Grammatikformalismen und Parsing

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HPSG as a Formal Linguistic Theory II

The grammar of HPSG'94

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Review

- general properties
- linguistic assumptions
- ID Schemata
  - SCHEMA 1 (HEAD-SUBJECT SCHEMA)
  - SCHEMA 2 (HEAD-COMPLEMENT SCHEMA)
  - SCHEMA 3 (HEAD-SUBJECT-COMPLEMENT SCHEMA)
  - SCHEMA 4 (HEAD-MARKER SCHEMA)
  - SCHEMA 5 (HEAD-ADJUNCT SCHEMA)
  - SCHEMA 6 (HEAD-FILLER SCHEMA)
- principles
  - The ID PRINCIPLE
  - HEAD FEATURE PRINCIPLE
  - SUBCATEGORIZATION PRINCIPLE
  - MARKING PRINCIPLE

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Open Issues

1. Schema 1 (Head-Subject Schema)
   (a) "head-daughter is a phrase"
   (b) "synsem | nonlocal | to-bind | slash value is {}"
2. Schema 6 (Head-Filler Schema)

Explanation 1a

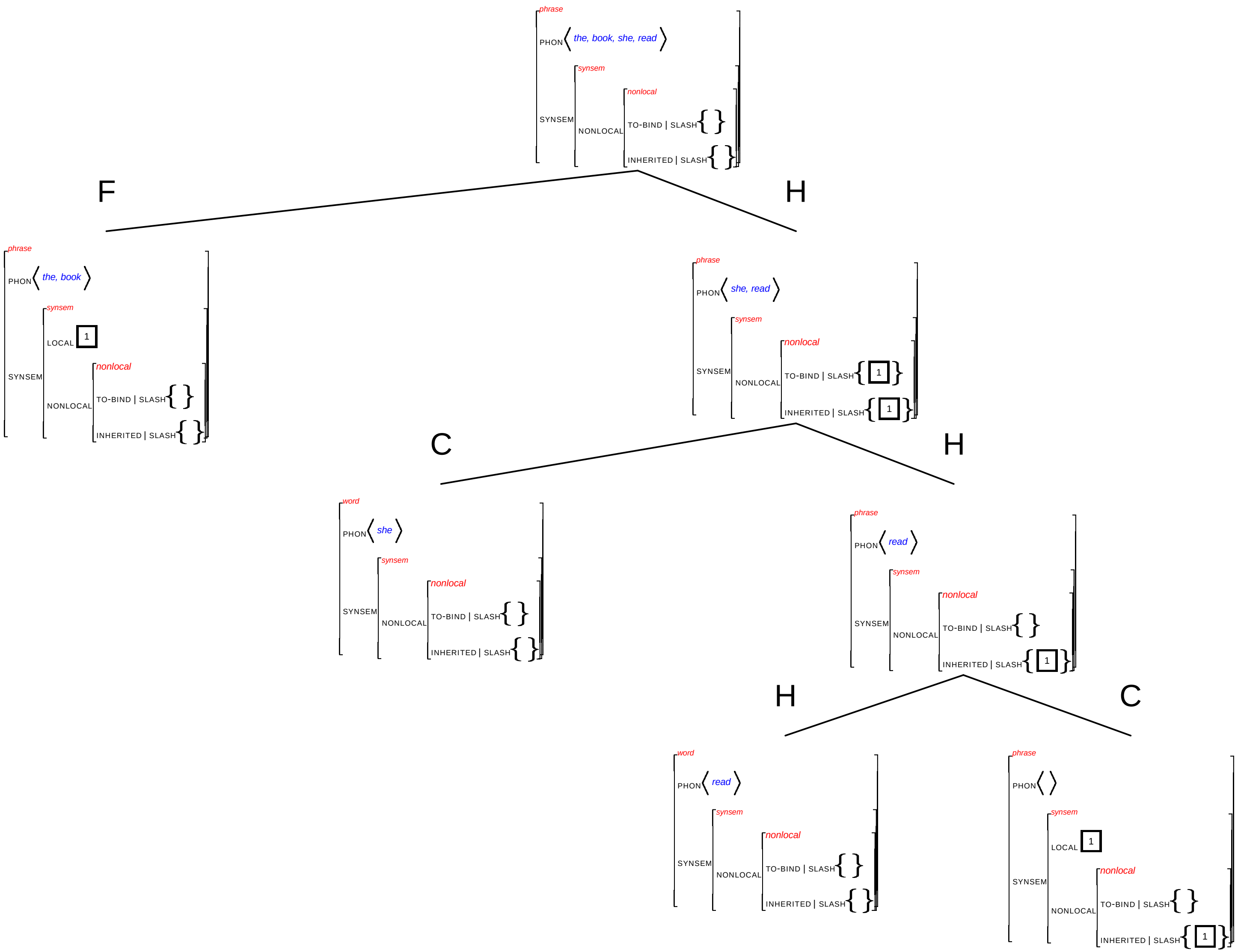
X-bar schema:

