Lexical Function Grammar

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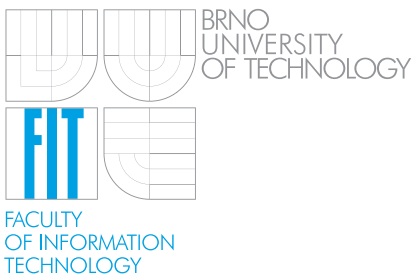

FRVŠ MŠMT FR97/2011/G1

Outline

- Introduction
- F-structures
- Constraints of f-structures
- C-structures
- Mapping c-structure to f-structure

- **Introduction**
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What is Lexical Functional Grammar?

Motivation

1. Lexical – to have richly structured lexicon, where relations between eg. verbal alternations are stated.

2. Functional – abstract grammatical functions like subject and object are primitives.

What is Lexical Functional Grammar?

LFG is a theory of:

- Syntax – how words can be combined together to make larger phrases, such as sentences.
- Morphology – how morphemes can be combined to make up words.
- Semantics – how and why various words and combinations of words mean what they mean
- Pragmatics – how expressions are used to transmit information.

- *morphemes* = parts of words, eg. writers, namely the verb write, the 'agentive affix' er and the plural marker +s
- Grammar is often taken to include phonology (the study of the sound systems of human languages).

Lexical Functional Grammar

- LFG consists of multiple dimensions of structure.
- Each of these dimensions is represented as a distinct structure with its own rules, concepts, and form.

LFG minimally distinguishes two kinds of representations:

- c-structure – the structure of syntactic constituents.
- f-structure – the representation of grammatical functions.

These are two completely different formalisms:

- *trees* for c-structure.
- *attribute-value matrices* for c-structure.

Other types of structures in LFG

There are also other kinds of structures:

- argument structure
- semantic structure
- information structure
- morphological structure
- phonological structure

The various structures can be said to be mutually constraining.

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F-structures

- F-structures maps closely to meaning and
- encodes abstract grammatical relations like subject and object as *primitives*, i.e. they are not reducible to anything else.

- Categories like subject and object are *cross-linguistic* → languages vary less in their *f-structure*

F-structures: Grammatical functions

Example

We have this inventory:
SUBJect, OBJect, OBJ_θ, COMP, XCOMP, OBLique_θ, ADJunct, XADJunct

- Terms (core functions): SUBJ, OBJ, OBJ_θ
- Semantically restricted:
  - OBJ_θ: secondary OBJ function associated with thematic roles ($\text{OBJ}_{\text{THEME}}$)
  - OBL_θ: thematically restricted oblique functions
- Open clausal functions:
  - COMP: sentencial or closed infinitival complement
  - XCOMP: open (predicative) complement with externally controlled subject

Subcategorization

- Verbs select for gramatical functions
- Use the predicate feature PRED to specify the semantic form:

- *yawn*: PRED 'YAWN<SUBJ>'
- *hit*: PRED 'HIT<SUBJ, OBJ>'
- *give*: PRED 'GIVE<SUBJ, OBJ, $\text{OBJ}_{\text{THEME}}$ >'
- *eat*: PRED 'EAT<SUBJ, (OBJ)>'

Simple f-structures

F-structure is a function from attributes to values.

Example

For the noun **David**:

- PRED and NUM are attributes.
- DAVID and SG are the corresponding values.

$$\begin{bmatrix} PRED & 'DAVID' \\ NUM & SG \end{bmatrix}$$

Example

F-structures within f-structures: ***David yawned.***

$$\begin{bmatrix} PRED & 'YAWN < SUBJ >' \\ TENSE & PAST \\ SUBJ & \begin{bmatrix} PRED & 'DAVID' \\ NUM & SG \end{bmatrix} \end{bmatrix}$$

Sets

Values can be sets, in order to handle phenomena with an unbounded number of elements.

