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Faculty of Philosophy
General Linguistics

Syntax & Semantics WS2019/2020

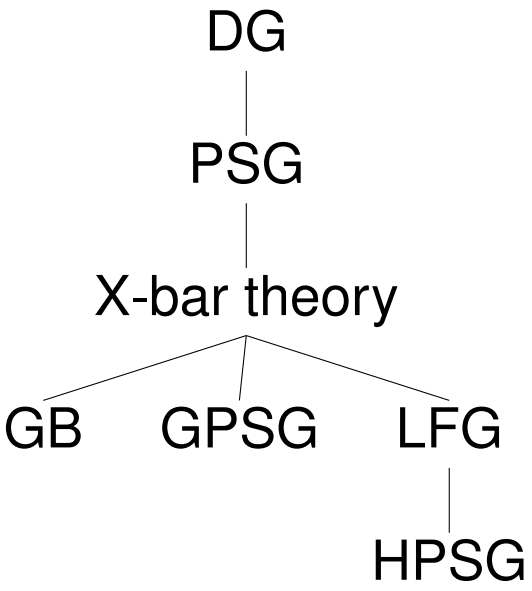
Lecture 13: Head-Driven Phrase Structure Grammar II (HPSG)

06/12/2019, Christian Bentz

Overview

Section 1: Recap of Lecture 12

Syntactic Framework Tree



DG: Dependency Grammar
PSG: Phrase Structure Grammar
GB: Government & Binding
GPSG: Generalized Phrase Structure Grammar
LFG: Lexical Functional Grammar
HPSG: Head-Driven Phrase Structure Grammar

Further Characteristics of HPSG

- HPSG "is a **lexicon-based theory**, that is, the majority of linguistic constraints are situated in the descriptions of words or roots."
- "HPSG is sign-based in the sense of Saussure (1916a): the **form and meaning** of linguistic signs are always represented together."
- "**Typed feature structures** are used to model all relevant information."
- "[...] trees [...] are only visualizations of the constituent structure and do not have any theoretical status. There are also **no rewrite rules in HPSG**."

Müller (2019), p. 266-271.

Simplified Typed Feature Description

We will not consider the semantic features of SYNSEM|LOC|CONT here. Also, SYNSEM|NONLOC is only relevant for particular constructions (e.g. long-distance dependencies) and can be dropped otherwise.

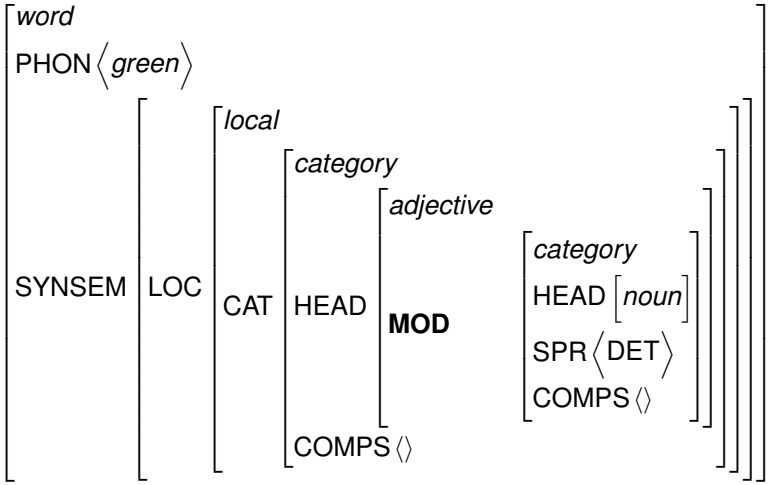
Typed feature description for the word *grammar*.

$$\begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{grammar} \right\rangle \\ \text{SYNSEM} \begin{bmatrix} \text{LOC} \begin{bmatrix} \textit{local} \\ \text{CAT} \begin{bmatrix} \textit{category} \\ \text{HEAD} \left[\textit{noun} \right] \\ \text{SPR} \left\langle \text{DET} \right\rangle \\ \text{COMPS} \left\langle \right\rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The Word Level: Adjectives

As in many other frameworks, *adjectives* are considered *adjuncts* to nouns (or noun phrases), hence they are construed with a MOD (modifier) feature in SYNSEM|LOC|CAT, which essentially means "modifier of..." and the value is then a (not further specified) noun phrase. This is a typical example of embedding, that is, one category with a noun as head is embedded into another category with an adjective as head.

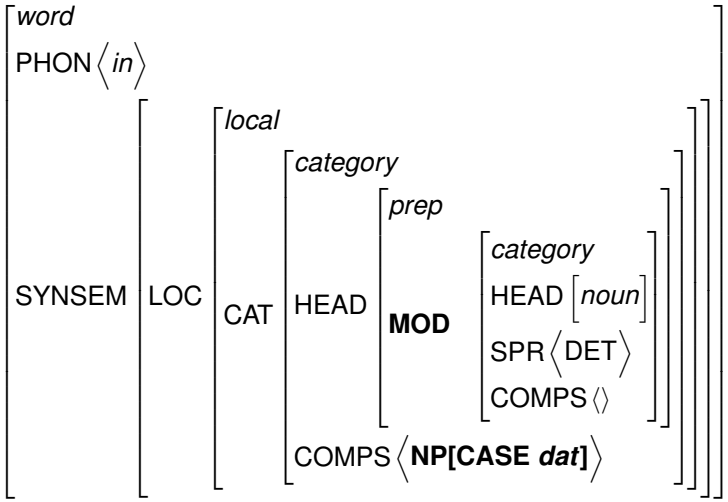
Typed feature description for the word *green*.



The Word Level: Prepositions

Prepositions are handled at the word level in a similar manner to adjectives. Namely, they have have a head feature MOD which takes a noun phrase as its value. One important difference here is that now we also have to mention a complement to the preposition under COMPS.

Typed feature description for the word *in*.