$$X^n \rightarrow \ldots X^{n-1} \ldots$$

Explanation 1b

$$
\begin{bmatrix}
\textit{sign} & \\
\text{SYNSEM} & \begin{bmatrix}
\textit{synsem} & \\
\text{NONLOCAL} & \begin{bmatrix}
\textit{nonlocal} & \\
\text{TO-BIND} & \begin{bmatrix}
\textit{nonlocall} \\
\text{SLASH } \textit{set (of locals)} \\
\text{REL } \textit{set (of refs)} \\
\text{QUE } \textit{set (of npros)}
\end{bmatrix} \\
\text{INHERITED} & \begin{bmatrix}
\textit{nonlocall} \\
\text{SLASH } \textit{set (of locals)} \\
\text{REL } \textit{set (of refs)} \\
\text{QUE } \textit{set (of npros)}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Explanation 1b



NONLOCAL FEATURE PRINCIPLE

In a headed phrase, for each nonlocal feature F = SLASH, QUE or REL, the value of SYNSEM | NONLOCAL | INHERITED | F is the set difference of the union of the values on all the daughters, and the value of SYNSEM | NONLOCAL | TO-BIND | F on the HEAD-DAUGHTER.

Explanation 2: SCHEMA 6 (HEAD-FILLER SCHEMA)

The DAUGHTERS value is an object of sort *head-filler-struc* whose HEAD-DAUGHTER | SYNSEM | LOCAL | CATEGORY value satisfies the description [HEAD *verb*[VFORM *finite*], SUBCAT ⟨⟩], whose HEAD-DAUGHTER | SYNSEM | NONLOCAL | INHERITED | SLASH value contains an element token-identical to the FILLER-DAUGHTER | SYNSEM | LOCAL value, and whose HEAD-DAUGHTER | SYNSEM | NONLOCAL | TO-BIND | SLASH value contains only that element.

Explanation 2: SCHEMA 6 (HEAD-FILLER SCHEMA) formalized

$$\begin{bmatrix} \text{DTRS} & \begin{bmatrix} \textit{head-filler-struc} & \\ \text{FILLER-DTR SS LOC} & \boxed{1} \\ \text{HEAD-DTR SS} & \begin{bmatrix} \text{LOC CAT} & \begin{bmatrix} \text{HEAD VFORM} & \textit{finite} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\ \text{NONLOC} & \begin{bmatrix} \text{INHERITED SLASH} & \boxed{2} \\ \text{TO-BIND SLASH} & \left\{\boxed{1}\right\} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\wedge\ \mathtt{member}(\boxed{1}, \boxed{2})$$

The Relation `member`

The relation `member`(x,y) holds iff x is an element of the list y, that is

- either x is identical with yFIRST or
- `member`(x, yREST) holds.

Formalization:

$$\forall x \forall y\ (\texttt{member}(x,y) \leftrightarrow \exists \boxed{1}\ ({}^{y}\left[\text{FIRST}\ x\right] \lor {}^{y}\left[\text{REST}\ \boxed{1}\right] \land \texttt{member}(x,\boxed{1})\ )\ )$$

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SUBCATEGORIZATION PRINCIPLE

In a headed phrase, the list value of DAUGHTERS | HEAD-DAUGHTER | SYNSEM | LOCAL | CATEGORY | SUBCAT is the concatenation of the list value of SYNSEM | LOCAL | CATEGORY | SUBCAT with the list consisting of the SYNSEM values (in order) of the elements of the list value of DAUGHTERS | COMPLEMENT-DAUGHTERS.

