Architecture of HPSG

The Organisation of a Grammar

Grammar consists of

- Language universal principles
- Language specific principles
- Grammar rules (Language specific)
- Lexicon

Universal Grammar:

$$\mathrm{UG} = P_1 \wedge \ldots \wedge P_n$$

Language Specific Grammars:

$$\text{English} = P_1 \wedge \ldots \wedge P_{n+1} \ldots \wedge P_{n+m} \wedge (L_1 \vee \ldots \vee L_p \vee R_1 \vee \ldots \vee R_q)$$

$$\text{French} = P_1 \wedge \ldots \wedge P'_{n+1} \ldots \wedge P'_{n+m} \wedge (L'_1 \vee \ldots \vee L'_p \vee R'_1 \vee \ldots \vee R'_q)$$

The Organization of a Linguistic Sign

Two types of Signs:

- Lexical Signs (do not have an internal phrase structure)
- Phrasal Signs (have phrase structure)

All signs represented by AVMs with attributes:

- `PHON(ology)`: Value is a list of phoneme strings representing the phonological structure of the constituent
- `SYNSEM`: Value is an AVM of type *synsem* describing syntactic and semantic aspects of the constituent
- `QSTORE`: Value is a set of AVMs of type *quantifier*; employed in the treatment of quantifier scoping ambiguities
- `DTRS`: Only for phrasal constituents; value describes constituent structure in terms of immediate dominance relations

The SYNSEM Attribute

- The value of the attribute **SYNSEM** describes syntactic and semantic properties of a sign
- Divided into two parts: **LOCAL** and **NON-LOCAL**
- **NON-LOCAL** attributes for treatment of unbounded dependencies, *wh*-questions, and relative clauses
- **LOCAL** attributes are **CONTENT**, **CONTEXT**, and **CAT**
- **CONTENT** and **CONTEXT** indicate the semantic content of a sign and contextual restrictions on its interpretation

The `CAT` Attribute

- The attributes in the value of **`CAT`** encode the locally relevant syntactic aspects of a constituent, i.e., **`LEX`**, **`HEAD`**, and **`SUBCAT`**

- **`LEX`** has as value $+$ for lexical constituents and $-$ for non-lexical constituents

- **`SUBCAT`** has as value a list of **`SYNSEM`** values, each element of the list corresponding to a complement; encodes degree of saturation of constituent

- **`HEAD`** encodes information that a constituent and its phrasal projection have in common

Basic Structure of Lexical Sign

$${}_{\textit{lexical sign}}\begin{bmatrix} \mathtt{PHON} & \langle\ldots\rangle \\ \mathtt{SYNSEM} & \begin{bmatrix} \mathtt{LOC} & \begin{bmatrix} \mathtt{CAT} & \begin{bmatrix} \mathtt{HEAD} & \ldots \\ \mathtt{LEX} & + \\ \mathtt{SUBCAT} & \ldots \end{bmatrix} \\ \mathtt{CONTENT} & \ldots \\ \mathtt{CONTEXT} & \ldots \end{bmatrix} \\ \mathtt{NONLOC} & \begin{bmatrix} \mathtt{SLASH} & \ldots \\ \mathtt{REL} & \ldots \\ \mathtt{QUE} & \ldots \end{bmatrix} \end{bmatrix} \\ \mathtt{QSTORE} & \{\ldots\} \end{bmatrix}$$

Some Sample Lexical Signs

$$\left[\begin{array}{ll} \texttt{PHON} & \langle \textit{eats} \rangle \\ \texttt{SYNSEM} & \left[\begin{array}{ll} \texttt{LOC} & \left[\begin{array}{ll} \texttt{CAT} & \left[\begin{array}{ll} \texttt{HEAD} & \left[\begin{array}{ll} \texttt{MAJ} & \textit{Verb} \\ \texttt{VFORM} & \textit{fin} \\ \texttt{AUX} & - \\ \texttt{INV} & - \\ \texttt{PRED} & - \end{array}\right] \\ \texttt{LEX} & + \\ \texttt{SUBCAT} & \left\langle \mathrm{NP[Nom]}_{\boxed{1}}, \mathrm{NP[Acc]}_{\boxed{2}} \right\rangle \end{array}\right] \\ \texttt{CONTENT} & \left[\begin{array}{ll} \texttt{RELN} & \textit{eat} \\ \texttt{AGENT} & \boxed{1} \\ \texttt{THEME} & \boxed{2} \end{array}\right] \end{array}\right] \end{array}\right] \\ \texttt{QSTORE} & \{\ \} \end{array}\right]$$

$$\begin{bmatrix} \texttt{PHON} & \langle \textit{kitten} \rangle \\ \texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{HEAD} & \begin{bmatrix} \texttt{MAJ} & \textit{Noun} \\ \texttt{NFORM} & \textit{norm} \\ \texttt{CASE} & \ldots \end{bmatrix} \\ \texttt{LEX} & + \\ \texttt{SUBCAT} & \langle \mathrm{Det} \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \texttt{QSTORE} & \{\ \} \end{bmatrix}$$

Head Features

`HEAD` attributes together with their possible values.