Note: The complement NP[CASE *dat*] is necessary since the preposition *in* requires a dative complement. While proper nouns do not inflect for dative in English, we can see this with pronouns, e.g. *in him*. Importantly, the noun phrase which is the value of MOD is not the same as the noun phrase in the COMPS list! The former would correspond to *the book* in a phrase like *the book in the library*, while the latter would correspond to *the library*.

The Word Level: Verbs (English)

Verbs have a feature structure similar to nouns. Instead of a CASE feature given in the type *noun*, the type *verb* gives a **VFORM** feature which takes the same values as in GPSG (*fin*: finite; *inf*: to-infinitive; *bse*: bare infinitive; *prp*: present participle; *psp*: past participle; *pas*: passive participle). Also, the potential complements of the verb phrase are now given in **COMPS** with phrase notation and case feature values. **For English**, the subject NP is considered a **specifier (SPR)**.

Typed feature description for the word *gives*.

$$\begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{gives} \right\rangle \\ \text{SYNSEM} \begin{bmatrix} \text{LOC} \begin{bmatrix} \textit{local} \\ \text{CAT} \begin{bmatrix} \textit{category} \\ \text{HEAD} \begin{bmatrix} \textit{verb} \\ \textbf{VFORM} \quad \textit{fin} \end{bmatrix} \\ \text{SPR} \left\langle \textbf{NP[}\textit{nom}\textbf{]} \right\rangle \\ \text{COMPS} \left\langle \textbf{NP[}\textit{dat}\textbf{], NP[}\textit{acc}\textbf{]} \right\rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The Word Level: Verbs (German)

For German, we have, in principle, the same structure, though with the important difference that the **subject NP** is not treated as a specifier, but also as a **complement**.

Typed feature description for the word *gibt* 'gives'.

$$\begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{gibt} \right\rangle \\ \text{SYNSEM} \begin{bmatrix} \text{LOC} \begin{bmatrix} \textit{local} \\ \text{CAT} \begin{bmatrix} \textit{category} \\ \text{HEAD} \begin{bmatrix} \textit{verb} \\ \textbf{VFORM} \quad \textit{fin} \end{bmatrix} \\ \text{COMPS} \left\langle \textbf{NP[}\textbf{\textit{nom}}\textbf{], NP[}\textbf{\textit{dat}}\textbf{], NP[}\textbf{\textit{acc}}\textbf{]} \right\rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

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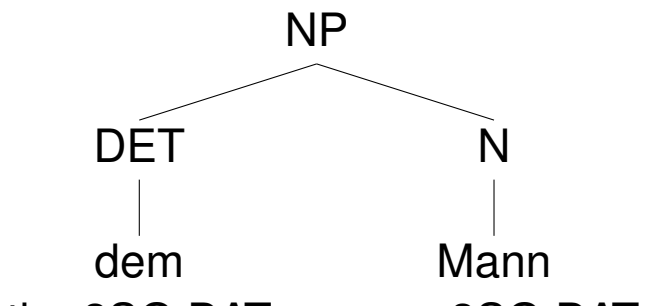
Section 2: The Phrase Level (Noun Phrases)

Representation of Constituent Structure

Just as for LFG, in HPSG **constituent tree structures** are represented by means of **feature description matrices**, such that trees have no theoretically important status anymore, but might be used for visualization.



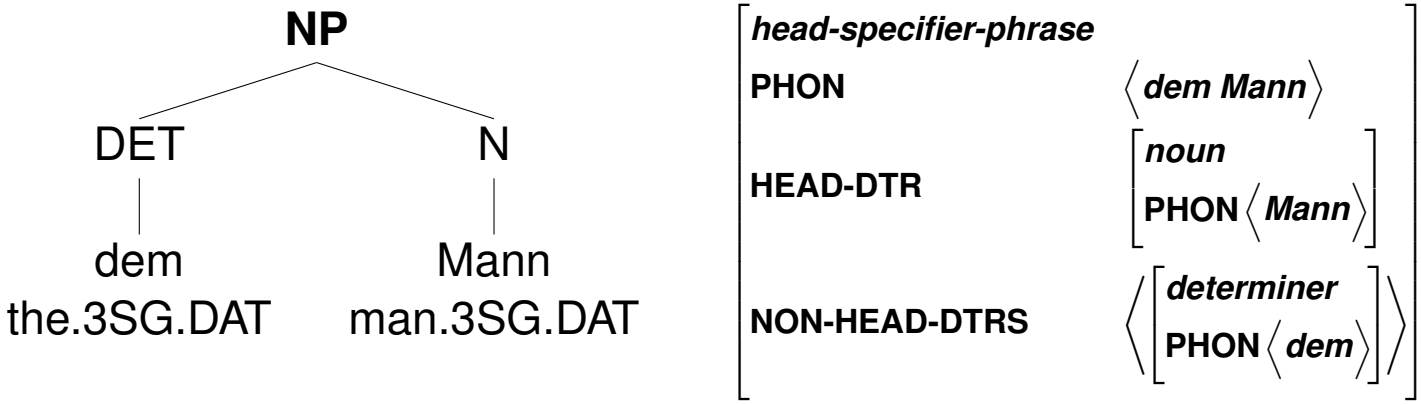
$$\begin{bmatrix} \textit{head-specifier-phrase} & \\ \text{PHON} & \langle \textit{dem Mann} \rangle \\ \text{HEAD-DTR} & \begin{bmatrix} \textit{noun} \\ \text{PHON} \langle \textit{Mann} \rangle \end{bmatrix} \\ \text{NON-HEAD-DTR} & \left\langle \begin{bmatrix} \textit{determiner} \\ \text{PHON} \langle \textit{dem} \rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

Adopted from Müller (2019). Grammatical theory, p. 270.

Note: I have here added the type *head-specifier-phrase*. Remember that determiners are considered specifiers to the head noun in this framework.