Example

David yawned quietly yesterday.

$$\begin{bmatrix} PRED & 'yawn < SUBJ >' \\ TENSE & PAST \\ SUBJ & \begin{bmatrix} PRED & 'David' \\ NUM & SG \end{bmatrix} \\ ADJ & \left\{ \begin{bmatrix} PRED & 'quietly' \end{bmatrix} \right. \\ & \left. \begin{bmatrix} PRED & 'yesterday' \end{bmatrix} \right\} \end{bmatrix}$$

Sets: F-structure Representations

- *Sets* can also have additional properties = have attributes and values which apply over whole set – hybrid objects.
- Properties can distribute over elements of the set.

Example

David and Chris yawned.

$$\begin{bmatrix} \mathit{PRED} & \mathit{'yawn < SUBJ >'} \\ \mathit{TENSE} & \mathit{PAST} \\ \mathit{SUBJ} & \left\{ \begin{bmatrix} \mathit{PRED} & \mathit{'David'} \\ \mathit{NUM} & \mathit{SG} \end{bmatrix} \begin{bmatrix} \mathit{PRED} & \mathit{'Chris'} \\ \mathit{NUM} & \mathit{SG} \end{bmatrix} \right\} \end{bmatrix}$$

Attributes with Common Values

- *Attributes* can share the same values, to describe phenomena such as raising, notated in different ways.

Example

David seemed to yawn.

$$\begin{bmatrix} PRED & 'SEEM < XCOMP > SUBJ' \\ TENSE & PAST \\ SUBJ & \boxed{1}\begin{bmatrix} PRED & 'David' \\ NUM & SG \end{bmatrix} \\ XCOMP & \begin{bmatrix} PRED & 'YAWN < SUBJ >' \\ SUBJ & \boxed{1} \end{bmatrix} \end{bmatrix}$$

This is like HPSG notation.

Nature of f-structures

An f-structure is rectricted by the principles of:

1. Completeness
2. Coherence
3. Uniqueness

Definition: Completeness

- An f-structure is locally complete iff it contains all the governable grammatical functions that its predicate governs.
- An f-structure is complete iff it and all its subsidiary f-structures are locally complete.

Completeness

- List of governable grammatical functions = argument list of semantic form.
- All governable grammatical functions mentioned in the predicate must be present in the f-structure.

Example

Completeness example:

- PRED ‘DEVOUR<SUBJ, OBJ>’
- *David devoured.*

Nature of f-structures

An f-structure is rectricted by the principles of:

1. Completeness
2. Coherence
3. Uniqueness

Definition: Coherence

- An f-structure is locally coherent iff all the governable grammatical functions that it contains are governed by a local predicate.
- An f-structure is coherent iff it and all its subsidiary f-structures are locally coherent.

Example

David yawned the sink.

$$\begin{bmatrix} PRED & 'YAWN < SUBJ >' \\ SUBJ & [PRED \quad 'DAVID'] \\ XCOMP & [PRED \quad 'SINK'] \end{bmatrix}$$

An f-structure is rectricted by the principles of:

1. Completeness
2. Coherence
3. Uniqueness

Definition: Uniqueness

- In a given f-structure, a particular attribute may have at most one value.

Example

The boys yawned.

$$\begin{bmatrix} PRED & 'YAWN < SUBJ >' \\ SUBJ & \begin{bmatrix} PRED & 'BOYS' \\ NUM & SG/PL \end{bmatrix} \end{bmatrix}$$

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Functional equations

We use functional equations on words and phrases to describe acceptable f-structures.

Example

F-description with a single equation:

$$(g\,NUM) = SG$$

Different f-structures which satisfy this f-description:

1. $$\begin{bmatrix} NUM & SG \end{bmatrix}$$

2. $$\begin{bmatrix} PRED & 'BOYS' \\ NUM & SG/PL \end{bmatrix}$$

Functional Constraints – Definition

The f-structure for an utterance is the *minimal solution* satisfying the constraints introduces by the words and phrase structure of the utterance.
Minimal solution satisfies all constraints in the f-description and has no additional structure.