Attribute	Value
MAJ	*Noun*, *Verb*, *Adj*, *Prep*, *Det*, ...
CASE	*nom*, *acc*, *gen*
VFORM	*fin*, *bse*, *psp*, *prp*, *pas*, *inf*, *ger*
NFORM	*norm*, *it*, *there*
PFORM	*of*, *on*, *to*, *from*
AUX	$+, -$
INV	$+, -$
PRED	$+, -$

Table 1: Head Attributes and Values

Phrase Structure

- Phrase structure is encoded by means of AVMs
- Immediate Dominance / Linear Precendence format (ID/LP)
- Dominance is encoded in `DTRS` attribute
- Precedence (implicitely) encoded in linear string of `PHON`
- `DTRS` value mainly of type *headed structure*

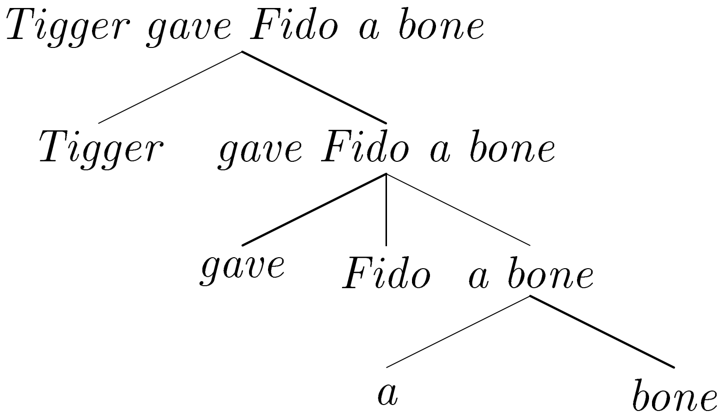
The DTRS Attribute

Subtypes of possible values of **DTRS**:

- *head-complement-structure* for standard subcategorization
- *head-adjunct-structure* for modification
- *head-filler-structure* for non-local dependencies

Attributes in value of **DTRS**:

- **HEAD-DTR**: single sign, head of constituent
- **COMP-DTRS**: list of signs, complements of head
- **ADJ-DTR**: single sign, adjunctive constituent or modifier
- **FILLER-DTR**: single sign, dislocated element in non-local dependencies
- **COORD-DTRS**: list or set of signs in coordination



$$\begin{bmatrix} \texttt{PHON}\ \langle \textit{Tigger gave Fido a bone} \rangle \\ \texttt{DTRS} \begin{bmatrix} \texttt{HEAD-DTR} \begin{bmatrix} \texttt{PHON}\ \langle \textit{gave Fido a bone} \rangle \\ \texttt{DTRS} \begin{bmatrix} \texttt{HEAD-DTR}\ \begin{bmatrix} \texttt{PHON}\ \langle \textit{gave} \rangle \end{bmatrix} \\ \texttt{COMP-DTRS} \left\langle \begin{bmatrix} \texttt{PHON}\ \langle \textit{Fido} \rangle \end{bmatrix}, \begin{bmatrix} \texttt{PHON}\ \langle \textit{a bone} \rangle \\ \texttt{DTRS} \begin{bmatrix} \texttt{HEAD-DTR}\ \begin{bmatrix} \texttt{PHON}\ \langle \textit{bone} \rangle \end{bmatrix} \\ \texttt{COMP-DTRS} \left\langle \begin{bmatrix} \texttt{PHON}\ \langle \textit{a} \rangle \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix} \\ \texttt{COMP-DTRS} \left\langle \begin{bmatrix} \texttt{PHON}\ \langle \textit{Tigger} \rangle \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

Sample Phrasal Sign

$$\begin{bmatrix} \mathtt{PHON} & \langle \mathit{the\ kitten} \rangle \\ \mathtt{SYNSEM} & \begin{bmatrix} \mathtt{LOC} & \begin{bmatrix} \mathtt{CAT} & \begin{bmatrix} \mathtt{HEAD} & \begin{bmatrix} \mathtt{MAJ} & \mathit{Noun} \\ \mathtt{NFORM} & \mathit{norm} \\ \mathtt{CASE} & \ldots \end{bmatrix} \\ \mathtt{LEX} & - \\ \mathtt{SUBCAT} & \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \mathtt{DTRS} & \begin{bmatrix} \mathtt{HEAD\text{-}DTR} & \begin{bmatrix} \mathtt{PHON} & \langle \mathit{kitten} \rangle \\ \mathtt{SYNSEM} & \begin{bmatrix} \mathtt{LOC} & \begin{bmatrix} \mathtt{CAT} & \begin{bmatrix} \mathtt{HEAD} & \begin{bmatrix} \mathtt{MAJ} & \mathit{Noun} \\ \mathtt{NFORM} & \mathit{norm} \\ \mathtt{CASE} & \ldots \end{bmatrix} \\ \mathtt{LEX} & - \\ \mathtt{SUBCAT} & \langle \boxed{1} \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \mathtt{COMP\text{-}DTRS} & \left\langle \begin{bmatrix} \mathtt{PHON} & \langle \mathit{the} \rangle \\ \mathtt{SYNSEM}\ \boxed{1} & \begin{bmatrix} \mathtt{LOC} & \begin{bmatrix} \mathtt{CAT} & \begin{bmatrix} \mathtt{HEAD} & \begin{bmatrix} \mathtt{MAJ} & \mathit{Det} \end{bmatrix} \\ \mathtt{LEX} & + \\ \mathtt{SUBCAT} & \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

Principles

- Principles are formulated as implications:

  "If a feature structure is of type *type-1* then it also has all the properties of a type *type-2*"

$$\mathit{type\text{-}1}\,[\;] \quad \Rightarrow \quad \mathit{type\text{-}2}\,[\;]$$

- Principles are constraints which hold over every sign to which their antecedent is applicable