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SUBCATEGORIZATION PRINCIPLE **formalized**

$$\begin{bmatrix} \textit{phrase} \\ \text{DTRS} \ \textit{headed-struc} \end{bmatrix} \rightarrow$$

$$\begin{bmatrix} \text{SYNSEM LOC CAT SUBCAT} \ \boxed{1} \\ \text{DTRS} \begin{bmatrix} \text{HEAD-DTR} \quad \text{SYNSEM LOC CAT SUBCAT} \ \boxed{2} \\ \text{COMP-DTRS} \ \boxed{3} \end{bmatrix} \end{bmatrix}$$

$\wedge$ `sign-to-synsem`$(\boxed{3},\boxed{4})$

$\wedge$ `append`$(\boxed{1},\boxed{4},\boxed{2})$

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The Relation `sign-to-synsem`

The Relation `sign-to-synsem` holds between a list x of *sign* objects and a list y of *synsem* objects iff

- x is an empty list and y is an empty list or
- the SYNSEM value of the first element of x is the first element of y and the relation `sign-to-synsem` holds between the lists x and y each shortened with respect to the first element.

Formalization:

$$\forall x \forall y$$

$$(\texttt{sign-to-synsem}(x,y) \leftrightarrow$$

$$\left(\left({}^{x}\begin{bmatrix} \textit{elist} \end{bmatrix} \wedge {}^{y}\begin{bmatrix} \textit{elist} \end{bmatrix} \right) \vee \right.$$

$$\exists \boxed{1} \exists \boxed{2} \exists \boxed{3}$$

$$\left({}^{x}\begin{bmatrix} \text{FIRST SYNSEM } \boxed{3} \\ \text{REST } \boxed{1} \end{bmatrix} \wedge {}^{y}\begin{bmatrix} \text{FIRST } \boxed{3} \\ \text{REST } \boxed{2} \end{bmatrix} \wedge \texttt{sign-to-synsem}(\boxed{1},\boxed{2}) \right)))$$

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The Relation append

The relation append(x,y,z) holds iff the list z is the concatenation of the list x and the list y.

Formalization:

$\forall x \forall y \forall z$ (append(x,y,z) $\leftrightarrow$

$$\left(\left({}^{x}[\textit{elist}] \wedge y = z\right) \vee\right.$$

$$\exists \boxed{1} \exists \boxed{2} \exists \boxed{3} \left({}^{x}\begin{bmatrix} \text{FIRST } \boxed{1} \\ \text{REST } \boxed{2} \end{bmatrix} \wedge {}^{z}\begin{bmatrix} \text{FIRST } \boxed{1} \\ \text{REST } \boxed{3} \end{bmatrix} \wedge \text{append}(\boxed{2}, y, \boxed{3}) \right)))$$

Schema 4 (Head-Marker Schema)

The DAUGHTERS value is an object of sort *head-marker-struc* whose HEAD-DAUGHTER | SYNSEM | NONLOCAL | TO-BIND | SLASH value is {}, and whose MARKER-DAUGHTER | SYNSEM | LOCAL | CATEGORY | HEAD value is of sort *marker*.

Formalization:

$$\left[\text{DTRS}\ \begin{bmatrix} \textit{head-marker-struc} \\ \text{HEAD-DTR SS NONLOC TO-BIND SLASH}\ \{\} \\ \text{MARKER-DTR SS LOC CAT HEAD}\quad \textit{marker} \end{bmatrix}\right]$$

AVM Description of a Functional Part of Speech

$$
\begin{bmatrix}
\textit{word} & \\
\text{SYNSEM} & \begin{bmatrix}
\textit{synsem} & \\
\text{LOCAL} & \begin{bmatrix}
\textit{local} & \\
\text{CATEGORY} & \begin{bmatrix}
\textit{category} & \\
\text{HEAD} & \begin{bmatrix}
\textit{functional} \\
\text{SPEC } \textit{synsem}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Spec Principle

In a headed phrase whose nonhead daughter (either the MARKER-DAUGHTER or COMPLEMENT-DAUGHTERS | FIRST) has a SYNSEM | LOCAL | CATEGORY | HEAD value of sort *functional*, the SPEC value of that value must be token-identical with the phrase's DAUGHTERS | HEAD-DAUGHTER | SYNSEM value.