Representation of Constituent Structure

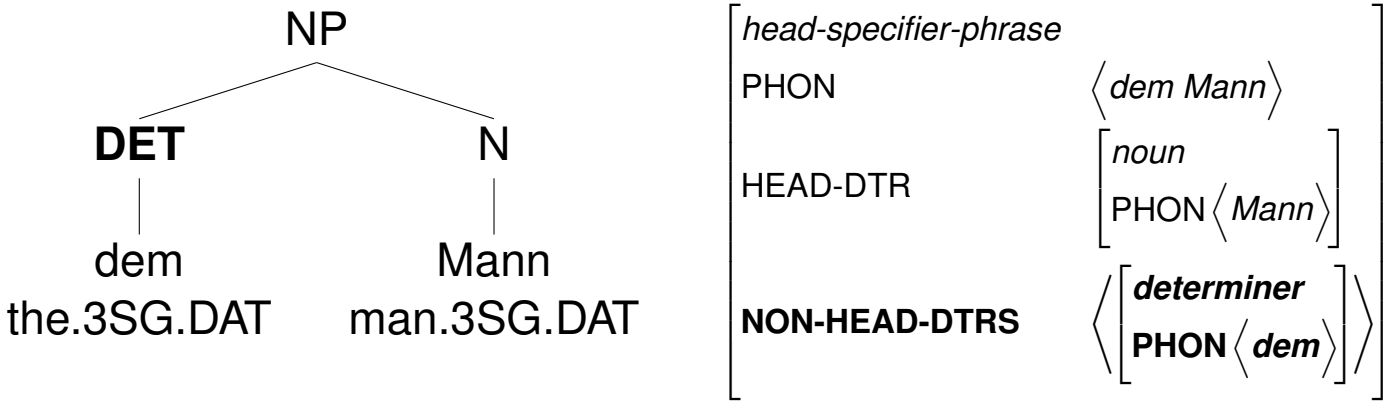
The nodes in the tree are then associated with particular parts in the feature description, e.g. **NP with the whole *head-specifier-phrase***, DET with NON-HEAD-DTR (non-head-daughter), and N with HEAD-DTR (head-daughter).



Adopted from Müller (2019). Grammatical theory, p. 270.

Representation of Constituent Structure

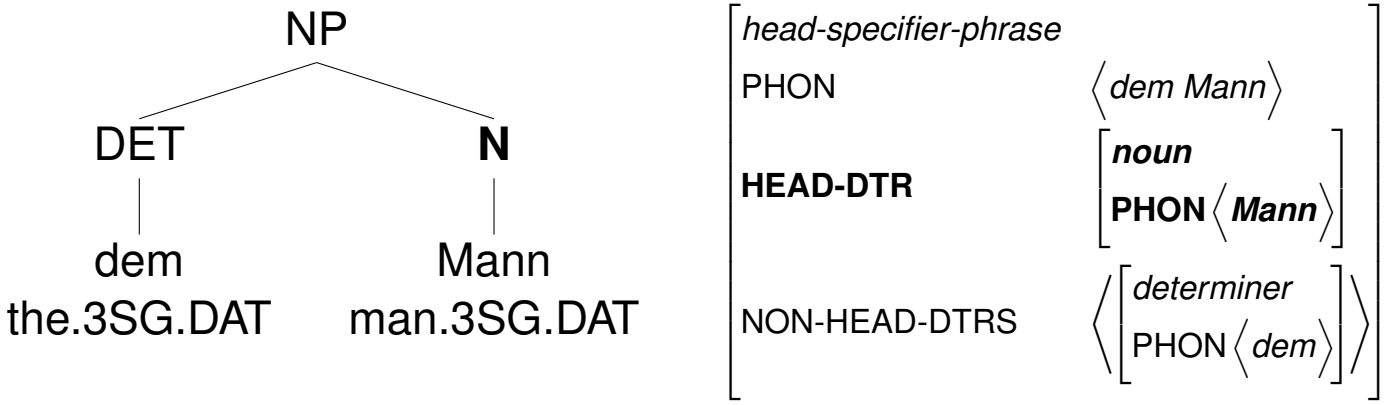
The nodes in the tree are then associated with particular parts in the feature description, e.g. NP with the whole *head-specifier-phrase*, **DET with NON-HEAD-DTRS (non-head-daughters)**, and N with HEAD-DTR (head-daughter).



Adopted from Müller (2019). Grammatical theory, p. 270.

Representation of Constituent Structure

The nodes in the tree are then associated with particular parts in the feature description, e.g. NP with the whole *head-specifier-phrase*, DET with NON-HEAD-DTR (non-head-daughter), and **N with HEAD-DTR (head-daughter)**.



Adopted from Müller (2019). Grammatical theory, p. 270.

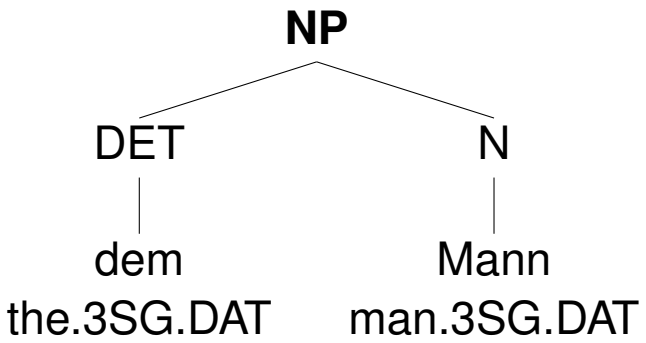
The Phrase Level: Noun-Phrase

However, note that the atribute-value matrix (AVM), i.e. feature description matrix, given by Müller (2019) for this particular *head-specifier-phrase dem Mann* is **highly underspecified**. Namely, it only specifies the PHON feature but none of the syntactically relevant features in SYNSEM|LOC|CAT. A more complete AVM is developed below.

$$\begin{bmatrix} \textit{head-specifier-phrase} & \\ \text{PHON} & \langle \textit{dem Mann} \rangle \\ \textbf{SYNSEM|LOC|CAT ...} & \\ \text{HEAD-DTR} & \begin{bmatrix} \textit{word} \\ \text{PHON} \langle \textit{Mann} \rangle \\ \textbf{SYNSEM|LOC|CAT ...} \end{bmatrix} \\ \text{NON-HEAD-DTRS} & \left\langle \begin{bmatrix} \textit{word} \\ \text{PHON} \langle \textit{dem} \rangle \\ \textbf{SYNSEM|LOC|CAT ...} \end{bmatrix} \right\rangle \end{bmatrix}$$

The Phrase Level: Noun-Phrase

First, we need to add the **SYNSEM|LOC|CAT feature** for the highest level NP *dem Mann*. Note that the CAT feature matrix is here not further specified, just represented **with an index** 1. Imagine that this reflects the fact that we are here in the highest level NP node in the tree, where we do not yet "see" the actual head and specifier features of the category.