- Principles could be also expressed by means of type inheritance

- Examples of principles:

  – Head Feature Principle

  – Subcategorization Principle

  – Semantics Principle

Head Feature Principle (HFP)

- For every headed phrase it holds that the value of the `HEAD` attribute of the mother is token identical to the value of the `HEAD` attribute of the `HEAD-DTR`

$$\left[\texttt{DTRS}\ {}_{\textit{headed-structure}}\left[\ \right]\right] \Rightarrow$$

$$\left[\begin{array}{ll}\texttt{SYNSEM} & \left[\texttt{LOC}\left[\texttt{CAT}\left[\texttt{HEAD}\ \boxed{1}\right]\right]\right] \\ \texttt{DTRS} & \left[\texttt{HEAD-DTR}\left[\texttt{SYNSEM}\left[\texttt{LOC}\left[\texttt{CAT}\left[\texttt{HEAD}\ \boxed{1}\right]\right]\right]\right]\right]\end{array}\right]$$

Semantics Principle (preliminary)

- For every headed phrase it holds that the value of the `CONTENT` attribute of the mother is token identical to the value of the `CONTENT` attribute of the `HEAD-DTR`

$$\begin{bmatrix}\texttt{DTRS}\ \mathit{headed\text{-}structure}\begin{bmatrix}\ \end{bmatrix}\end{bmatrix} \Rightarrow$$

$$\begin{bmatrix}\texttt{SYNSEM} & \begin{bmatrix}\texttt{LOC} & \begin{bmatrix}\texttt{CONTENT}\ \boxed{1}\end{bmatrix}\end{bmatrix} \\ \texttt{DTRS} & \begin{bmatrix}\texttt{HEAD-DTR} & \begin{bmatrix}\texttt{SYNSEM} & \begin{bmatrix}\texttt{LOC} & \begin{bmatrix}\texttt{CONTENT}\ \boxed{1}\end{bmatrix}\end{bmatrix}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

Subcategorization Principle

- If a constituent is a headed phrase, then the subcategorization requirements of that constituent are those of its **HEAD-DTR** minus any that have been met by sisters to the head (**COMP-DTRS**)

$$\left[\texttt{DTRS}\ {}_{\textit{headed-structure}}[\ ]\right] \Rightarrow$$

$$\left[\begin{array}{ll} \texttt{SYNSEM} & \left[\texttt{LOC}\left[\texttt{CAT}\left[\texttt{SUBCAT}\ \boxed{2}\right]\right]\right] \\ \texttt{DTRS} & \left[\begin{array}{ll}\texttt{HEAD-DTR} & \left[\texttt{SYNSEM}\left[\texttt{LOC}\left[\texttt{CAT}\left[\texttt{SUBCAT}\ \text{append}(\boxed{2},\boxed{1})\right]\right]\right]\right] \\ \texttt{COMP-DTRS} & \boxed{1}\end{array}\right]\end{array}\right]$$

(where $\boxed{1}$ $\equiv$ list of the **SYNSEM** values of the **COMP-DTRS** list)

Subcategorization

- Value of attribute **SUBCAT** indicates degree of saturation of constituent

- If the value is the empty list, the constituent is fully saturated (corresponding to a maximal projection)

- If there is one item on the list, the constituent is (normally) predicative, i.e., lacks a subject

- The subject of an expression is subcategorized for and appears as last remaining item on the list

- Correspondences between **SUBCAT** values and $\overline{\mathrm{X}}$ – Categories:

$$\begin{array}{lcl} [\texttt{subcat}\ \langle\ \rangle] & \approx & \overline{\overline{\mathrm{X}}} \\ [\texttt{subcat}\ \langle[\ ]\rangle] & \approx & \overline{\mathrm{X}} \\ [\texttt{subcat}\ \langle[\ ], \ldots\rangle] & \approx & \mathrm{X}. \end{array}$$

Obliqueness Hierarchy

- Complements are ordered according to an obliqueness hierarchy (least oblique = first element of list)
- Obliqueness order on `SUBCAT` – list is independent from actual word order
- Obliqueness hierarchy based on data from control, word-order, reflexivization and binding, passivization, case theory etc.

Accessibility hierarchy of [Keenan & Comrie 77]:

$$\text{SUBJECT} \Rightarrow \begin{array}{l}\text{DIRECT}\\\text{OBJECT}\end{array} \Rightarrow \begin{array}{l}\text{INDIRECT}\\\text{OBJECT}\end{array} \Rightarrow \text{OBLIQUES}$$

$$\Rightarrow \text{GENITIVES} \Rightarrow \begin{array}{l}\text{OBJECTS OF}\\\text{COMPARISON}\end{array}$$

The Syntax/Semantics Interface

`SUBCAT` attribute also encodes role linking between syntax and semantics

Lexical sign for *meows*:

$$\begin{bmatrix} \mathtt{PHON} & \langle \textit{meows} \rangle \\ \mathtt{SYNSEM|LOC} & \begin{bmatrix} \mathtt{CAT} & \begin{bmatrix} \mathtt{HEAD} & \begin{bmatrix} \mathtt{MAJ} & \textit{Verb} \\ \mathtt{VFORM} & \textit{fin} \\ \mathtt{AUX} & - \\ \mathtt{INV} & - \end{bmatrix} \\ \mathtt{LEX} & + \\ \mathtt{SUBCAT} & \left\langle \begin{bmatrix} \mathtt{LOC} & \begin{bmatrix} \mathtt{CAT} & \begin{bmatrix} \mathtt{HEAD} & \ldots \\ \mathtt{SUBCAT} & \langle\ \rangle \end{bmatrix} \\ \mathtt{CONTENT} & \boxed{1} \end{bmatrix} \end{bmatrix} \right\rangle \end{bmatrix} \\ \mathtt{CONTENT} & \begin{bmatrix} \mathtt{RELN} & \textit{meow} \\ \mathtt{AGENT} & \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Notational abbreviation for semantic link

$$\mathrm{NP[nom]}_{\boxed{1}} \equiv \left[\ \mathtt{LOC}\left[\mathtt{CONTENT}\ \boxed{1}\right]\right]$$

