Grammar Formalisms:

Lexical Functional Grammar (LFG)

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Overview

Principle ideas of LFG (1)

Lexical Functional Grammar (Kaplan & Bresnan, 1982):

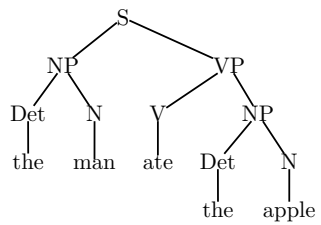
- One level of constituent structure, c-structure, non-transformational.

  C-structures are represented with trees.
- A separate level of functional structure, f-structure, representing grammatical functions and predicate-argument relations.

  F-structures are represented with feature structures.
- Other levels such as argument structure (encoding thematic roles), semantic structure, morphological structure.
- Syntactic phenomena (including long-distance dependencies) are treated locally.

Principle ideas of LFG (2)

C-structure



F-structure

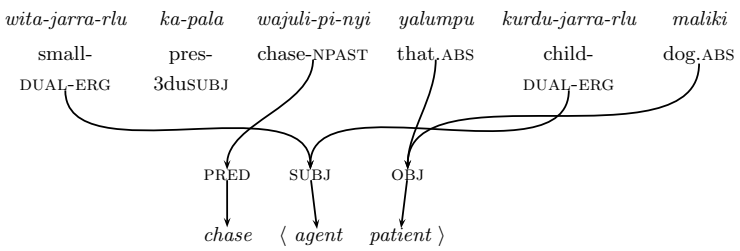
$$\begin{bmatrix} \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{man} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix} \\ \text{TENSE} & \text{past} \\ \text{PRED} & \text{'eat} \langle \text{subj, obj} \rangle\text{'} \\ \text{OBJ} & \begin{bmatrix} \text{PRED} & \text{apple} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}$$

Principle ideas of LFG (3)

Evidence for a functional representational level comes from non-configurational languages.

Example: Warlpiri.

(1) The two small children are chasing that dog.



F-structures (1)

F-structures are attribute-value structures notated with the usual avm-notation.

Linguistic terminology:

- Attributes whose values are f-structues are called *grammatical functions*.
- Attributes whose values are symbols are called *features*.
- Attributes whose values are semantic forms are called *semantic features*.

F-structures (2)

Description of f-structures:

$$f_1\begin{bmatrix} \text{SUBJ} & f_2\begin{bmatrix} \text{PRED} & \text{'man'} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix} \\ \text{TENSE} & \text{past} \\ \text{PRED} & \text{'eat} \langle \text{subj, obj} \rangle\text{'} \\ \text{OBJ} & f_3\begin{bmatrix} \text{PRED} & \text{'apple'} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}$$

$(f_1\text{SUBJ}) = f_2$
$(f_2\text{PRED}) = \text{'MAN'}$
$(f_2\text{DEF}) = +$
$(f_2\text{NUM}) = \text{SG}$
$(f_1\text{TENSE}) = \text{PAST}$
$(f_1\text{PRED}) = \text{'EAT} \langle \text{SUBJ, OBJ} \rangle\text{'}$
$(f_1\text{OBJ}) = f_3$
$(f_3\text{PRED}) = \text{'APPLE'}$
$(f_3\text{DEF}) = +$
$(f_3\text{NUM}) = \text{SG}$

F-structures (3)

More examples

- $(f_1 \text{ SUBJ NUM}) = \text{SG}$

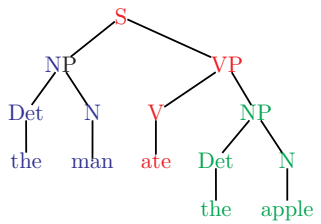
  $f_1\begin{bmatrix} \text{SUBJ} & \begin{bmatrix} \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}$

- $(f_1 \text{ SUBJ}) = (f_1 \text{ XCOMP SUBJ})$

  $f_1\begin{bmatrix} \text{SUBJ} & \boxed{1} \\ \text{XCOMP} & \begin{bmatrix} \text{SUBJ} & \boxed{1} \end{bmatrix} \end{bmatrix}$

Linking C-structures and F-structures (1)

Each node in the c-structure is linked to exactly one f-structure.



$$f_1\begin{bmatrix} \text{SUBJ} & f_2\begin{bmatrix} \text{PRED} & \text{'man'} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix} \\ \text{TENSE} & \text{past} \\ \text{PRED} & \text{'eat}\ \langle\ \text{subj, obj}\rangle\text{'} \\ \text{OBJ} & f_3\begin{bmatrix} \text{PRED} & \text{'apple'} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix} \end{bmatrix}$$

Linking C-structures and F-structures (2)

C-structures are described with standard phrase structure rules.

S → NP VP, NP → Det N, ...

The phrase structure rules are equipped with information about how the mother f-structure and the daughter f-structures are related.

