A new approach to control and raising

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Research program

- To get us from words to what they mean (in a logical formalism, e.g. CLLS)
- Requirements:
  - Simplicity
  - Concurrency
- To this end: need an appropriate grammar formalism

Some grammar formalisms

GB (Chomsky 86)
HPSG (Pollard/Sag 94)
LFG (Bresnan/Kaplan 82)
TAG (Joshi 87)

FGD (Sgall et al 86)
MTT (Melcuk 88)

CCG (Ades/Steedman 82)

- So plenty of them already exist. Why not simply pick one of them?

Problems of existing grammar formalisms

- Tend to conflate levels of representation
  - Syntactic function
  - Word order
  - Predicate-argument structure
- Lack of language-independence (esp. Problems with free word order languages)
- Lack of simplicity (matter of taste)

Solving these problems

- Claim: dependency-based formalisms have the prerequisites to solve these problems:
  - Levels of representation distinguished more properly
  - Less problems with free word order languages (in fact FGD and MTT developed for Czech/Russian)
  - Simpler
- But do they really?

Unfortunately not

- Dependency-based formalisms like FGD and MTT have serious problems:
  - Lack of declarativity (esp. when it comes to handling word order)
  - No (concurrent) syntax-semantics interface

From PS to DG

- Current dependency-based grammar formalisms cannot solve the problems of PS-based ones
- One idea: equip PS-based grammar formalisms with ideas from dependency-based ones

From PS to DG

- In fact: PS-based grammar formalisms have picked up more and more ideas from dependency-based ones:
  - GB: X-bar theory
  - HPSG: DEPS-feature in new versions
  - f-structure
  - Derivation tree represents dependency-like structure

PS and MS-DOS

- But why shall we keep the PS-backbone at all (like hanging on to MS-DOS)?
- E.g. TAG: why do we need the derived tree when all we need for semantics construction is encoded in the derivation tree?
- What we do: develop a new dependency-based grammar formalism: Topological Dependency Grammar (TDG)

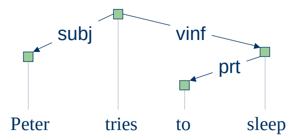
TDG solves some problems

- Lack of declarativity (esp. when it comes to handling word order):
  - TDG 2001: Debusmann 2001 MSc, Duchier/Debusmann 2001 ACL
- No (concurrent) syntax-semantics interface:
  - TDG 2002+: PhD research, Korthals/Debusmann 2002 COLING
- Today: introduce the main building block of the interface: the argument structure level

TDG architecture

- Multiple clearly separated levels:
  - Dependency tree
  - Topology tree
  - Argument-structure
- Constraint-based, concurrent
- Well-formedness conditions:
  - Shape vs. lexicalized constraints
  - Within vs. across constraints

Dependency tree level



- Basic assumptions:
  - 1:1 mapping from word occurrences to nodes
  - Labeled directed edges (labels: syntactic functions)

Well-formedness conditions: Shape constraints

- General constraints on the shape of the structure
- E.g. the dependency tree must be a tree (in the graph-theoretical sense), and the argument structure must be a DAG

Well-formedness conditions: Lexicalized constraints

- Each node is assigned a lexical entry
- The lexical entry contains lexical attributes and their values
- Lexical ambiguity dealt with nicely by the Selection Constraint (Duchier 99)
- Lexicalized constraints: make statements about the lexical attributes

Example lexical entries

$$tries = \begin{bmatrix} dep & \begin{bmatrix} in & \{\,\} \\ out & \{\mathrm{subj}, \mathrm{vinf}\} \end{bmatrix} \\ top & \ldots \\ arg & \ldots \end{bmatrix}$$

$$sleep = \begin{bmatrix} dep & \begin{bmatrix} in & \{\mathrm{vinf}\} \\ out & \{\mathrm{prt}\} \end{bmatrix} \\ top & \ldots \\ arg & \ldots \end{bmatrix}$$

Lexicalized constraints: The out-constraint

- Determines number and type of outgoing edges:

$$l \in out(v) \quad \text{then 1 outgoing edge labeled } l$$

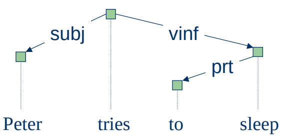
$$l \notin out(v) \quad \text{then 0 outgoing edges labeled } l$$