Example:

$$\left[\begin{array}{ll}
\mathtt{PHON} & \langle \textit{meows} \rangle \\
\mathtt{SYNSEM} \mid \mathtt{LOC} & \left[\begin{array}{ll}
\mathtt{CAT} & \left[\begin{array}{ll}
\mathtt{HEAD} & \left[\begin{array}{ll}
\mathtt{MAJ} & \textit{Verb} \\
\mathtt{VFORM} & \textit{fin} \\
\mathtt{AUX} & - \\
\mathtt{INV} & -
\end{array}\right] \\
\mathtt{LEX} & + \\
\mathtt{SUBCAT} & \left\langle \mathrm{NP[nom]}_{\boxed{1}} \right\rangle
\end{array}\right] \\
\mathtt{CONTENT} & \left[\begin{array}{ll}
\mathtt{RELN} & \textit{meow} \\
\mathtt{AGENT} & \boxed{1}
\end{array}\right]
\end{array}\right]
\end{array}\right]$$

Example: Ditransitive verb *give*

$$
\begin{bmatrix}
\mathtt{PHON} & \langle \textit{gives} \rangle \\
\mathtt{SYNSEM|LOC} & \begin{bmatrix}
\mathtt{CAT} & \begin{bmatrix}
\mathtt{HEAD} & \begin{bmatrix}
\mathtt{MAJ} & \textit{Verb} \\
\mathtt{VFORM} & \textit{fin} \\
\mathtt{AUX} & - \\
\mathtt{INV} & -
\end{bmatrix} \\
\mathtt{LEX} & + \\
\mathtt{SUBCAT} & \left\langle \mathrm{NP[nom]}_{\boxed{1}}, \mathrm{NP[acc]}_{\boxed{2}}, \mathrm{PP}_{\boxed{3}} \right\rangle
\end{bmatrix} \\
\mathtt{CONTENT} & \begin{bmatrix}
\mathtt{RELN} & \textit{give} \\
\mathtt{AGENT} & \boxed{1} \\
\mathtt{THEME} & \boxed{2} \\
\mathtt{GOAL} & \boxed{3}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Control

Raising constructions

- Non-finite verb phrases have one complement (subject) on their **SUBCAT** – list:

$$\mathrm{VP}[\mathit{inf}, \texttt{subcat}\ \langle \boxed{1} \rangle]$$

- Subject raising verbs coindex their own subject with the entire subject of their VP-complement

- Different types of subjects of raising verbs

(1) *These men* appear to be mad

(2) *It* appears to be raining

(3) *There* appear to be three men in the garden

Lexical entry for *appear*

$$
\begin{bmatrix}
\texttt{PHON} & \langle \textit{appears} \rangle \\
\texttt{SYNSEM}|\texttt{LOC} & \begin{bmatrix}
\texttt{CAT} & \begin{bmatrix}
\texttt{HEAD} & \begin{bmatrix} \texttt{MAJ} & \textit{Verb} \\ \texttt{VFORM} & \textit{fin} \\ \texttt{AUX} & - \\ \texttt{INV} & - \end{bmatrix} \\
\texttt{LEX} & + \\
\texttt{SUBCAT} & \left\langle \boxed{1}\ \mathrm{NP}, \mathrm{VP}\begin{bmatrix} \texttt{VFORM} & \textit{inf}, \\ \texttt{SUBCAT} & \langle \boxed{1} \rangle \end{bmatrix}_{\boxed{2}} \right\rangle
\end{bmatrix} \\
\texttt{CONTENT} & \begin{bmatrix} \texttt{RELN} & \textit{appear} \\ \texttt{THEME} & \boxed{2} \end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Equi constructions

- Control in Equi constructions is a relation between semantic argument of matrix verb and semantic content of the subject of the subcategorized VP

- Only the values of **`synsem | content`** of the controller and the controlled subject are unified

Examples:

(4) John promised Mary to wash the dishes

(5) John persuaded Mary to wash the dishes

(6) *Viele Leute* versuchten, das Problem zu lösen.
Many people tried to solve the problem

(7) *Von vielen Leuten* wurde versucht, das Problem zu lösen.
By many people was tried to solve the problem

(8) Mehrmals wurde versucht, das Problem zu lösen.
Often was tried to solve the problem