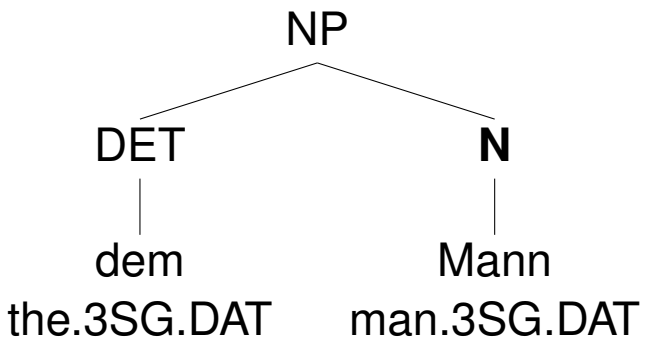


$$\begin{bmatrix} \textit{head-specifier-phrase} \\ \text{PHON} \left\langle \textit{dem Mann} \right\rangle \\ \textbf{SYNSEM|LOC|CAT } \boxed{1} \\ \text{HEAD-DTR} \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{Mann} \right\rangle \end{bmatrix} \\ \text{NON-HEAD-DTRS} \left\langle \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{dem} \right\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

Note: From here on we use the path notation SYNSEM|LOC|CAT instead of spelling out all the matrices.

The Phrase Level: Noun-Phrase

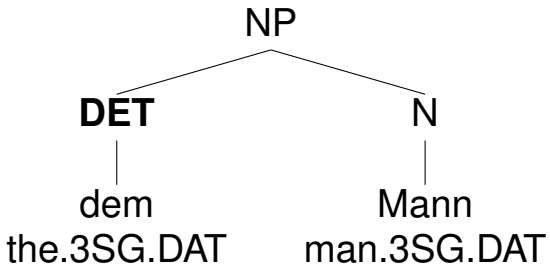
Secondly, we need to add the **SYNSEM|LOC|CAT feature** for the **HEAD-DTR** *Mann*. Here the **HEAD feature** is further specified as a noun which takes CASE. The CASE value is represented with another index 2 for structure sharing. The SPR feature is still not specified, but just takes another index 3. Remember that we are here in the branch of the head *Mann*, where we do not really yet "see" the specifier *dem*. The **whole CAT matrix** is then structure shared with the highest level NP by using the index 1.

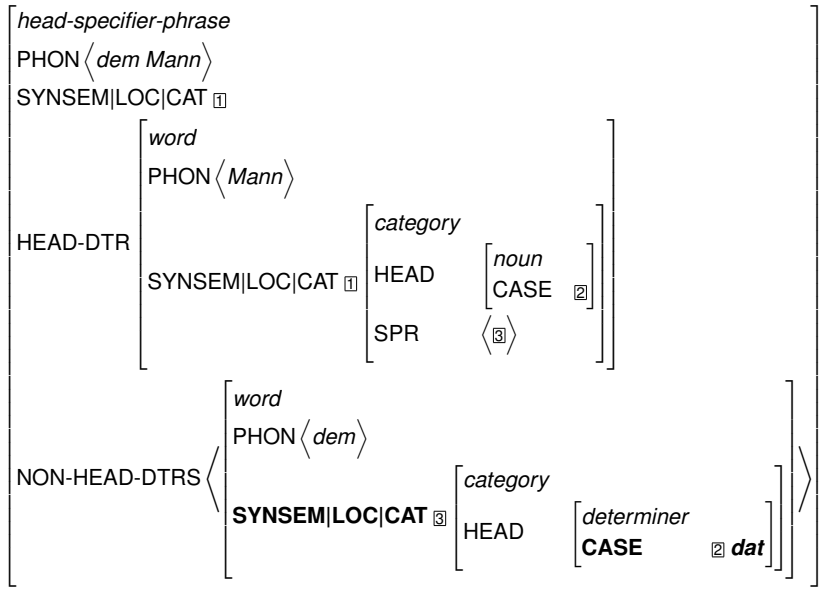


$$\begin{bmatrix} \textit{head-specifier-phrase} \\ \text{PHON} \left\langle \textit{dem Mann} \right\rangle \\ \text{SYNSEM|LOC|CAT } \boxed{1} \\ \text{HEAD-DTR} \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{Mann} \right\rangle \\ \textbf{SYNSEM|LOC|CAT } \boxed{1} \begin{bmatrix} \textit{category} \\ \text{HEAD} \begin{bmatrix} \textit{noun} \\ \text{CASE } \boxed{2} \end{bmatrix} \\ \text{SPR} \left\langle \boxed{3} \right\rangle \end{bmatrix} \end{bmatrix} \\ \text{NON-HEAD-DTRS} \left\langle \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{dem} \right\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

The Phrase Level: Noun-Phrase

Finally, we need to specify the CAT value of the NON-HEAD-DTR *dem*. The HEAD within this category is now of the type *determiner*, and the whole CAT matrix is structure shared with the HEAD-DTR as its specifier via the index 3. Also, it takes a CASE value which is specfied as *dative* and structure shared via the index 2.