Constraining Equations

- used for checking the properties of the minimal solution
- eg. the SUBJ of f must meet certain conditions:
  (f SUBJ NUM) $=_c$ *SG*

Functional Constraints – Example

Example

Lexical constraints:

- *John*
  - (g PRED) = 'JOHN'
  - (g NUM) = SG
- *runs*
  - (f PRED) = 'RUN<SUBJ>'
  - (f SUBJ CASE) = NOM
  - (f SUBJ NUM) = SG

Phrasal constraints:

- (f SUBJ) $= g$

By combining lexical and phrasal constraints we get:

- (f SUBJ) $= g$
- (g PRED) = 'JOHN'
- (g NUM) = SG
- (f PRED) = 'RUN<SUBJ>'
- (f SUBJ CASE) = NOM
- (g NUM) = SG

Example

Minimal solution:

$$\text{f:} \begin{bmatrix} PRED & 'RUN < SUBJ >' \\ SUBJ & g: \begin{bmatrix} PRED & 'JOHN' \\ CASE & NOM \\ NUM & SG \end{bmatrix} \end{bmatrix}$$

More Functional Constraints

Disjunction

Different options can be used to satisfy an f-description.

Example

I met/have met him.
Lexical entry for *met*:

- (f PRED) = 'MEET<SUBJ,OBJ>'
- {(f TENSE) = PAST|(f FORM) = PASTPART}

More Functional Constraints

Negation

It is specified what can not be true in an f-description.

Example

1. *I know whether/if David yawned.*
2. *You have to justify whether/*if your journey is really necessary.*

☹ *if* is not allowed with *justify* (*know*)

- *justify* $\vee$(*f* COMP COMPFORM) $\neq$ *IF*

Existential Constraints

An f-structure must have some attributes, but the value of that attribute is unconstrained.

Example

1. *The man who yawns/yawned/will yawn.*
2. ☹*The man who yawning.*

$\Rightarrow$ In a relative clause ,*yawn* must be tensed, but it is not important which tense.

- Relative clause constraints is: (f TENSE).
- We can also specify negative existencial constraints, e.g. $\neg$(f TENSE)

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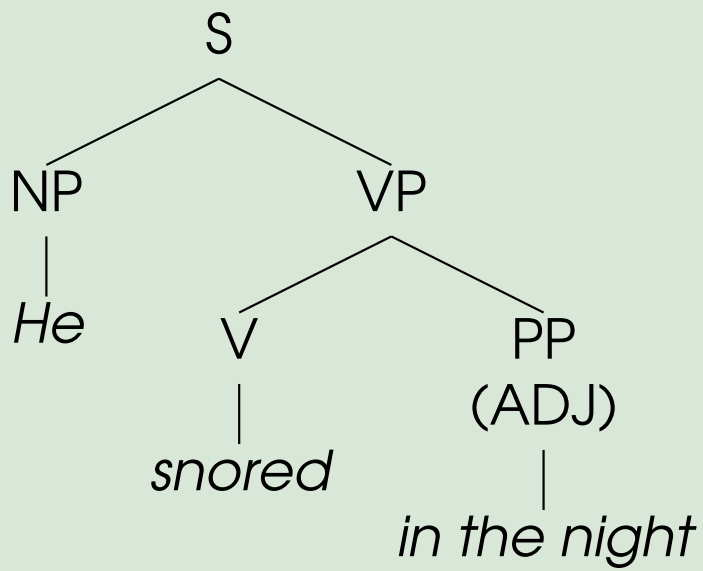
C-structure

- c-structure corresponds to traditional notion of *phrase grammars*.

Example

Example of a c-structure:



C-structure Rules

- c-structure rules are like phrase structure rules with a few differencies
- phrase structure rules with *optionality*, *disjunction* and *Kleene star*

We can also use:

- Metacategories
- ID/LP rules

Metarules and ID/PL Rules

Metacategories

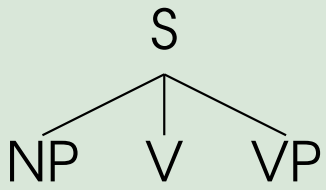
represent several different sets of categories

a. $X \equiv \{NP|PP|VP|AP|AdvP\}$

b. $VP \equiv VNP$

Example

using *VP* in b. in rule $S \rightarrow NPVP$ results in tree:



ID/PL Rules

rules can be written in ID/LP format: ID = *immediate dominance*, LP = *linear precedence*