Subject control verb *promise*

$$
\begin{bmatrix}
\texttt{PHON} & \langle \textit{promises} \rangle \\
\texttt{SYNSEM|LOC} & \begin{bmatrix}
\texttt{CAT} & \begin{bmatrix}
\texttt{HEAD} & \begin{bmatrix} \texttt{MAJ} & \textit{Verb} \\ \texttt{VFORM} & \textit{fin} \\ \texttt{AUX} & - \\ \texttt{INV} & - \end{bmatrix} \\
\texttt{LEX} & + \\
\texttt{SUBCAT} & \left\langle \text{NP}_{\boxed{1}}, \text{NP}_{\boxed{2}}, \text{VP}\begin{bmatrix} \texttt{VFORM} & \textit{inf}, \\ \texttt{SUBCAT} & \left\langle \text{NP}_{\boxed{1}} \right\rangle \end{bmatrix}_{\boxed{3}} \right\rangle
\end{bmatrix} \\
\texttt{CONTENT} & \begin{bmatrix} \texttt{RELN} & \textit{promise} \\ \texttt{AGENT} & \boxed{1} \\ \texttt{PATIENT} & \boxed{2} \\ \texttt{THEME} & \boxed{3} \end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Object control verb *persuade*

$$
\begin{bmatrix}
\texttt{PHON} & \langle \textit{persuades} \rangle \\
\texttt{SYNSEM}|\texttt{LOC} &
\begin{bmatrix}
\texttt{CAT} &
\begin{bmatrix}
\texttt{HEAD} & \begin{bmatrix} \texttt{MAJ} & \textit{Verb} \\ \texttt{VFORM} & \textit{fin} \\ \texttt{AUX} & - \\ \texttt{INV} & - \end{bmatrix} \\
\texttt{LEX} & + \\
\texttt{SUBCAT} & \left\langle \mathrm{NP}_{\boxed{1}}, \mathrm{NP}_{\boxed{2}}, \mathrm{VP}\begin{bmatrix} \texttt{VFORM} & \textit{inf}, \\ \texttt{SUBCAT} & \left\langle \mathrm{NP}_{\boxed{2}} \right\rangle \end{bmatrix}_{\boxed{3}} \right\rangle
\end{bmatrix} \\
\texttt{CONTENT} &
\begin{bmatrix}
\texttt{RELN} & \textit{promise} \\
\texttt{AGENT} & \boxed{1} \\
\texttt{PATIENT} & \boxed{2} \\
\texttt{THEME} & \boxed{3}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Auxiliary Verbs

- Auxiliaries and modals are analyzed as raising verbs
- Auxiliary is head of the verb phrase and subcategorizes for a VP with a specific `VFORM` value

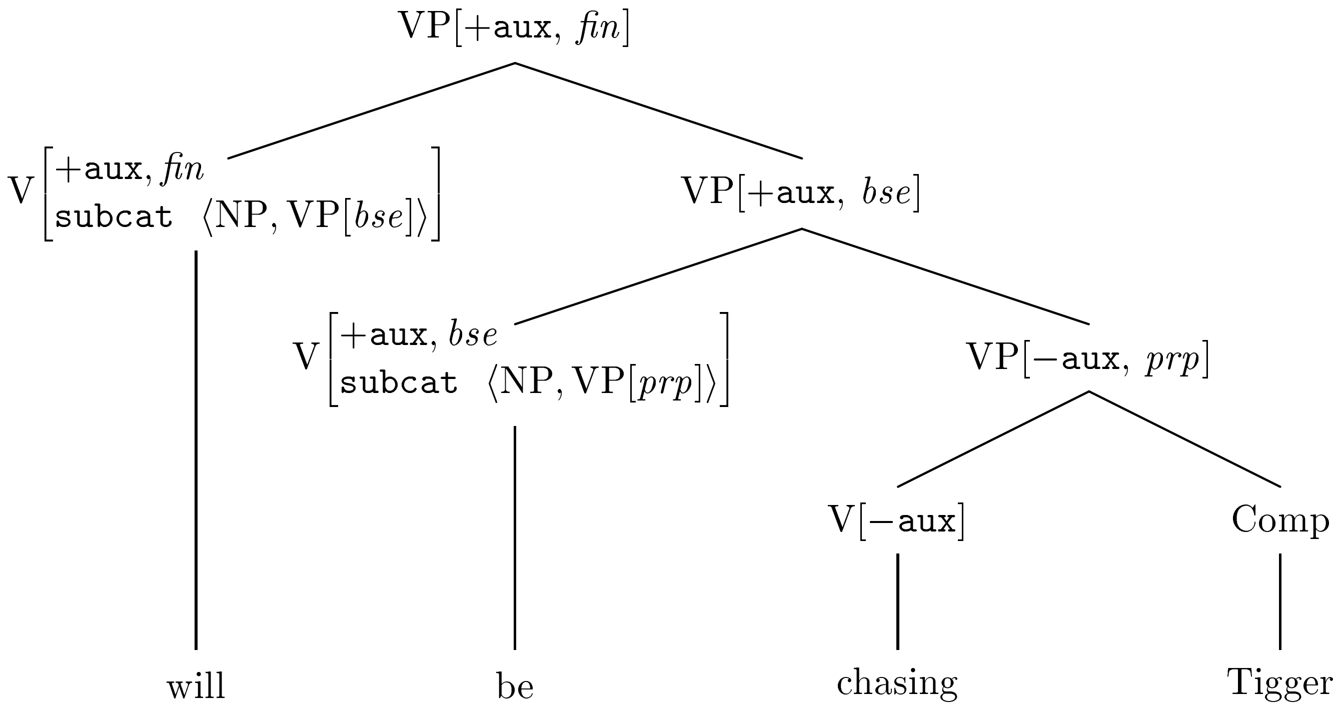


Figure 1: The Auxiliary Chain

Grammar Rules

- No rules in traditional (derivational) sense, but well-formedness constraints on structures
- Separation of derivation and description – no derivation concept implied in rule schemata
- Rules are schematic description of phrasal signs in a uniform representation
- Every phrasal sign must be an extension (instance) of a rule schema plus all the relevant principles
- Separation of immediate dominance and linear precedence
- Immediate dominance schemata are assumed to be universal
- Linear precedence constraints are language specific