SPEC PRINCIPLE formalized

$$\forall \boxed{1}\ \forall \boxed{2}$$

$$\left(\left(\begin{bmatrix} \text{DTRS} & \left[\begin{bmatrix} \text{MARKER-DTR} & \boxed{1} \end{bmatrix} \vee \begin{bmatrix} \text{COMP-DTRS} & \langle \boxed{1} | \textit{list} \rangle \end{bmatrix} \right] \end{bmatrix} \wedge \boxed{1} \begin{bmatrix} \text{SS LOC CAT HEAD} & \begin{bmatrix} \textit{functional} \\ \text{SPEC} & \boxed{2} \end{bmatrix} \end{bmatrix} \right) \rightarrow \begin{bmatrix} \text{DTRS HEAD-DTR SS} & \boxed{2} \end{bmatrix} \right)$$

TRACE PRINCIPLE

The SYNSEM value of any trace must be a (noninitial) member of the SUBCAT list of a substantive word.

TRACE PRINCIPLE formalized

$$
\forall x\ \forall \boxed{2}
$$

$$
\left(
\begin{array}{l}
\exists \boxed{1} \\
\left(
\begin{bmatrix}
\text{PHON} & \textit{nelist} \\
\text{SS} & \begin{bmatrix}
\text{LOC CAT} & \begin{bmatrix} \text{HEAD VFORM} & \textit{finite} \\ \text{SUBCAT} & \langle\rangle \end{bmatrix} \\
\text{NONLOC INHERITED} & \begin{bmatrix} \text{QUE} & \{\} \\ \text{REL} & \{\} \\ \text{SLASH} & \{\} \end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\wedge\ {}_{x}\begin{bmatrix}
\textit{sign} & \\
\text{PHON} & \langle\rangle \\
\text{SS} & \boxed{2}\begin{bmatrix}
\text{LOC} & \boxed{1} \\
\text{NONLOC} & \begin{bmatrix}
\text{INHERITED} & \begin{bmatrix} \text{QUE} & \{\} \\ \text{REL} & \{\} \\ \text{SLASH} & \{\boxed{1}\} \end{bmatrix} \\
\text{TO-BIND} & \begin{bmatrix} \text{QUE} & \{\} \\ \text{REL} & \{\} \\ \text{SLASH} & \{\} \end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\right) \rightarrow \\
\exists y\ \exists \boxed{3} \\
\left({}_{y}\begin{bmatrix}
\textit{word} & \\
\text{SS LOC CAT} & \begin{bmatrix} \text{HEAD} & \textit{substantive} \\ \text{SUBCAT} & \left\langle \textit{object} \,|\, \boxed{3} \right\rangle \end{bmatrix}
\end{bmatrix}
\wedge\ \texttt{member}(\boxed{2}, \boxed{3}) \right)
\end{array}
\right)
$$

AVM Description of Traces

$$
\begin{bmatrix}
\textit{word} & \\
\text{PHON} & \langle\rangle \\
\text{SYNSEM} & \begin{bmatrix}
\textit{synsem} & \\
\text{LOCAL} & \boxed{1} \\
\text{NONLOCAL} & \begin{bmatrix}
\textit{nonlocal} & \\
\text{TO-BIND} & \begin{bmatrix}
\textit{nonlocal1} & \\
\text{SLASH} & \{\} \\
\text{REL} & \{\} \\
\text{QUE} & \{\}
\end{bmatrix} \\
\text{INHERITED} & \begin{bmatrix}
\textit{nonlocal1} & \\
\text{SLASH} & \left\{\boxed{1}\right\} \\
\text{REL} & \{\} \\
\text{QUE} & \{\}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

Word Principle

$$\begin{bmatrix} \textit{word} \\ \\ \end{bmatrix} \rightarrow (\text{LE}_1 \vee \ldots \vee \text{LE}_n)$$