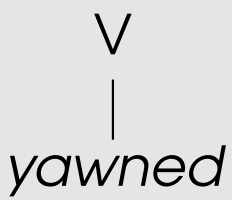
- No LP rules: $VP \rightarrow V, NP; VP \rightarrow \{V\ NP|NP\ V\}$
- One LP rule: $VP \rightarrow V, NP; VP \rightarrow V\ NP; V < NP$
- Interacting LP rules:
  $VP \rightarrow V, NP, PP; VP \rightarrow \{V\ NP\ PP|V\ PP\ NP\}; V < NP, V < PP$

C-structure: String

How a string is licensed

- context-free c-structure grammarlicenses the c-structure of a *string*
- the grammar is augmented with functional descriptions, which *map* the c-structure to an f-structure; ϕ is the *mapping function*

- Each c-structure is related to *only one* f-structure.



$$\phi(V): \begin{bmatrix} PRED & 'YAWN < SUBJ >' \\ TENSE & PAST \end{bmatrix}$$

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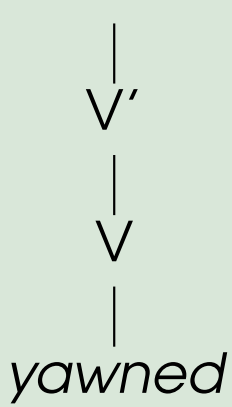
Head Convention

- Multiple c-structures can map *onto the same* f-structure.
- This allows nodes to inherit properties from their head.

Example



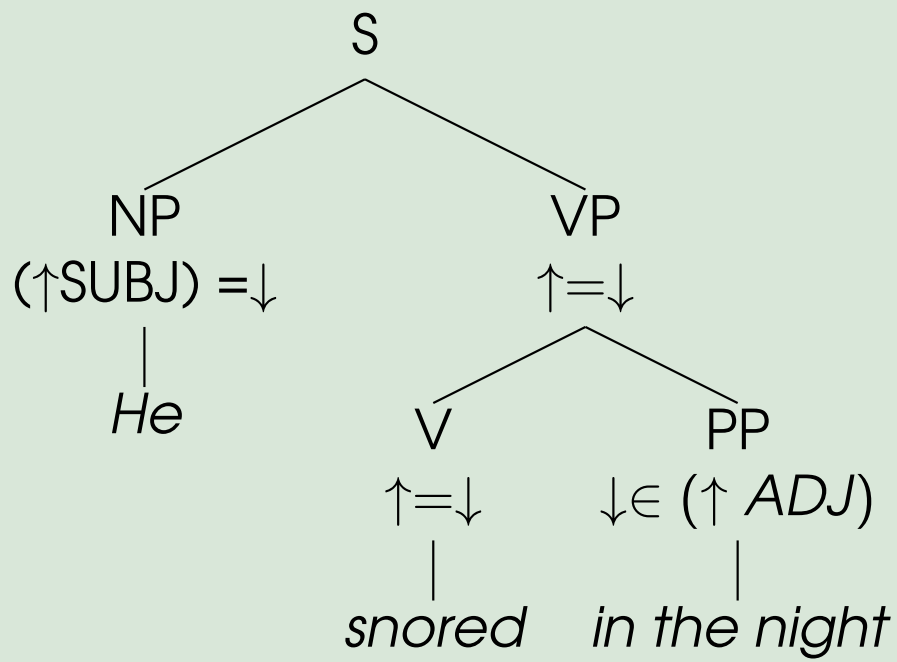
$$\phi(VP) = \phi(V') = \phi(V) : \begin{bmatrix} PRED & 'YAWN < SUBJ >' \\ TENSE & PAST \end{bmatrix}$$

Mapping c-structure to f-structure

- Functional designator $\uparrow$ refers to f-structure associated with node.
- Functional designator $\downarrow$ refers to a node's own f-structure.

Example

- $\uparrow=\downarrow$: Identifies a node's f-structure of its parent.
- $(\uparrow, \mathit{SUBJ}) = \downarrow$: Identifies a node's f-structure with the SUBJ path of it's parent's f-structure



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