Grammar Rule 1: Non-Lexical Heads + Subjects

- Combines non-lexical head (e.g., VP) with subject or specifier

- Conditions:

  Head must have exactly one complement on its **SUBCAT** – list

  Head must be non-lexical, i.e., [**LEX** −]

- Some instances in terms of phrase structure rules:

$$
\begin{array}{llll}
\mathrm{S} & \rightarrow & \mathrm{NP[nom]} & \mathrm{VP} \\
\mathrm{NP} & \rightarrow & \mathrm{Det} & \overline{\mathrm{N}} \\
\mathrm{NP} & \rightarrow & \mathrm{NP[gen]} & \overline{\mathrm{N}}
\end{array}
$$

- In terms of $\overline{\mathrm{X}}$-syntax

$$\overline{\overline{\mathrm{X}}} \quad \rightarrow \quad \mathrm{Subj} \quad \overline{\mathrm{X}}$$

- In informal re-write notation

$$[\texttt{SUBCAT}\ \langle\ \rangle] \rightarrow \mathrm{C} \quad \mathrm{H}[\texttt{LEX}\ -]$$

- Representation in AVM terms as well-formedness constraint on phrasal signs

$$\begin{bmatrix} \texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{SUBCAT}\ \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \texttt{DTRS} & \begin{bmatrix} \texttt{HEAD-DTR} & \begin{bmatrix} \texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{LEX}\ - \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \texttt{COMP-DTRS} & \left\langle \begin{bmatrix}\ \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$$

Rule 1: Full representation after conjunction with

- Constituent Order Principle (for English: “Non-lexical heads follow their complements”)
- Subcategorisation Principle
- Head Feature Principle

$$\begin{bmatrix}
\texttt{PHON} & \boxed{2} \bullet \boxed{1} \\
\texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{HEAD} & \boxed{3} \\ \texttt{LEX} & - \\ \texttt{SUBCAT} & \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\
\texttt{DTRS} & \begin{bmatrix} \texttt{HEAD-DTR} & \begin{bmatrix} \texttt{PHON} & \boxed{1} \\ \texttt{SYNSEM}|\texttt{LOC}|\texttt{CAT} & \begin{bmatrix} \texttt{HEAD} & \boxed{3} \\ \texttt{LEX} & - \\ \texttt{SUBCAT} & \langle \boxed{4} \rangle \end{bmatrix} \end{bmatrix} \\ \texttt{COMP-DTRS} & \left\langle \begin{bmatrix} \texttt{PHON} & \boxed{2} \\ \texttt{SYNSEM} & \boxed{4} \end{bmatrix} \right\rangle \end{bmatrix}
\end{bmatrix}$$

Rule 1: Instantiation of `HEAD-DTR` with VP *meows*:

$$
\begin{bmatrix}
\mathtt{PHON} & \boxed{2} \bullet \langle \textit{meows} \rangle \\
\mathtt{SYNSEM} & \begin{bmatrix}\mathtt{LOC} & \begin{bmatrix}\mathtt{CAT} & \begin{bmatrix}\mathtt{HEAD} & \boxed{3}\begin{bmatrix}\mathtt{MAJ} & \textit{Verb}\\ \mathtt{VFORM} & \textit{fin}\\ \mathtt{PRD} & -\\ \mathtt{INV} & - \\ \mathtt{AUX} & -\end{bmatrix}\\ \mathtt{LEX} & - \\ \mathtt{SUBCAT} & \langle\ \rangle\end{bmatrix}\end{bmatrix}\end{bmatrix}\\
\mathtt{DTRS} & \begin{bmatrix}\mathtt{HEAD\text{-}DTR} & \begin{bmatrix}\mathtt{PHON} & \langle\textit{meows}\rangle\\ \mathtt{SYNSEM|LOC|CAT} & \begin{bmatrix}\mathtt{HEAD} & \boxed{3}\\ \mathtt{LEX} & -\\ \mathtt{SUBCAT} & \langle\boxed{4}\rangle\end{bmatrix}\end{bmatrix}\\
\mathtt{COMP\text{-}DTRS} & \left\langle\begin{bmatrix}\mathtt{PHON} & \boxed{2}\\ \mathtt{SYNSEM} & \boxed{4}\begin{bmatrix}\mathtt{LOC|CAT} & \begin{bmatrix}\mathtt{HEAD} & \begin{bmatrix}\mathtt{MAJ} & \textit{Noun}\\ \mathtt{NFORM} & \textit{norm}\\ \mathtt{CASE} & \textit{nom}\end{bmatrix}\\ \mathtt{LEX} & -\\ \mathtt{SUBCAT} & \langle\ \rangle\end{bmatrix}\end{bmatrix}\end{bmatrix}\right\rangle\end{bmatrix}
\end{bmatrix}
$$

Grammar Rule 2:
Lexical Heads + Non-Subject Complements

- Combines lexical head with all its complements but one (subject)

- Conditions:

  Head must be lexical

  Mother constituent must have one item on its **SUBCAT** – list

- Instances in terms of phrase structure rules

VP	$\rightarrow$	V	(for intransitive verbs)
VP	$\rightarrow$	V NP	(for transitive verbs)
VP	$\rightarrow$	V NP PP	(for ditransitive verbs)
AP	$\rightarrow$	A PP	(for adjectives)
$\overline{\mathrm{N}}$	$\rightarrow$	N	(for most common nouns)
$\overline{\mathrm{N}}$	$\rightarrow$	N PP[of]	(for "picture" nouns)

- In $\overline{\mathrm{X}}$ – terms:

$$\overline{\mathrm{X}} \quad \rightarrow \quad \mathrm{X} \quad \mathrm{C}^*$$

- In informal re-write notation:

$$[\texttt{SUBCAT}\ \langle[\ ]\rangle] \quad \rightarrow \quad \mathrm{H}[\texttt{INV}\ \ -, \texttt{LEX}\ \ +] \quad \mathrm{C}^*$$

- In AVM notation:

$$\begin{bmatrix} \texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{SUBCAT} & \left\langle [\quad] \right\rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \texttt{DTRS} & \begin{bmatrix} \texttt{HEAD-DTR} & \begin{bmatrix} \texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{HEAD} & \begin{bmatrix} \texttt{INV} & - \\ \texttt{LEX} & + \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Rule 2: Conjunction with HFP, SCP, and COP

(COP for English: " Lexical heads must be head initial")

$$\begin{bmatrix}
\texttt{PHON} & \boxed{1} \bullet \text{order}(\boxed{2}) \\
\texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{HEAD} & \boxed{3}\begin{bmatrix}\texttt{INV} & -\end{bmatrix} \\ \texttt{LEX} & - \\ \texttt{SUBCAT} & \langle \boxed{4} \rangle \end{bmatrix}\end{bmatrix}\end{bmatrix} \\
\texttt{DTRS} & \begin{bmatrix} \texttt{HEAD-DTR} & \begin{bmatrix}\texttt{PHON} & \boxed{1} \\ \texttt{SYNSEM}|\texttt{LOC}|\texttt{CAT} & \begin{bmatrix}\texttt{HEAD} & \boxed{3} \\ \texttt{LEX} & + \\ \texttt{SUBCAT} & \langle \boxed{4} \mid \boxed{2} \rangle\end{bmatrix}\end{bmatrix} \\ \texttt{COMP-DTRS} & \boxed{2}\end{bmatrix}
\end{bmatrix}$$

Rule 2: Instantiation licensing the verb phrase *meows* from the lexical intransitive verb *meows*:

$$
\left[\begin{array}{ll}
\texttt{PHON} & \langle \mathit{meows} \rangle \\
\texttt{SYNSEM} & \left[\texttt{LOC} \left[\texttt{CAT} \left[\begin{array}{ll}
\texttt{HEAD} & \boxed{3} \left[\begin{array}{ll}
\texttt{MAJ} & \mathit{Verb} \\
\texttt{INV} & - \\
\texttt{PRD} & - \\
\texttt{AUX} & -
\end{array}\right] \\
\texttt{LEX} & - \\
\texttt{SUBCAT} & \langle \boxed{4}\ \mathrm{NP[nom]} \rangle
\end{array}\right]\right]\right] \\
\texttt{DTRS} & \left[\begin{array}{ll}
\texttt{HEAD-DTR} & \left[\texttt{SYNSEM}|\texttt{LOC}|\texttt{CAT} \left[\begin{array}{ll}
\texttt{HEAD} & \boxed{3} \\
\texttt{LEX} & + \\
\texttt{SUBCAT} & \langle \boxed{4} \rangle
\end{array}\right]\right] \\
\texttt{COMP-DTRS} & \langle\ \rangle
\end{array}\right]
\end{array}\right]
$$

Grammar Rule 3: Inverted Structures

- Inverts lexical head (auxiliary) with subject and VP
- Conditions:

  Head must be lexical and invertible (only auxiliaries)

  All non-auxiliaries are marked as [`HEAD` [`INV` $-$]]

  All auxiliaries are unmarked wrt [`HEAD` [`INV` [ ]]]

- Example: *Did Tigger chase Fido*
- In terms of phrase structure rules:

$$\overline{\mathrm{S}} \rightarrow \mathrm{V} \quad \mathrm{NP[nom]} \quad \mathrm{VP}$$

- In $\overline{\mathrm{X}}$ terms:

$$\overline{\overline{\mathrm{X}}} \quad \rightarrow \quad \mathrm{X} \quad \mathrm{Subj} \quad \mathrm{C}^*$$

- In informal re-write notation:

$$[\texttt{SUBCAT}\ \langle\ \rangle] \quad \rightarrow \quad \mathrm{H}[\texttt{INV}\ \ +, \texttt{LEX}\ \ +] \quad \mathrm{C}^*$$

- In AVM notation:

$$\begin{bmatrix} \texttt{SYNSEM} \begin{bmatrix} \texttt{LOC} \begin{bmatrix} \texttt{CAT} \begin{bmatrix} \texttt{SUBCAT}\ \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\ \texttt{DTRS} \quad \begin{bmatrix} \texttt{HEAD-DTR} \begin{bmatrix} \texttt{SYNSEM} \begin{bmatrix} \texttt{LOC} \begin{bmatrix} \texttt{CAT} \begin{bmatrix} \texttt{HEAD} \begin{bmatrix} \texttt{INV}\ + \\ \texttt{LEX}\ + \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Rule 3: Conjunction with HFP, SCP, COP

(COP for English: Lexical head must be head initial)