Lexicalized constraints: The in-constraint

- Determines type of incoming edge:

$$v \xrightarrow{l} v' \quad \text{only if} \quad l \in in(v')$$

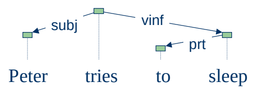
In and out-constraints: example



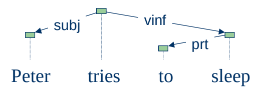
$$tries = \begin{bmatrix} in & \{\,\} \\ out & \{\mathrm{subj}, \mathrm{vinf}\} \end{bmatrix} \qquad Peter = \begin{bmatrix} in & \{\mathrm{subj}, \mathrm{obj}, \mathrm{iobj}\} \\ out & \{\,\} \end{bmatrix}$$

$$sleep = \begin{bmatrix} in & \{\mathrm{vinf}\} \\ out & \{\mathrm{prt}\} \end{bmatrix} \qquad to = \begin{bmatrix} in & \{\mathrm{prt}\} \\ out & \{\,\} \end{bmatrix}$$

Levels of representation

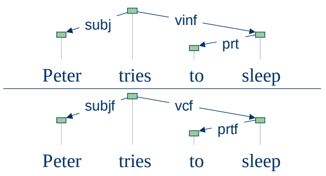


Levels of representation



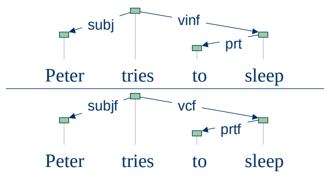
Tree
In
Out

Levels of representation



Tree
In
Out

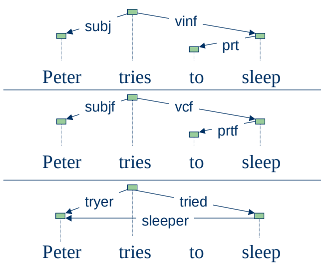
Levels of representation



Tree
In
Out

Tree
In
Out
Order

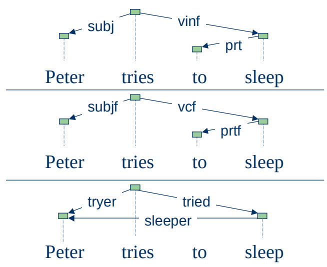
Levels of representation



Tree
In
Out

Tree
In
Out
Order

Levels of representation



Tree
In
Out

Tree
In
Out
Order

DAG
In
Out

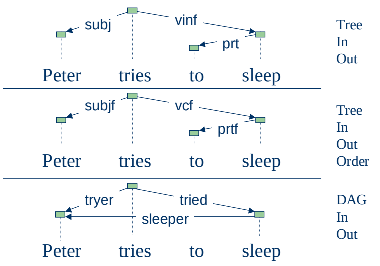
Within vs. across-constraints

- So far: well-formedness conditions for the three levels kept separate: only within-level constraints
- How can we establish a mutual relationship between the levels?

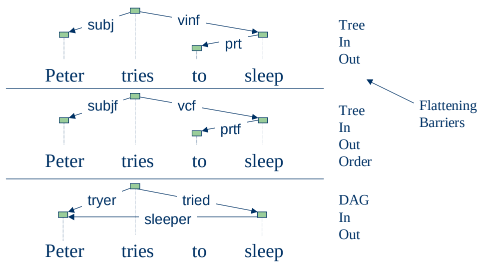
Across-constraints

- Topology/Dependency
  - Flattening
  - Barriers
- Argument Structure/Dependency
  - Linking

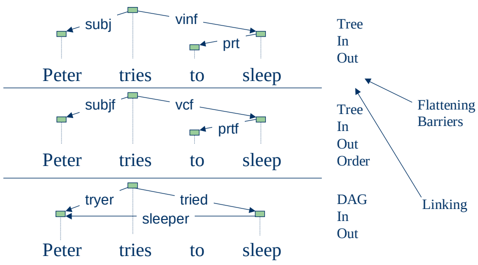
Levels of representation



Levels of representation

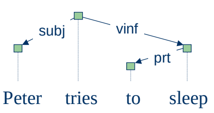


Levels of representation



The argument structure-level

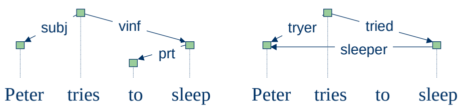
- dependency trees are already close to semantic argument structure, but not close enough
- E.g. control:



- Who is the sleeper?