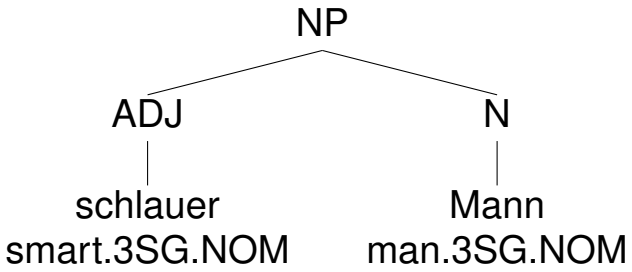


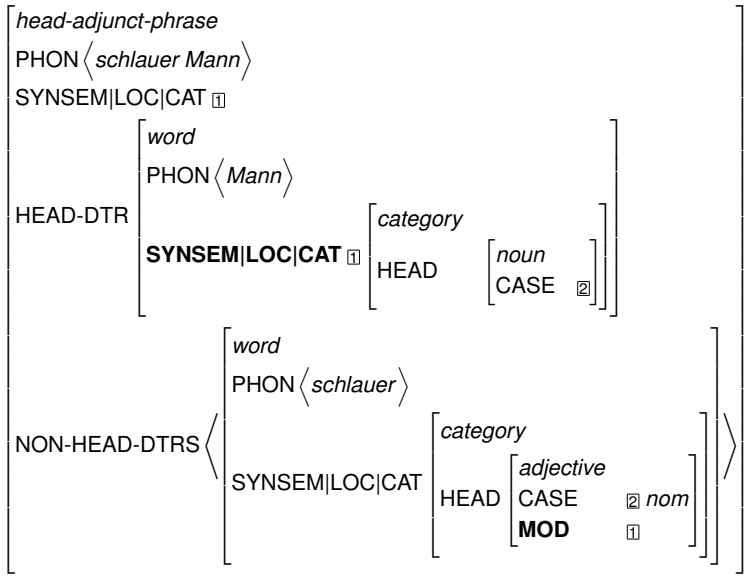


Note: While the determiner is construed as a feature (DET) of the specifier feature SPR as part of the type *noun*, in an actual noun phrase, there has to be a word for the determiner with its own typed feature description i.e. *determiner*.

The Phrase Level: Noun-Phrase

In the case of nouns being modified by **adjectives**, we have a so-called **head-adjunct-phrase**. The **CAT value** of the highest level NP is again indicated by index 1. This is then specified and structure shared via the same index in the CAT value of the **HEAD-DTR**. As outlined above, the connection between the adjective and the noun is expressed by the **MOD feature** of the *adjective* type which takes the element modified by the adjective as its value, i.e. the noun in this case.





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Section 3: The Phrase Level (Verb Phrases)

The Verb Phrase: Valence Information

Just as in earlier frameworks, in HPSG the **valence information** of a verb is explicitely modelled in a so-called **argument structure (ARG-ST)**, which combines information about the **specifier (SPR)**, i.e. the subject of a sentence, as well as the **complements (COMPS)**.

verb	SPR	COMPS	ARG-ST
sleep	⟨ NP[*nom*] ⟩	⟨ ⟩	⟨ NP[*nom*] ⟩
expect	⟨ NP[*nom*] ⟩	⟨ NP[*acc*] ⟩	⟨ NP[*nom*], NP[*acc*] ⟩
talk	⟨ NP[*nom*] ⟩	⟨ PP[*about*]⟩	⟨ NP[*nom*], PP[*about*] ⟩
give	⟨ NP[*nom*] ⟩	⟨ NP[*dat*], NP[*acc*]⟩	⟨ NP[*nom*], NP[*dat*], NP[*acc*] ⟩
serve	⟨ NP[*nom*] ⟩	⟨ NP[*acc*], PP[*with*]⟩	⟨ NP[*nom*], NP[*acc*], PP[*with*] ⟩

Adopted from Müller (2019), p. 269.

Note: For German, there is no distinction between COMPS and SPR, all the elements would be listed in COMPS.

Interlude: Appending Lists

Note that the ARG-ST list is the outcome of **appending** the COMPS list to the SPR list. Formally we have:

$$\text{ARG-ST} = \text{SPR} \oplus \text{COMPS}, \tag{1}$$

where the symbol $\oplus$ represents the *appending* of one list to another. More generally, a list containing two elements x and y can be the outcome of the following appending steps:

$$\begin{aligned} \langle x, y \rangle = \langle x \rangle \oplus \langle y \rangle, \textit{or} \\ \langle \rangle \oplus \langle x, y \rangle, \textit{or} \\ \langle x, y \rangle \oplus \langle \rangle. \end{aligned} \tag{2}$$

Example: Intransitive Sentence

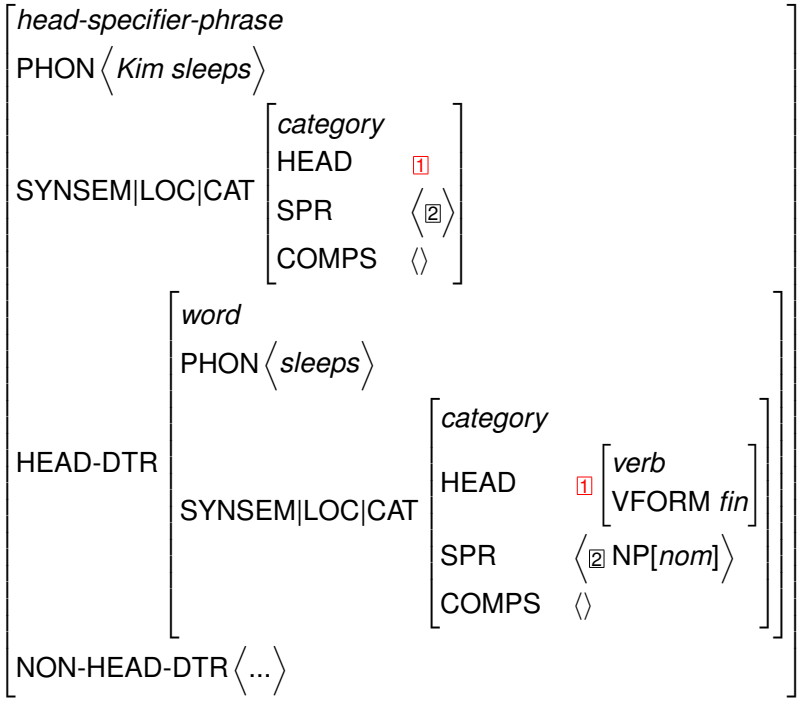
We can now built a simple ***intransitive phrase***. We here proceed from "top to bottom" (though the other way around is also possible) by first specifying the CAT value of the highest level phrase (i.e. the VP). This CAT value has a HEAD feature, a SPR feature, and a COMPS feature (in this case empty, since we are dealing with an intranstive sentence). We supply the **HEAD and SPR features** with **indeces**, i.e. 1 and 2. Note that neither the HEAD feature, nor the SPR list is further specified here. Again, imagine that we are in the highest (VP) node in a syntactic tree, where we do not "know" yet which values the features actually take.

