Polysemy and Coercion – A Frame-based Approach Using LTAG and Hybrid Logic

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AG 11 *Coercion Across Linguistic Fields*

Introduction

Our approach to the syntax-semantics interface:

- Semantic composition is triggered by syntactic composition.
- Every meaning component is linked to some fragment of the syntactic structure.
- Semantic composition is monotonic.

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- Semantic composition is monotonic.

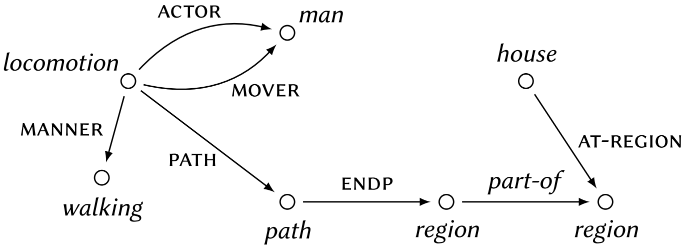
Particularly challenging: **coercion** phenomena, where meaning "changes" in an apparently non-monotonic way, often explained by the presence of some hidden operator.

(1) a. Mary began the book.
    b. John left the party.
    c. Mary mastered the heavy book on magic.

Introduction

Proposal: **Frames** as a way to represent rich lexical content.

- Semantic frames are commonly depicted as **graphs** with labeled nodes and edges, where **nodes** correspond to entities (individuals, events, ...) and **edges** to functional (or non-functional) relations between these entities.



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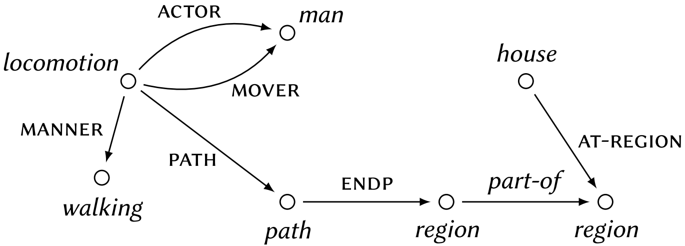

- Frames in this sense can be formalized as **feature structures** with types and relations (e.g. Kallmeyer & Osswald, 2013).

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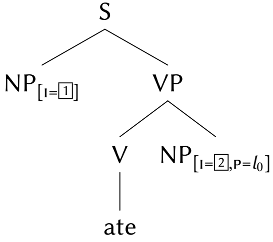

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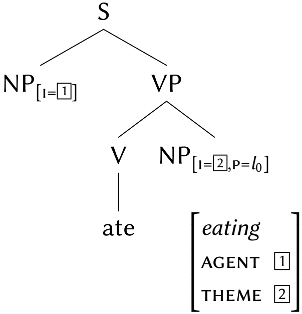

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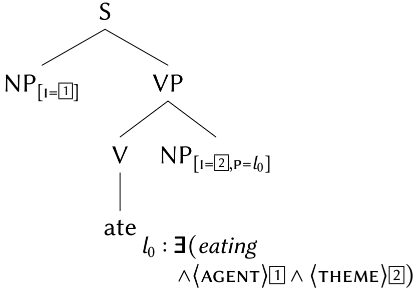

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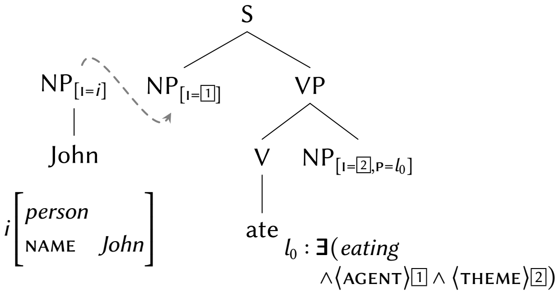

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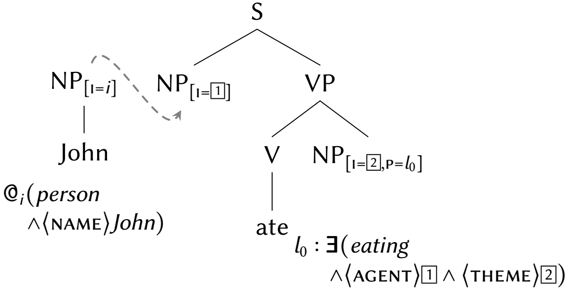

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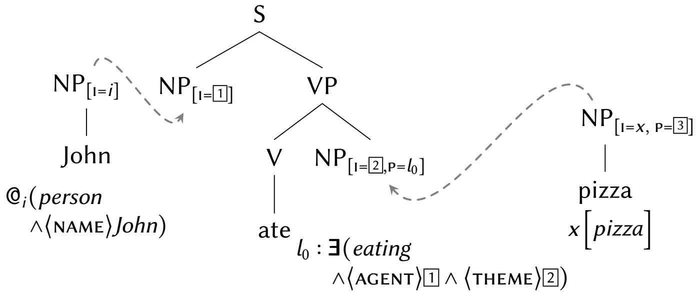