The argument structure-level

- We introduce the argument structure-level to represent the argument structure information:



Linking the argument structure to the dependency tree

- How do the argument structure and the dependency tree relate to each other?
- Idea: semantic arguments are realized by syntactic functions (e.g. the tryer is realized by the subject)

The link-feature

- The link-feature describes a function from semantic arguments to sets of syntactic functions which realize them, e.g.:

$$tries = \begin{bmatrix} dep & \begin{bmatrix} in & \{\ \} \\ out & \{\text{subj}, \text{vinf}\} \end{bmatrix} \\ arg & \begin{bmatrix} in & \{\ \} \\ out & \{\text{tryer}, \text{tried}\} \\ link & \{\text{tryer} \rightarrow \{\text{subj}\}, \text{tried} \rightarrow \{\text{vinf}\}\} \end{bmatrix} \end{bmatrix}$$

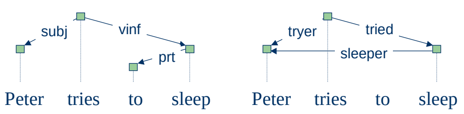
Linking constraint (first version)

- Semantic arguments may only be realized by appropriate syntactic functions:

$$v \xrightarrow{\Theta} v' \quad \text{only if} \quad v \xrightarrow{\varphi} v' \wedge \varphi \in link_{\Theta}(v)$$

Control

- The linking principle given does not license the following analysis:



- There is no edge corresponding to the sleeper-edge in the dependency tree

What happened?

- Sleep does not have a subject in the dependency tree but has a sleeper-argument in the argument structure
- Tries offers its subject for the embedded verb to take
- Sleep takes the subject of tries as ist subject and realizes the sleeper therewith

The offer-feature

- The offer-feature is a set of syntactic functions offered by a control-verb (for embedded verbs to take as their subject)

$$tries = \begin{bmatrix} dep & \begin{bmatrix} in & \{\ \} \\ out & \{\text{subj}, \text{vinf}\} \end{bmatrix} \\ arg & \begin{bmatrix} in & \{\ \} \\ out & \{\text{tryer}, \text{tried}\} \\ link & \{\text{tryer} \to \{\text{subj}\}, \text{tried} \to \{\text{vinf}\}\} \\ offer & \{\text{subj}\} \end{bmatrix} \end{bmatrix}$$

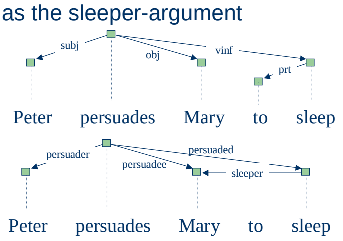
Linking constraint (second version)

- Semantic arguments may only be realized by appropriate syntactic functions
- Embedded verbs can take offered dependents of control verbs as their argument

$$v \xrightarrow{\Theta} v' \text{ only if } v \xrightarrow{\varphi} v' \wedge \varphi \in link_{\Theta}(v)$$
$$\text{or } v'' \to \ldots \to v \wedge v'' \xrightarrow{\varphi} v' \wedge$$
$$\varphi \in offer(v'') \wedge \text{subj} \in link_{\Theta}(v)$$

Examples: object-control

- Here: persuades offers its object for sleep to take as the sleeper-argument



Control vs. Raising

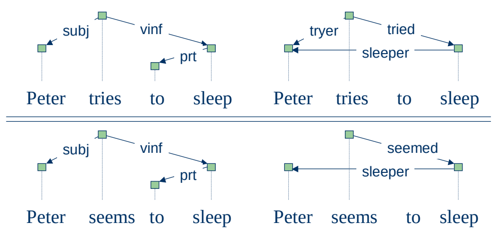
- Raising verbs do also offer a syntactic function for an embedded verb to take, but this argument is not theirs on the argument structure-level

Control vs. Raising

$$tries = \begin{bmatrix} dep & \begin{bmatrix} in & \{\ \} \\ out & \{\text{subj}, \text{vinf}\} \end{bmatrix} \\ arg & \begin{bmatrix} in & \{\ \} \\ out & \{\text{tryer}, \text{tried}\} \\ link & \{\text{tryer} \to \{\text{subj}\}, \text{tried} \to \{\text{vinf}\}\} \\ offer & \{\text{subj}\} \end{bmatrix} \end{bmatrix}$$

$$seems = \begin{bmatrix} dep & \begin{bmatrix} in & \{\ \} \\ out & \{\text{subj}, \text{vinf}\} \end{bmatrix} \\ arg & \begin{bmatrix} in & \{\ \} \\ out & \{\text{seemed}\} \\ link & \{\text{seemed} \to \{\text{vinf}\}\} \\ offer & \{\text{subj}\} \end{bmatrix} \end{bmatrix}$$

Control vs. Raising



Conclusions

- Introduced the TDG grammar formalism
- Went the first step towards a concurrent syntax-semantics interface: addition of the argument structure
- Control and raising-phenomena dealt with rather elegantly
- For the curious: parser implementation available on www.mozart-oz.org

Outlook

- Extend the syntax-semantics interface (esp. To handle modifiers more properly)
- Use argument structure to construct a semantics in a logical formalism (first choice: CLLS; CHORUS-project)
- Investigate in which ways concurrency can prove useful