For a given node, the symbols ↑ and ↓ refer to the f-structures of the mother node and of the node itself.

$$\begin{array}{lcccc} \text{S} & \rightarrow & \text{NP} & \text{VP} \\ & & (\uparrow \textsc{subj}) = \downarrow & \uparrow = \downarrow \end{array}$$

$$\begin{array}{lcccc} \text{NP} & \rightarrow & \text{Det} & \text{N} \\ & & \uparrow = \downarrow & \uparrow = \downarrow \end{array}$$

$$\begin{array}{lcccc} \text{VP} & \rightarrow & \text{V} & \text{NP} \\ & & \uparrow = \downarrow & (\uparrow \textsc{obj}) = \downarrow \end{array}$$

Linking C-structures and F-structures (3)

The leaves of c-structure trees are words. The f-structures of their pre-terminals come from the lexicon.

$$\begin{array}{lcc} \text{N} & \rightarrow & \text{man} \\ & & (\uparrow \textsc{pred}) = \text{'man'}, \\ & & (\uparrow \textsc{num}) = \textsc{sg} \end{array}$$

$$\begin{array}{lcc} \text{Det} & \rightarrow & \text{the} \\ & & (\uparrow \textsc{def}) = + \end{array}$$

With the NP-rule $\begin{array}{lcccc} \text{NP} & \rightarrow & \text{Det} & \text{N} \\ & & \uparrow = \downarrow & \uparrow = \downarrow \end{array}$ we obtain for the NP *the man* the f-structure

$$\begin{bmatrix} \text{PRED} & \text{'man'} \\ \text{DEF} & + \\ \text{NUM} & \text{sg} \end{bmatrix}$$

Linking C-structures and F-structures (4)

Further conditions on the final minimal f-structure constructed from the defining equations specify that the predicate-argument requirements in the f-structure must be satisfied.

- *Completeness*

  All functions specified in the value of a PRED must be present in the local f-structure of that PRED.

- *Coherence*

  All argument functions in an f-structure must be selected by the local PRED feature.

Control and raising (1)

Control:

(2) John believes to understand f-structures.

(3) John promised Bill to eat the apples.

(4) John persuaded Bill to eat the apples.

An argument of the matrix verb is identical to the non-overt subject of the complement clause.

There is no empty category PRO; the control relation is represented only in the f-structure.

Control and raising (2)

(5) John believes to understand f-structures.

$$\begin{bmatrix} \textsc{subj} & \boxed{1}\begin{bmatrix} \textsc{pred} & \text{'John'} \end{bmatrix} \\ \textsc{tense} & \text{pres} \\ \textsc{pred} & \text{'believe} \langle \text{ subj, xcomp } \rangle\text{'} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{subj} & \boxed{1} \\ \textsc{pred} & \text{'understand} \langle \text{ subj, obj } \rangle\text{'} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{'f-structure'} \\ \textsc{def} & - \\ \textsc{num} & \text{pl} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\begin{array}{lc} \text{V} \rightarrow & \text{believes} \\ & (\uparrow \textsc{pred}) = \text{'believe} \langle \text{ subj, xcomp } \rangle\text{'} \\ & (\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp subj}) \end{array}$$

Control and raising (3)

(6) John persuaded Bill to eat the apples.

$$\begin{bmatrix} \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{'John'} \end{bmatrix} \\ \textsc{tense} & \text{past} \\ \textsc{pred} & \text{'persuade} \langle \text{ subj, obj, xcomp } \rangle\text{'} \\ \textsc{obj} & \boxed{1}\begin{bmatrix} \textsc{pred} & \text{'Bill'} \end{bmatrix} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{subj} & \boxed{1} \\ \textsc{pred} & \text{'eat} \langle \text{ subj, obj } \rangle\text{'} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{'apple'} \\ \textsc{def} & + \\ \textsc{num} & \text{sg} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

$$\begin{array}{lc} \text{V} \rightarrow & \text{persuaded} \\ & (\uparrow \textsc{pred}) = \text{'persuade} \langle \text{ subj, obj, xcomp } \rangle\text{'} \\ & (\uparrow \textsc{obj}) = (\uparrow \textsc{xcomp subj}) \end{array}$$

Control and raising (4)

Raising:

(7) John seems to eat the apples

(8) John believes Bill to like Mary

An athematic argument of the main verb is identical with the non-overt subject of the embedded verb.

Athematic arguments are listed in the PRED value (to satisfy coherence) but occur outside the brackets $\langle \ldots \rangle$.

Control and raising (5)

(9) John seems to eat the apples

$$\begin{bmatrix} \textsc{subj} & \boxed{1}\begin{bmatrix} \textsc{pred} & \text{'John'} \end{bmatrix} \\ \textsc{tense} & \text{past} \\ \textsc{pred} & \text{'seem} \langle \text{ xcomp } \rangle \text{ subj'} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{subj} & \boxed{1} \\ \textsc{pred} & \text{'eat} \langle \text{ subj, obj } \rangle\text{'} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{'apple'} \\ \textsc{def} & + \\ \textsc{num} & \text{sg} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

V → seems
(↑ PRED) = 'seem ⟨ xcomp ⟩ subj'
(↑ SUBJ) = (↑ XCOMP SUBJ)

Control and raising (6)