PARTIAL LEXICAL ENTRY OF A SUBJECT RAISING VERB

$$
\begin{bmatrix}
\textit{word} \\
\text{PHON} \ \langle \textit{tend} \rangle \\
\text{SYNSEM} \begin{bmatrix}
\textit{synsem} \\
\text{LOCAL} \begin{bmatrix}
\textit{local} \\
\text{CATEGORY} \begin{bmatrix}
\textit{category} \\
\text{HEAD} \begin{bmatrix}
\textit{verb} \\
\text{SUBCAT} \left\langle \boxed{1}, \text{VP}\left[\textit{inf}, \text{SUBCAT} \langle \boxed{1} \rangle : \boxed{2}\right] \right\rangle
\end{bmatrix}
\end{bmatrix} \\
\text{CONTENT} \begin{bmatrix}
\textit{tend} \\
\text{SOA-ARG} \ \boxed{2}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
\end{bmatrix}
$$

PARTIAL LEXICAL ENTRY OF AN OBJECT RAISING VERB

$$\begin{bmatrix} \textit{word} \\ \text{PHON} \ \langle \textit{believe} \rangle \\ \text{SYNSEM} \begin{bmatrix} \textit{synsem} \\ \text{LOCAL} \begin{bmatrix} \textit{local} \\ \text{CATEGORY} \begin{bmatrix} \textit{category} \\ \text{HEAD} \begin{bmatrix} \textit{verb} \\ \text{SUBCAT} \left\langle \text{NP}_{\boxed{1}}, \boxed{2}, \text{VP}\left[\textit{inf}, \text{SUBCAT} \left\langle \boxed{2} \right\rangle : \boxed{3}\right] \right\rangle \end{bmatrix} \end{bmatrix} \\ \text{CONTENT} \begin{bmatrix} \textit{believe} \\ \text{BELIEVER} \ \boxed{1}\textit{ref} \\ \text{SOA-ARG} \ \boxed{3} \end{bmatrix} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Partial Lexical Entry of a Subject Control Verb

$$\begin{bmatrix} \textit{word} \\ \text{PHON } \langle \textit{try} \rangle \\ \text{SYNSEM } \begin{bmatrix} \textit{synsem} \\ \text{LOCAL } \begin{bmatrix} \textit{local} \\ \text{CATEGORY } \begin{bmatrix} \textit{category} \\ \text{HEAD } \begin{bmatrix}\textit{verb} \\ \text{SUBCAT } \left\langle \text{NP}\boxed{1}, \text{VP}\left[\textit{inf}, \text{SUBCAT}\langle \text{NP}\boxed{1}\rangle{:}\,\boxed{3}\right] \right\rangle \end{bmatrix}\end{bmatrix} \\ \text{CONTENT } \begin{bmatrix} \textit{try} \\ \text{TRYER } \boxed{1}\,\textit{ref} \\ \text{SOA-ARG } \boxed{3}\end{bmatrix}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

Partial Lexical Entry of an Object Control Verb

- *word*
- PHON ⟨*persuade*⟩
- SYNSEM
  - *synsem*
  - LOCAL
    - *local*
    - CATEGORY
      - *category*
      - HEAD
        - *verb*
        - SUBCAT ⟨NP[1], NP[2], VP[*inf*, SUBCAT ⟨NP[2]⟩ : [3]]⟩
    - CONTENT
      - *persuade*
      - PERSUADER [1] *ref*
      - PERSUADEE [2] *ref*
      - SOA-ARG [3]

RAISING PRINCIPLE

Let E be a lexical entry in which the (description of the) SUBCAT list L contains (a description corresponding to) a member X (of L) that is not explicitly described in E as an expletive. Then in (the description of) the CONTENT value, X is (described as) assigned no semantic role if and only if L (is described as if it) contains a non-subject whose own SUBCAT value is $\langle \mathrm{X} \rangle$.

Logical structure of RAISING PRINCIPLE:

$$A \rightarrow (B \leftrightarrow C)$$

EXAMPLES I

1.
$$\begin{bmatrix} \textit{word} & \\ \text{SYNS LOC} & \begin{bmatrix} \text{CAT SUBCAT} & \left\langle \text{NP}_{\boxed{1}}, \text{NP}_{\boxed{1}} \right\rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{rel1} \\ \text{REL-ER} \ \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

2.
$$\begin{bmatrix} \textit{word} & \\ \text{SYNS LOC} & \begin{bmatrix} \text{CAT SUBCAT} & \left\langle \text{NP}_{\boxed{1}\textit{it}} \right\rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{rel2} \\ \text{REL-ER} \ \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