Instance of sign for ***Is Tigger meowing***:

$$\begin{bmatrix}
\texttt{PHON} & \langle \textit{is Tigger meowing} \rangle \\
\texttt{SYNSEM} & \begin{bmatrix} \texttt{LOC} & \begin{bmatrix} \texttt{CAT} & \begin{bmatrix} \texttt{HEAD} & \boxed{1} \begin{bmatrix} \texttt{MAJ} & \textit{Verb} \\ \texttt{INV} & + \\ \texttt{AUX} & + \\ \texttt{PRED} & + \end{bmatrix} \\ \texttt{LEX} & - \\ \texttt{SUBCAT} & \langle\ \rangle \end{bmatrix} \end{bmatrix} \end{bmatrix} \\
\texttt{DTRS} & \begin{bmatrix} \texttt{HEAD-DTR} & \begin{bmatrix} \texttt{PHON} & \langle \textit{is} \rangle \\ \texttt{SYNSEM|LOC|CAT} & \begin{bmatrix} \texttt{HEAD} & \boxed{1} \\ \texttt{LEX} & + \\ \texttt{SUBCAT} & \left\langle \boxed{\alpha}, \boxed{\beta} \right\rangle \end{bmatrix} \end{bmatrix} \\ \texttt{COMP-DTRS} & \left\langle \begin{bmatrix} \texttt{SYNSEM} & \boxed{\alpha} \end{bmatrix}, \begin{bmatrix} \texttt{SYNSEM} & \boxed{\beta} \end{bmatrix} \right\rangle \end{bmatrix}
\end{bmatrix}$$

where $\boxed{\alpha} \equiv$ NP *Tigger* and $\boxed{\beta} \equiv$ VP *meowing*.

Rule 4: Adjunct + Headed Structures

- Combines adjunct(s) with headed structure

- Conditions:

  Head must have exactly one complement on its `SUBCAT` – list (alternative for sentential adjunction: no complement),

  Head must be non-lexical ([`LEX` −])

  Adjunct must be saturated

- In terms of phrase structure rules:

$$\mathrm{VP} \rightarrow \mathrm{VP} \quad \mathrm{Adv}$$
$$\overline{\mathrm{N}} \rightarrow \mathrm{Adj} \quad \overline{\mathrm{N}}$$

- In terms of $\overline{\mathrm{X}}$-syntax

$$\overline{\mathrm{X}} \rightarrow \mathrm{XP} \quad \overline{\mathrm{X}}$$

- In informal re-write notation

$$[\texttt{SUBCAT}\ \langle[\ ]\rangle] \rightarrow \mathrm{A}[\texttt{SUBCAT}\ \langle\ \rangle] \quad \mathrm{H}[\texttt{LEX}\ \ -, \texttt{SUBCAT}\ \ \langle[\ ]\rangle]$$

- In AVM terms:

$$\left[\texttt{DTRS}\left[\begin{array}{ll}\texttt{HEAD-DTR} & \left[\texttt{SYNSEM}\ \boxed{1}\left[\texttt{LOC}\left[\texttt{CAT}\left[\begin{array}{ll}\texttt{LEX} & - \\ \texttt{SUBCAT} & \langle[\ ]\rangle\end{array}\right]\right]\right]\right] \\ \texttt{ADJ-DTR} & \left[\texttt{SYNSEM}\left[\texttt{LOC}\left[\texttt{CAT}\left[\begin{array}{ll}\texttt{SUBCAT} & \langle\ \rangle \\ \texttt{MOD} & \boxed{1}\end{array}\right]\right]\right]\right]\end{array}\right]\right]$$

Revision of Semantics Principle (SemP)

- Split between syntactic head and semantic head in the case of adjuncts ($\approx$ head vs. functor)

- Adjunct functions as syntactic modifier, but semantic operator over head

- Example: *Hans schwimmt gerne*

Semantics Priniple

"In a headed phrase the `CONTENT` value is token-identical to that of the `ADJ-DTR` if the `DTRS` value is of the type *head-adj-struc*, and with that of the `HEAD-DTR` otherwise."

Rule 4: Conjunction with HFP, SCP and SemP

$$
\left[\begin{array}{ll}
\texttt{SYNSEM} & \left[\texttt{LOC}\ \left[\begin{array}{ll}
\texttt{CAT} & \left[\begin{array}{ll}
\texttt{HEAD} & \boxed{1} \\
\texttt{LEX} & - \\
\texttt{SUBCAT} & \langle \boxed{2} \rangle
\end{array}\right] \\
\texttt{CONTENT} & \boxed{3}
\end{array}\right]\right] \\
\texttt{DTRS} & \left[\begin{array}{ll}
\texttt{HEAD-DTR} & \left[\texttt{SYNSEM}\ \boxed{4}\ \left[\texttt{LOC}\ \left[\texttt{CAT}\ \left[\begin{array}{ll}
\texttt{HEAD} & \boxed{1} \\
\texttt{LEX} & - \\
\texttt{SUBCAT} & \langle \boxed{2} \rangle
\end{array}\right]\right]\right]\right] \\
\texttt{ADJ-DTR} & \left[\texttt{SYNSEM}\ \left[\texttt{LOC}\ \left[\begin{array}{ll}
\texttt{CAT} & \left[\begin{array}{ll}
\texttt{SUBCAT} & \langle\ \rangle \\
\texttt{MOD} & \boxed{4}
\end{array}\right] \\
\texttt{CONTENT} & \boxed{3}
\end{array}\right]\right]\right]
\end{array}\right]
\end{array}\right]
$$