrix} \text{INDEX} & \boxed{1} \\ \text{RESTR} & \left\langle \begin{bmatrix} \textit{red-rel} & \\ \text{ARG1} & \boxed{1} \end{bmatrix} \middle| \boxed{2} \right\rangle \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

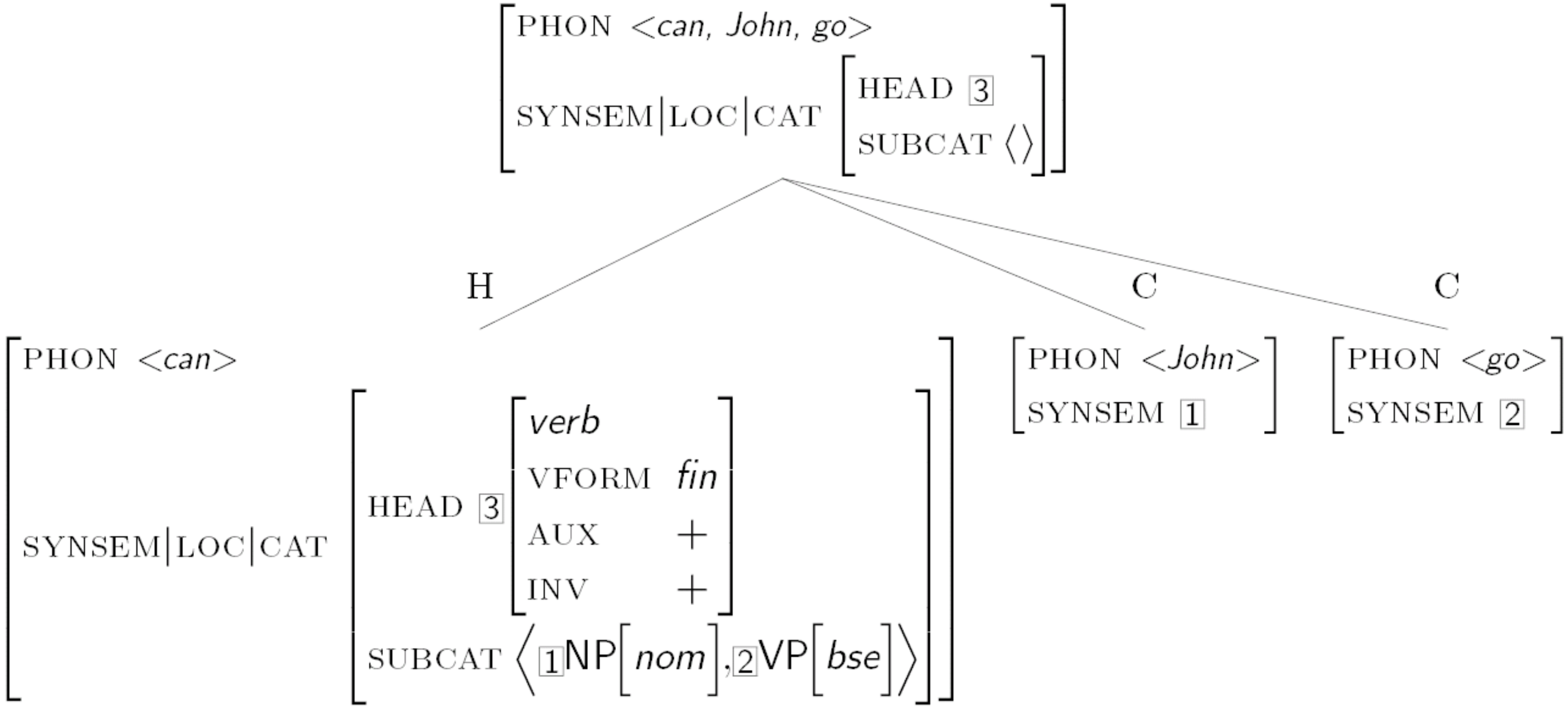
Sketch of an example for a head-adjunct structure



Sketch of an example with an auxiliary



Sketch of an example with an inverted auxiliary



SPEC Principle:

$$\begin{bmatrix} \textit{phrase} \\ \text{DTRS} \begin{bmatrix} \left(\text{MARKER-DTR} \vee \text{COMP-DTRS}|\text{FIRST}\right)|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{HEAD} \;\; \textit{functional} \end{bmatrix} \end{bmatrix}$$

$$\longrightarrow \begin{bmatrix} \text{DTRS} \begin{bmatrix} \left(\text{MARKER-DTR} \vee \text{COMP-DTRS}|\text{FIRST}\right)|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{HEAD}|\text{SPEC} & \boxed{1} \\ \text{HEAD-DTR}|\text{SYNSEM} & \boxed{1} \end{bmatrix} \end{bmatrix}$$