EXAMPLES II

1.

$$\begin{bmatrix} \textit{word} & \\ \text{SYNS LOC} & \begin{bmatrix} \text{CAT SUBCAT} & \left\langle \text{NP}_{\boxed{1}}, \text{VP}[\textsc{sc}\ \langle \text{VP}_{\boxed{1}} \rangle] \right\rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{rel3} \\ \text{REL-ER}\ \boxed{1} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

2.

$$\begin{bmatrix} \textit{word} & \\ \text{SYNS LOC} & \begin{bmatrix} \text{CAT SUBCAT} & \left\langle \boxed{1}_{\boxed{2}}, \text{VP}[\textsc{sc}\ \langle \boxed{1} \rangle]{:}\boxed{3} \right\rangle \\ \text{CONTENT} & \begin{bmatrix} \textit{rel4} & \\ \text{REL-ER} & \boxed{2} \\ \text{SOA-ARG} & \boxed{3} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

Examples III

1.
$$\left[\begin{array}{ll} \textit{word} & \\ \text{SYNS LOC} & \left[\begin{array}{ll} \text{CAT SUBCAT} & \left\langle \boxed{1}, \text{VP}[\text{SC} \left\langle \boxed{1}_{ref} \right\rangle]{:}\boxed{2} \right\rangle \\ \text{CONTENT} & \left[\begin{array}{l} \textit{rel6} \\ \text{SOA-ARG } \boxed{2} \end{array}\right] \end{array}\right] \end{array}\right]$$

2.
$$\left[\begin{array}{ll} \textit{word} & \\ \text{SYNS LOC} & \left[\begin{array}{ll} \text{CAT SUBCAT} & \left\langle \boxed{1}_{ref}, \text{VP}[\text{SC} \left\langle \boxed{1} \right\rangle]{:}\boxed{2} \right\rangle \\ \text{CONTENT} & \left[\begin{array}{l} \textit{rel7} \\ \text{SOA-ARG } \boxed{2} \end{array}\right] \end{array}\right] \end{array}\right]$$

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1. Principle A.
   A locally o-commanded anaphor must be locally o-bound.
2. Principle B.
   A personal pronoun must be locally o-free.
3. Principle C.
   A nonpronoun must be o-free.

THE BINDING THEORY **formalized**

Principle A:

$$\forall x \left(\exists y \ \texttt{loc-o-command}(y, {}^{x}\left[\text{LOC CONT } \textit{ana}\right]) \rightarrow \exists z \ \texttt{loc-o-bind}(z, x) \right)$$

Principle B:

$$\forall x \ \left(\ {}^{x}\left[\text{LOC CONT } \textit{ppro}\right] \ \rightarrow \neg\exists y \ \texttt{loc-o-bind}(y, x) \right)$$

Principle C:

$$\forall x \ \left(\ {}^{x}\left[\text{LOC CONT } \textit{npro}\right] \ \rightarrow \neg\exists y \ \texttt{o-bind}(y, x) \right)$$

THE RELATION LOC-O-COMMAND

A referential *synsem* object *locally o-commands* another *synsem* object provided they have distinct LOCAL values and either

(1) the second is more oblique than the first, or

(2) the second is a member of the SUBCAT list of a *synsem* object that is more oblique than the first.

The Relation LOC-O-COMMAND formalized

$$\forall x\ \forall y$$
$$\left(\texttt{loc-o-command}(x,y) \leftrightarrow \right.$$
$$\exists s\ \exists \boxed{1}\ \exists \boxed{2}\ \exists \boxed{3}$$
$$\left(\left({}^{x}\left[\text{LOC}\ \boxed{1}\left[\text{CONT INDEX}\ \textit{ref}\right]\right] \wedge {}^{y}\left[\text{LOC}\ \boxed{2}\right] \wedge \neg \boxed{1} = \boxed{2} \right) \wedge \right.$$
$$\left(\texttt{more-oblique}(y,x) \vee \right.$$
$$\left(\texttt{more-oblique}\left({}^{s}\begin{bmatrix} \textit{synsem} \\ \text{LOC CAT SUBCAT}\ \boxed{3} \end{bmatrix}, x \right) \right.$$
$$\left.\left.\left.\left. \wedge\ \texttt{member}(y, \boxed{3}) \right) \right) \right) \right)$$

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THE RELATION MORE-OBLIQUE

One *synsem* object is *more oblique* than another provided it appears to the right of the other on the SUBCAT list of some word.