$$\begin{bmatrix} \textit{head-specifier-phrase} \\ \text{PHON} \left\langle \textit{Kim sleeps} \right\rangle \\ \textbf{SYNSEM|LOC|CAT} \begin{bmatrix} \textit{category} \\ \text{HEAD} & \boxed{1} \\ \text{SPR} & \left\langle \boxed{2} \right\rangle \\ \text{COMPS} & \langle\rangle \end{bmatrix} \\ \text{HEAD-DTR} \left[\ldots \right] \\ \text{NON-HEAD-DTRS} \left\langle \ldots \right\rangle \end{bmatrix}$$

Note: The phrase is here called a *head-specifier phrase*, since the COMPS list is empty, and the subject is considered a specifier in English. The equivalent German example *Peter schläft* in Müller (2019), p. 274 is called a *head-complement-phrase*, since in German the subject is considered a complement. For a discussion of *head-specifier-phrases* see Müller (2015), p. 7.

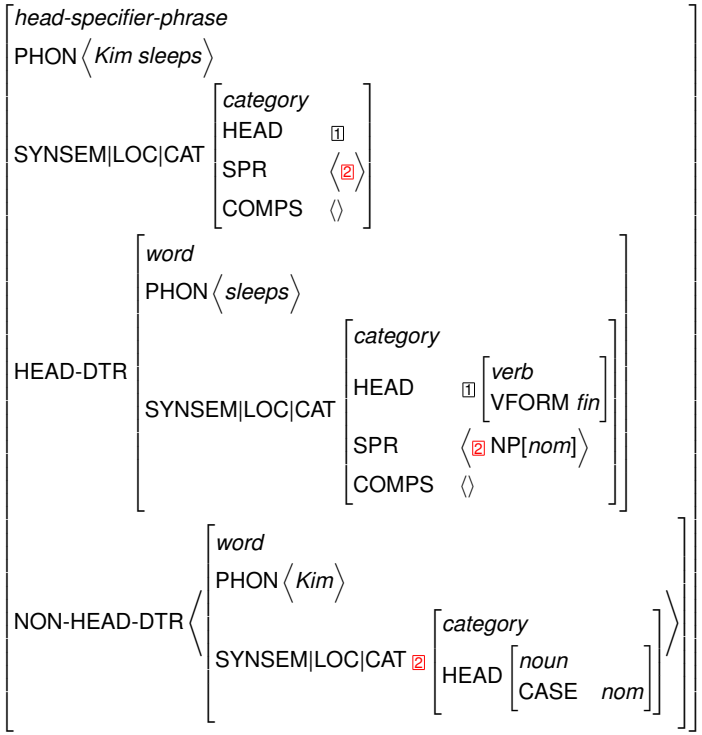
Example: Intransitive Sentence

The **head daughter** (HEAD-DTR) is the **finite verb**, which is **structure shared** via the index with the highest level CAT feature. The SPR feature value is still to be fully specified, though via the valence information for *sleeps* we know that it must take an NP[*nom*].