(10) John believes Bill to like Mary

$$\begin{bmatrix} \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{'John'} \end{bmatrix} \\ \textsc{tense} & \text{pres} \\ \textsc{pred} & \text{'believe} \langle \text{ subj, xcomp } \rangle \text{ obj'} \\ \textsc{obj} & \boxed{1}\begin{bmatrix} \textsc{pred} & \text{'Bill'} \end{bmatrix} \\ \textsc{xcomp} & \begin{bmatrix} \textsc{subj} & \boxed{1} \\ \textsc{pred} & \text{'like} \langle \text{ subj, obj } \rangle\text{'} \\ \textsc{obj} & \begin{bmatrix} \textsc{pred} & \text{'Mary'} \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

V → believes
(↑ PRED) = 'believe ⟨ subj, xcomp ⟩ obj'
(↑ OBJ) = (↑ XCOMP SUBJ)

Long-distance dependencies (1)

(11) Which book does Mary think John prefers?

F-structure for a wh-question without a long-distance dependency:

(12) Which book does John prefer?

$$\begin{bmatrix} \textsc{type} & \text{q} \\ \textsc{focus} & \boxed{1}\begin{bmatrix} \textsc{pron} & \text{wh} \\ \textsc{pred} & \text{'book'} \\ \textsc{num} & \text{sg} \end{bmatrix} \\ \textsc{subj} & \begin{bmatrix} \textsc{pred} & \text{'John'} \end{bmatrix} \\ \textsc{tense} & \text{pres} \\ \textsc{pred} & \text{'prefer} \langle \text{ subj, obj } \rangle\text{'} \\ \textsc{obj} & \boxed{1} \end{bmatrix}$$

Inside-out equation:

which:

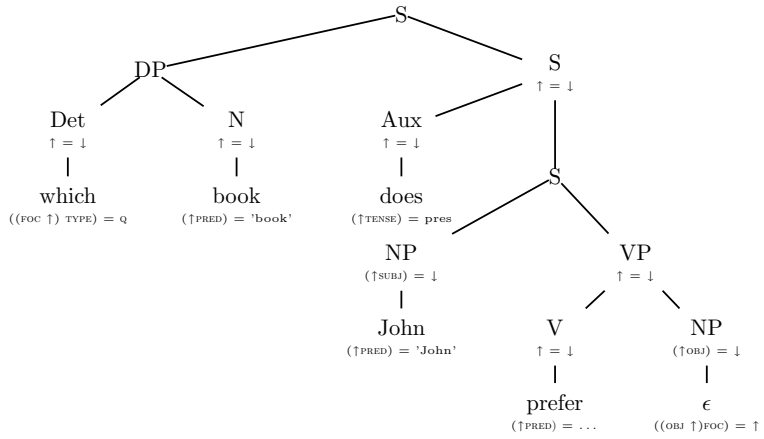
((FOCUS ↑) TYPE) = Q

Long-distance dependencies (2)

So far, *which book* is linked to the FOCUS f-structure. Because of completeness, an object f-structure is needed as well.

Therefore, an empty category is introduced and equipped with an inside-out equation ((OBJ ↑)FOCUS) = ↑.

Long-distance dependencies (3)



Long-distance dependencies (4)

(13) Which book does Mary think John prefers?

$$\begin{bmatrix} \text{TYPE} & \text{q} \\ \text{FOCUS} & \boxed{1}\begin{bmatrix} \text{PRON} & \text{wh} \\ \text{PRED} & \text{'book'} \\ \text{NUM} & \text{sg} \end{bmatrix} \\ \text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{'Mary'} \end{bmatrix} \\ \text{TENSE} & \text{pres} \\ \text{PRED} & \text{'think} \langle \text{subj, comp} \rangle\text{'} \\ \text{COMP} & \begin{bmatrix} \text{SUBJ} & p\begin{bmatrix} \text{RED} & \text{'John'} \end{bmatrix} \\ \text{PRED} & \text{'prefer} \langle \text{subj, obj} \rangle\text{'} \\ \text{OBJ} & \boxed{1} \end{bmatrix} \end{bmatrix}$$

empty category:

$((\text{COMP OBJ} \uparrow)\text{FOC}) = \uparrow$

Long-distance dependencies (5)

(14) Which book does Mary think Bill claims ... John prefers?

$((\ldots \text{COMP OBJ} \uparrow)\text{FOC}) = \uparrow$

$\Rightarrow$ we need to describe an infinite number of paths (attribute sequences) within a single expression.

For this, LFG provides *functional uncertainty*: Instead of specifying only a single path, one can use regular expressions to specify sets of paths.

$((\text{COMP}^* \text{ OBJ} \uparrow)\text{FOC}) = \uparrow$

Summary

- LFG distinguishes between two levels of representation: a constituent structure (a tree) and a functional structure (an attribute value structure).
- This distinction allows to capture languages where single elements in the f-structure are linked to discontinuous parts in the c-structure.
- C-structure is described with phrase structure rules. The single nodes in the c-structure are equipped with equations defining properties of their own and their mother's f-structure.
- The description language for the f-structures is very powerful, including in particular *functional uncertainty*, a device that allows to describe paths of arbitrary length in the f-structure.