Formalization:

$$\forall x \forall y \left(\texttt{more-oblique}(x, y) \leftrightarrow \exists w \, \exists \boxed{1} \left({}^{w}\begin{bmatrix} \textit{word} \\ \text{SS LOC CAT SUBCAT } \boxed{1} \end{bmatrix} \wedge \texttt{to-the-right}(x, y, \boxed{1}) \right) \right)$$

THE RELATION TO-THE-RIGHT

The relation `to-the-right` holds for three objects x, y und z within a configuration of objects if y stands before x on the list z.

Formalization:

$$\forall x \forall y \forall z \left(\texttt{to-the-right}(x, y, z) \leftrightarrow \left(\begin{array}{l} \exists \boxed{1} \left({}^{z}\begin{bmatrix} \text{FIRST} & y \\ \text{REST} & \boxed{1} \end{bmatrix} \wedge \texttt{member}(x, \boxed{1}) \right) \\ \vee \exists \boxed{1} \left({}^{z}\begin{bmatrix} \text{REST} & \boxed{1} \end{bmatrix} \wedge \texttt{to-the-right}(x, y, \boxed{1}) \right) \end{array} \right) \right)$$

THE RELATION O-COMMAND

A referential *synsem* object *o-commands* another *synsem* object provided they have distinct LOCAL values and either (1) the second is more oblique than the first, (2) the second is a member of the SUBCAT list of a *synsem* object that is o-commanded by the first, or (3) the second has the same LOCAL | CATEGORY | HEAD value as a *synsem* object that is o-commanded by the first.

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The Relation o-command formalized

$$\forall x\, \forall y$$

$$\Big(\texttt{o-command}(x, y) \leftrightarrow$$

$$\exists s_1\, \exists s_2\, \exists \boxed{1}\, \exists \boxed{2}\, \exists \boxed{3}\, \exists \boxed{4}$$

$$\Big(\big({}^{x}[\text{LOC } \boxed{1}[\text{CONT INDEX } \mathit{ref}]] \wedge {}^{y}[\text{LOC } \boxed{2}[\text{CAT HEAD } \boxed{4}]] \wedge \neg \boxed{1} = \boxed{2} \big) \wedge$$

$$\Big(\texttt{more-oblique}(y, x) \vee$$

$$\Big(\texttt{o-command}\big(x, {}^{s_1}\begin{bmatrix} \mathit{synsem} \\ \text{LOC CAT SUBCAT } \boxed{3} \end{bmatrix}\big) \wedge \texttt{member}(y, \boxed{3}) \Big) \vee$$

$$\Big(\texttt{o-command}(x, s_2) \wedge {}^{s_2}\begin{bmatrix} \mathit{synsem} \\ \text{LOC CAT HEAD } \boxed{4} \end{bmatrix} \Big) \Big) \Big) \Big)$$

THE RELATIONS LOC-O-BIND AND O-BIND

One referential *synsem* object *(locally) o-binds* another provided it (locally) o-commands and is coindexed with the other. A referential *synsem* object is *(locally) o-free* provided it is not (locally) o-bound. Two *synsem* objects are *coindexed* provided their LOCAL | CONTENT | INDEX values are token-identical.

$$\forall x \forall y \left(\begin{array}{l} \texttt{loc-o-bind}(x, y) \leftrightarrow \\ \exists_{\boxed{1}}\ \texttt{loc-o-command}\left({}^{x}[\text{LOC CONT INDEX } \boxed{1}], {}^{y}[\text{LOC CONT INDEX } \boxed{1}]\right) \end{array} \right)$$

$$\forall x \forall y \left(\begin{array}{l} \texttt{o-bind}(x, y) \leftrightarrow \\ \exists_{\boxed{1}}\ \texttt{o-command}\left({}^{x}[\text{LOC CONT INDEX } \boxed{1}], {}^{y}[\text{LOC CONT INDEX } \boxed{1}]\right) \end{array} \right)$$