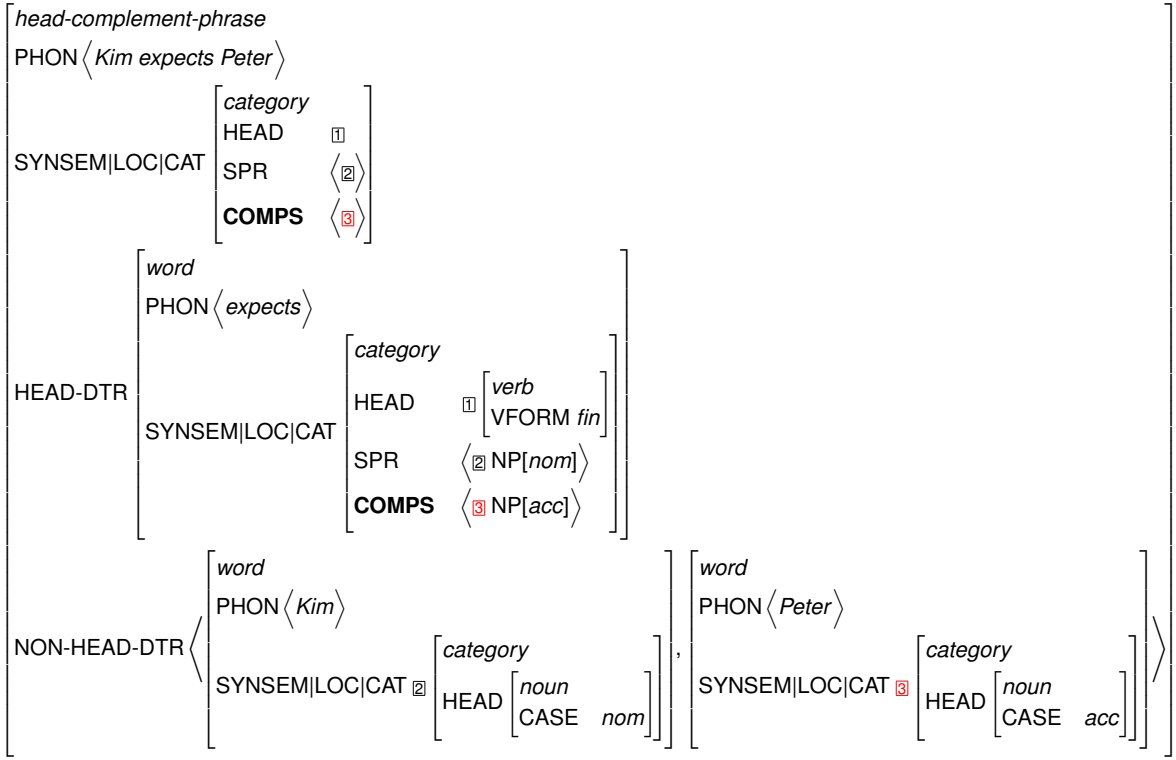
Example: Intransitive Sentence

The **SPR feature value** is then specified in the CAT feature of the NON-HEAD-DTR, namley as a noun (or NP) in the nominative case. Note that while nominative case here does not require inflection on a proper noun, it might on a pronoun, and is hence given for completeness.



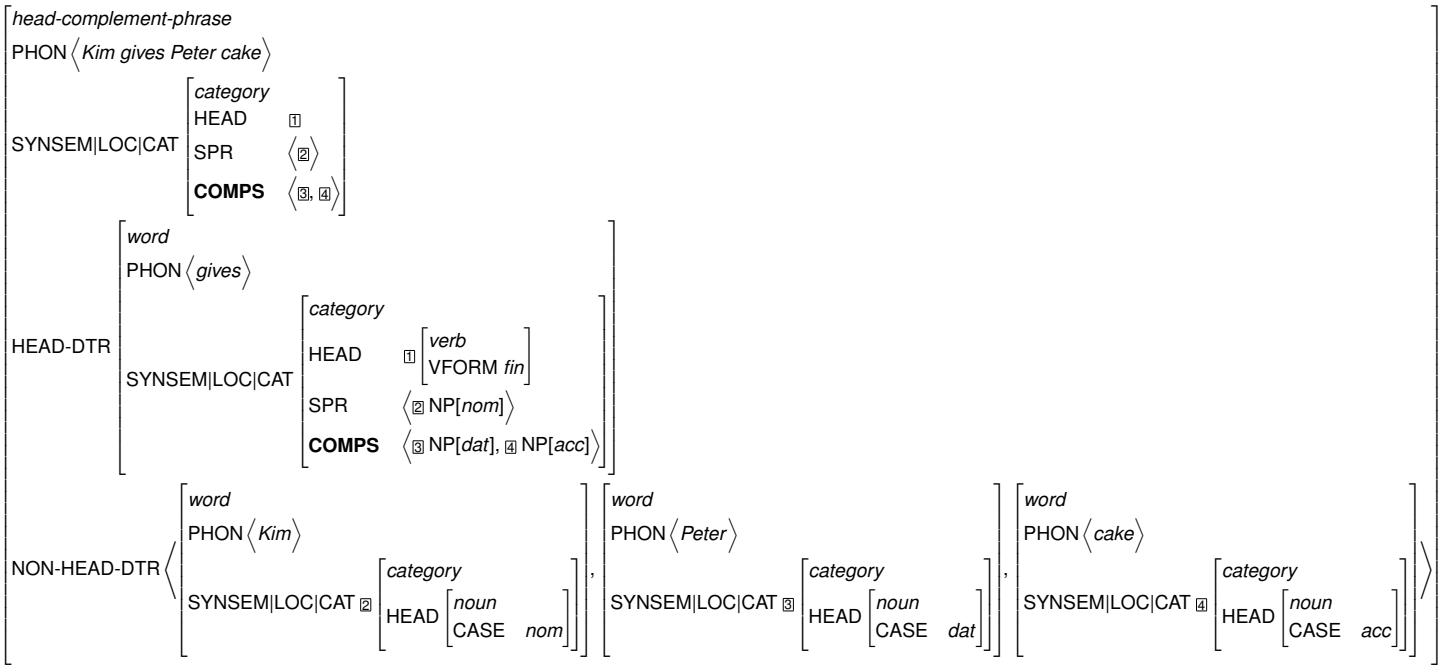
Example: Transitive Sentence

Transitive sentences are then straightforwardly handled by adding the object of the sentence to the complements list, and adding another word matrix to the list of NON-HEAD-DTRS. We then need to using different indeces (2 and 3) for structure sharing.



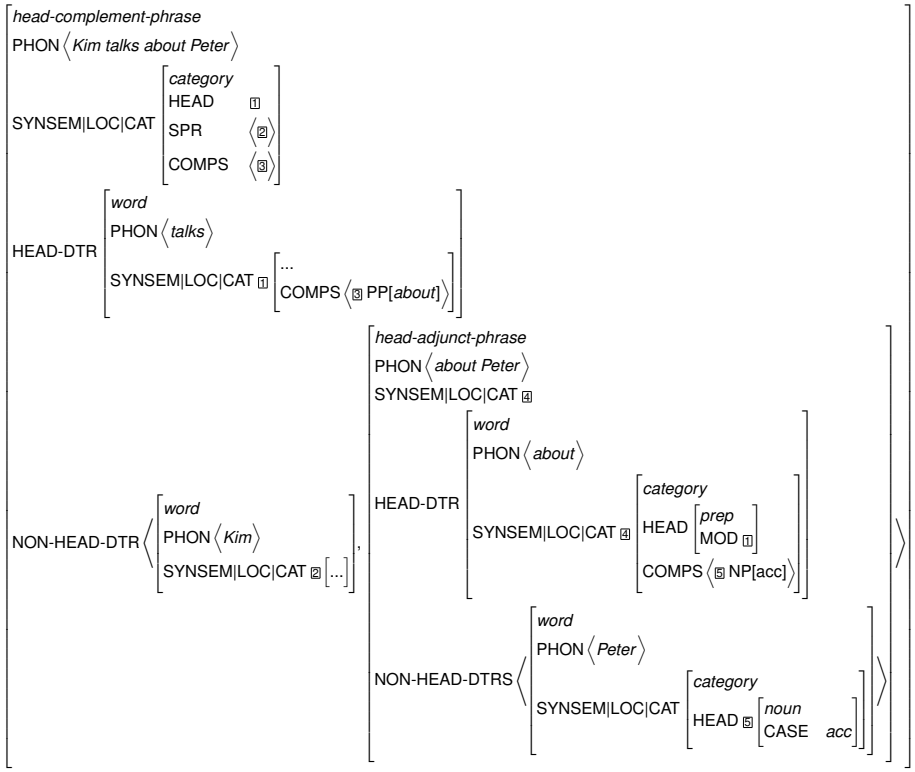
Example: Ditransitive Sentence

By extension, the exact same principle applies to **ditransitive sentences**.