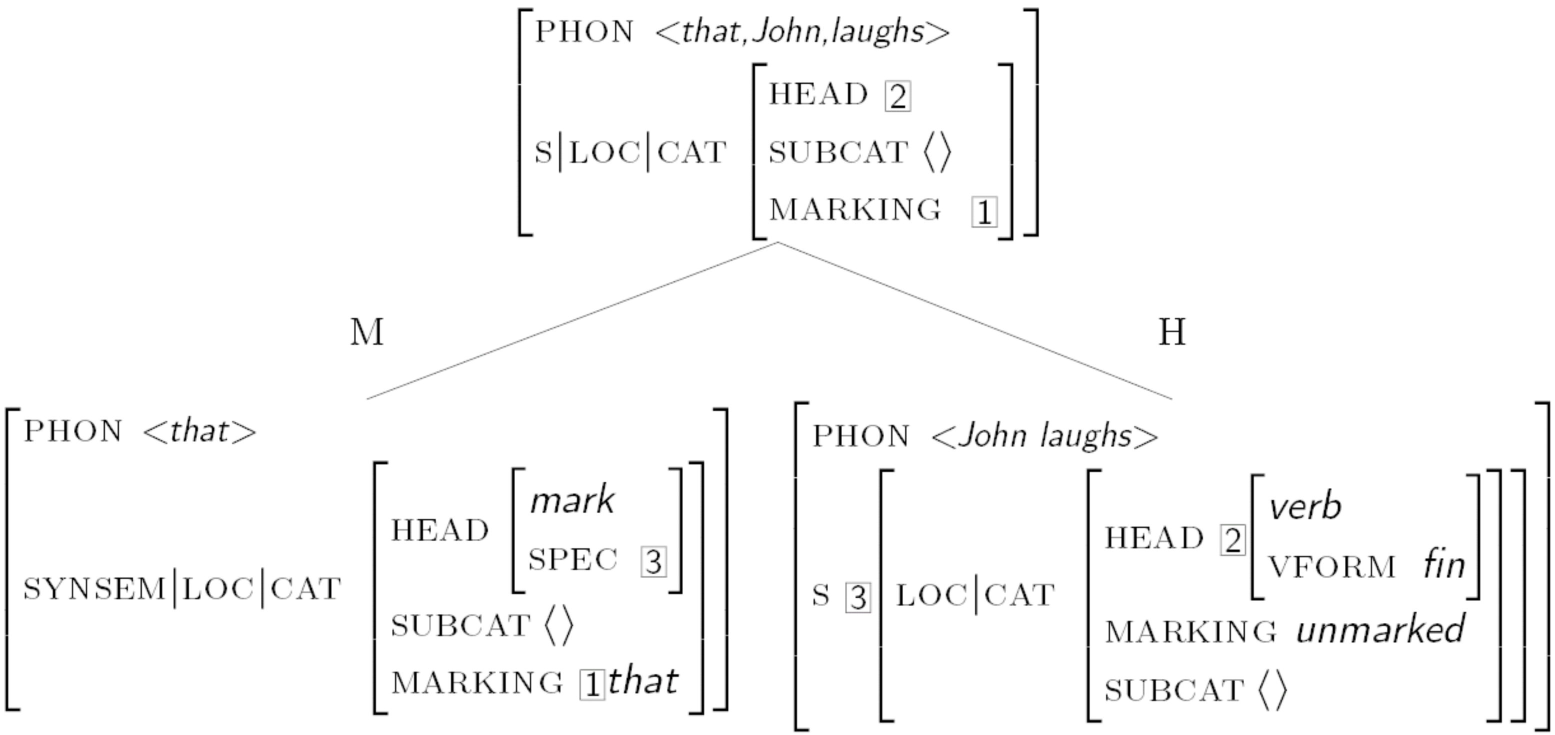
Marking Principle:

$$\begin{bmatrix} \textit{phrase} \\ \text{DTRS} \quad \textit{headed-structure} \end{bmatrix} \rightarrow \begin{bmatrix} \text{SYNSEM}|\text{LOC}|\text{CAT}|\text{MARKING} \ \boxed{1} \\ \text{DTRS} \begin{bmatrix} \textit{head-mark-struc} \\ \text{MARKER-DTR}|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{MARKING} \ \boxed{1} \end{bmatrix} \end{bmatrix} \lor \begin{bmatrix} \text{SYNSEM}|\text{LOC}|\text{CAT}|\text{MARKING} \ \boxed{1} \\ \text{DTRS} \begin{bmatrix} \neg \textit{head-mark-struc} \\ \text{HEAD-DTR}|\text{SYNSEM}|\text{LOC}|\text{CAT}|\text{MARKING} \ \boxed{1} \end{bmatrix} \end{bmatrix}$$

Lexical entry of the marker *that*

$$
\begin{bmatrix}
\text{PHON} & \langle \textit{that} \rangle \\
\text{SYNSEM}|\text{LOC}|\text{CAT} &
\begin{bmatrix}
\text{HEAD} &
\begin{bmatrix}
\textit{mark} & \\
\text{SPEC} &
\begin{bmatrix}
\text{LOC}|\text{CAT} &
\begin{bmatrix}
\text{HEAD} & \begin{bmatrix} \textit{verb} & \\ \text{VFORM} & \textit{fin} \vee \textit{bse} \end{bmatrix} \\
\text{MARKING} & \textit{unmarked} \\
\text{SUBCAT} & \langle \rangle
\end{bmatrix}
\end{bmatrix}
\end{bmatrix} \\
\text{SUBCAT} & \langle \rangle \\
\text{MARKING} & \textit{that}
\end{bmatrix}
\end{bmatrix}
$$

Sketch of an example for a head-marker structure



A few more points on HPSG

- We can view a grammar as a set of **constraints**: formulas which have to be true in order for a feature structure to be well-formed

  With such a view, parsing with HPSG falls into the realm of **constraint-based processing**

- Two important points about relating descriptions are subsumption and unification, loosely defined as:
  - **subsumption**: the description F subsumes the description G iff G entails F; i.e., F is more general than G
  - **unification**: the description of F and G unify iff their values are compatible

- **Closed World Assumption**: there are no linguistic species beyond what is specified in the type hierarchy