Modified o-command Relation

$$\forall x \, \forall y$$

$$\left(\begin{array}{l} \texttt{o-command}(x, y) \leftrightarrow \\ \exists s_1 \; \exists s_2 \; \exists z \; \exists \boxed{1} \; \exists \boxed{2} \; \exists \boxed{3} \\ \left(\begin{array}{l} \left({}^{x}\left[\text{LOC } \boxed{1} \left[\text{CONT INDEX } \textit{ref}\right]\right] \wedge {}^{y}\left[\text{LOC } \boxed{2} \left[\text{CAT HEAD } \boxed{4}\right]\right] \wedge \neg \boxed{1} = \boxed{2} \right) \wedge \\ \left(\begin{array}{l} \texttt{more-oblique}(y, x) \vee \\ \left(\begin{array}{l} \texttt{o-command}\left(x, {}^{s_1}\left[\begin{array}{l} \textit{synsem} \\ \text{LOC CAT SUBCAT } \boxed{3} \end{array}\right]\right) \\ \wedge \, \texttt{member}(y, \boxed{3}) \end{array} \right) \vee \\ \left(\texttt{o-command}(x, s_2) \wedge {}^{z}\left[\text{SYNSEM DTRS H-DTR SYNSEM } y\right] \right) \end{array} \right) \end{array} \right) \end{array} \right)$$

SEMANTICS PRINCIPLE (clause (b))

If the semantic head's SYNSEM | LOCAL | CONTENT value is of sort *psoa*, then the SYNSEM | LOCAL | CONTENT | NUCLEUS value is token-identical with that of the semantic head, and the SYNSEM | LOCAL | CONTENT | QUANTS value is the concatenation of the RETRIEVED value and the semantic head's SYNSEM | LOCAL | CONTENT | QUANTS value; otherwise the RETRIEVED value is the empty list, and the SYNSEM | LOCAL | CONTENT value is token-identical with that of the semantic head.

SEMANTICS PRINCIPLE **formalized**

$$
\left(
\begin{bmatrix} \textit{phrase} \\ \text{SS LOC CONT } \textit{psoa} \end{bmatrix} \rightarrow
\forall \boxed{1}
\left(
\begin{bmatrix} \text{DTRS} \left[\begin{bmatrix} \textit{head-adj-struc} \\ \text{ADJUNCT-DTR } \boxed{1} \end{bmatrix} \vee \left[\neg \left[\textit{head-adj-struc}\right] \wedge \left[\text{HEAD-DTR } \boxed{1}\right] \right] \right] \end{bmatrix} \rightarrow
\exists \boxed{2} \exists \boxed{3} \exists \boxed{4} \exists \boxed{5}
\left(
\begin{bmatrix} \text{SS LOC CONT} \begin{bmatrix} \text{QUANTS } \boxed{2} \\ \text{NUCLEUS } \boxed{3} \end{bmatrix} \\ \text{RETRIEVED } \boxed{4} \end{bmatrix}
\wedge \boxed{1} \begin{bmatrix} \text{SS LOC CONT} \begin{bmatrix} \text{QUANTS } \boxed{5} \\ \text{NUCLEUS } \boxed{3} \end{bmatrix} \end{bmatrix}
\wedge \textbf{append}(\boxed{4}, \boxed{5}, \boxed{2})
\right)
\right)
\right)
$$

$$\wedge$$

$$
\left(
\begin{bmatrix} \textit{phrase} \\ \text{SS LOC CONT } \neg\textit{psoa} \end{bmatrix} \rightarrow
\forall \boxed{1}
\left(
\begin{bmatrix} \text{DTRS} \left[\begin{bmatrix} \textit{head-adj-struc} \\ \text{ADJUNCT-DTR } \boxed{1} \end{bmatrix} \vee \left[\neg \left[\textit{head-adj-struc}\right] \wedge \left[\text{HEAD-DTR } \boxed{1}\right] \right] \right] \end{bmatrix} \rightarrow
\exists \boxed{2}
\left(
\begin{bmatrix} \text{SS LOC CONT } \boxed{2} \\ \text{RETRIEVED } \langle\rangle \end{bmatrix}
\wedge \boxed{1} \left[\text{SS LOC CONT } \boxed{2} \right]
\right)
\right)
\right)
$$