Example: Sentences with Prepositional Phrases

Note that **prepositional phrases** are also handled via the COMPS list. Below is an example based on the valence information for *talk*, which takes an *obligatory subject NP* as SPR, and an optional prepostional phrase headed by *about* in the COMPS list. Importantly, the noun of the prepositional phrase is here not included in the highest level COMPS list, since it is rather a complement of the preposition (*about*).



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Section 4: Linearization Rules

Linearization Rules

Note that the HPSG typed feature descriptions capture **immediate dominance rules** (as in GPSG), but they do not capture **linear precedence rules**. See the example of a simplified HPSG feature description for a ditransitive sentence below.

$$\begin{bmatrix} \textit{head-complement-phrase} \\ \text{PHON} \left\langle \textit{Kim gives Peter cake} \right\rangle \\ \text{HEAD-DTR} \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{gives} \right\rangle \end{bmatrix} \\ \text{NON-HEAD-DTR} \left\langle \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{Kim} \right\rangle \end{bmatrix}, \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{Peter} \right\rangle \end{bmatrix}, \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{cake} \right\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

While the order of the specifier *Kim* and the complements *Peter* and *cake* is fixed (since they occur in a list which specifies the order), the head-daughter *gives* could occur in any position.

Feature Description (Simplified):

$$\begin{bmatrix} \textit{head-complement-phrase} \\ \text{PHON} \left\langle \textit{Kim gives Peter cake} \right\rangle \\ \text{HEAD-DTR} \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{gives} \right\rangle \end{bmatrix} \\ \text{NON-HEAD-DTR} \left\langle \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{Kim} \right\rangle \end{bmatrix}, \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{Peter} \right\rangle \end{bmatrix}, \begin{bmatrix} \textit{word} \\ \text{PHON} \left\langle \textit{cake} \right\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

Orders Licensed:

gives	Kim			Peter		cake	
	Kim	**gives**		Peter		cake	
	Kim			Peter	**gives**	cake	
	Kim			Peter		cake	**gives**

Linearization Rules

Hence, **linearization rules** need to be specified for the different features. An English linearization rule could look like below:

$$\text{SPR} \prec \text{HEAD} \prec \text{COMPS} \tag{3}$$

This rule (almost) correctly linearizes the phrases we have analyzed above:

- *the man*, i.e. SPR $\prec$ HEAD
- *Kim sleeps*, i.e. SPR $\prec$ HEAD
- *Kim expects Peter*, i.e. SPR $\prec$ HEAD $\prec$ COMPS
- *Kim gives Peter cake*, i.e. SPR $\prec$ HEAD $\prec$ COMPS
  (though the order of *Peter* and *cake* is not captured here!)
- *Kim talks about Peter*, i.e. SPR $\prec$ HEAD $\prec$ COMPS

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Section 5: Basic Concepts in HPSG

Basic Concepts in HPSG

- Constituency ✓
- POS ✓
- Heads ✓
- Valency ✓
- Grammatical Functions ✓

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Section 6: Pros and Cons of HPSG

Pros (Advantages)

- Highly formalized and hence computationally implementable.
- Allows for adjustments to capture typologically diverse languages (similar to LFG).
- Can handle different syntactic phenomena such as passives and long-distance dependencies without transformations.
- The usage of typed feature descriptions allows for inheritance of feature structures via type hierarchies.

Cons (Disadvantages)

- The format of analyses using typed feature description matrices instead of syntactic trees is very cumbersome to handle.
- The fact that features relevant for building phrases have to be already specified in the individual lexical items is another structural characteristic of HPSG which makes it hard to handle in everyday linguistic analyses.

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Exercises

Exercise 1: HPSG I

Take the following German sentence:

(1) Das Kind lies-t ei-n interessant-es
the.NOM.SG child.NOM.SG read-3.SG.PRES a-ACC.SG interesting-ACC.SG
Buch.
book.ACC.SG
"The child reads an interesting book."

Assume that both *das* and *ein* are treated simply as determiner DET.

1. Give the HPSG typed feature descriptions for the following words and phrases. Use the simplified version of the typed feature description (without the CONT feature). Importantly: use the CASE values that are given here in the glossings (the individual words by themselves could potentially also take other case values).
   - *Kind*
   - *liest*
   - *das Kind*
   - *interessantes Buch*

Exercise 1: HPSG I

2. Give a binary branching PSG tree for the phrase *interessantes Buch*, and indicate which nodes in the tree correspond to which parts of the HPSG typed feature description. You can use arrows (remember that the arrow heads have to end at the left bracket of the feature value). Alternatively you can give the *bracket notation* for the node(s) in the tree and the *path* to the corresponding feature value.

Exercise 2: HPSG II

Take the following English sentence: *Peter serves Kim with cake*.

1. Give the typed feature description of the overall sentence, assuming it is a *head-complement-phrase*. However, only specify the feature descriptions to the PHON features, i.e. no SYNSEM features.
2. Now give the SYNSEM/LOC/CAT values for
   - the overall head-complement-phrase,
   - the HEAD-DTR,
   - the SPR (*Peter*).

Section 7: References

References

Müller, Stefan. (2015). HPSG - a synopsis. In: Artemis Alexiadou & Tibor Kiss (eds.), *Syntax – Ein internationales Handbuch*. Berlin: De Gruyter.

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Thank You.

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