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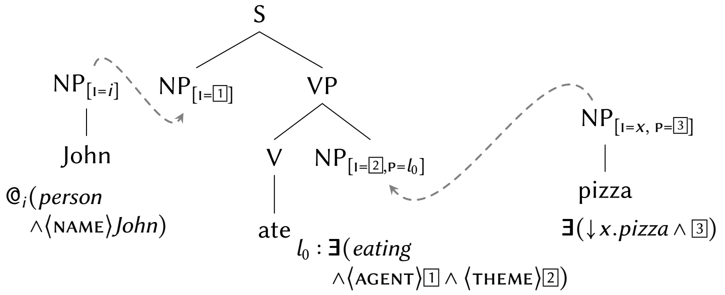
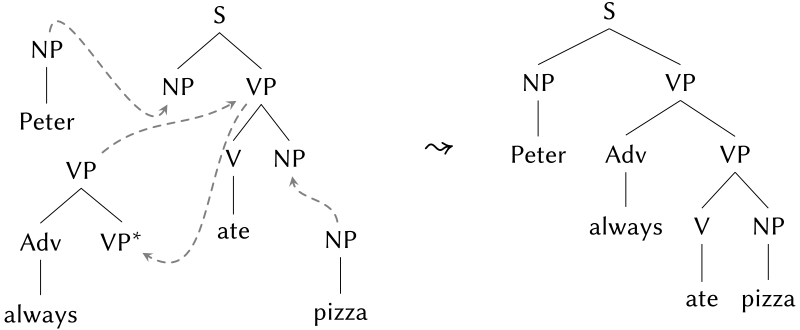


LTAG and frames

Lexicalized Tree Adjoining Grammar (LTAG, Joshi & Schabes 1997; Abeillé & Rambow 2000):

- Finite set of **elementary trees**.
- Larger trees are derived via the tree composition operations **substitution** (replacing a leaf with a new tree) and **adjunction** (replacing an internal node with a new tree).



LTAG and frames

Components of the syntax semantics interface (Kallmeyer & Osswald, 2013; Kallmeyer et al., 2016):

- Semantic representations are linked to entire elementary trees.
- Semantic representations: frames, expressed as typed feature structures, or rather HL formulas that describe frames.
- Interface features relate nodes in the syntactic tree to nodes in the frame graph.
- Composition by unification is triggered by substitution and adjunction.

Polysemy, dot objects and coercion

(2) a. The book is heavy. *phys-obj*

b. The book is interesting. *information*

The noun 'book' is inherently polysemous between a physical object interpretation and an information content interpretation (**dot object** nominals, Pustejovsky, 1995, 1998).

(2) a. The book is heavy. *phys-obj*
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The noun ‘book’ is inherently polysemous between a physical object interpretation and an information content interpretation (**dot object** nominals, Pustejovsky, 1995, 1998).

(3) a. John read the book.
b. John read the story.
c. John read the blackboard.

- The verb ‘read’ allows for the direct selection of the dot object *book* (3-a).
- It also enables coercion of its complement from the type *information* (3-b) as well as from the type *phys-obj* (3-c).

Polysemy, dot objects and coercion

Semantics of the dot object nominal ‘book’:

- Background constraints:

  $\forall(book \rightarrow \textit{info-carrier})$

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  $$\textit{info-carrier} \rightsquigarrow \textit{info-carrier} \wedge \textit{phys-obj} \xrightarrow[\textsc{content}]{} \textit{information}$$

- The lexical entry of ‘book’ only specifies that the word contributes an element of type *book*.

  By the above constraints, it follows that a *book* “node” is of type *info-carrier* (supertype of *book*) and *phys-obj* (supertype of *info-carrier*), and that it has an attribute ⟨CONTENT⟩ with a value of type *information*.

Polysemy, dot objects and coercion

Semantics of ‘read’ (inspired by Pustejovsky, 1998):

- Reading events consist of two subevents, the action of looking at a physical object (the **perception**) and the action of processing the provided information (the **comprehension**).

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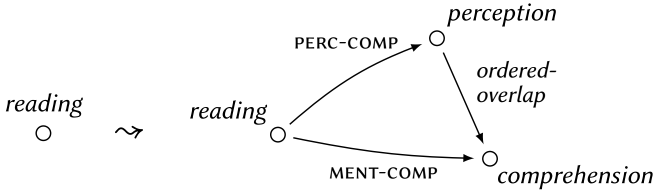
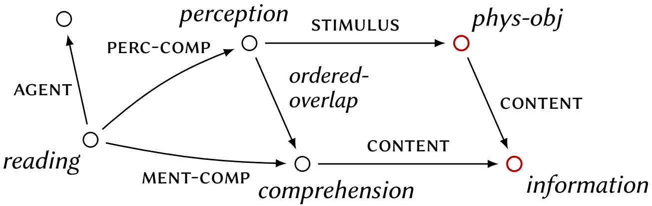
$$\forall\big(\mathit{reading} \rightarrow \exists v.\langle \text{PERC-COMP}\rangle(\mathit{perception} \wedge \langle \mathit{ordered\text{-}overlap}\rangle\, v) \\ \wedge \langle \text{MENT-COMP}\rangle(\mathit{comprehension} \wedge v)\big)$$



Polysemy, dot objects and coercion

Semantics of ‘read’ (continued):

- The *perception* component has an attribute STIMULUS of type *phys-obj* and the *comprehension* node has an attribute CONTENT whose value is the *information* that is being read and which coincides with the CONTENT of the STIMULUS.



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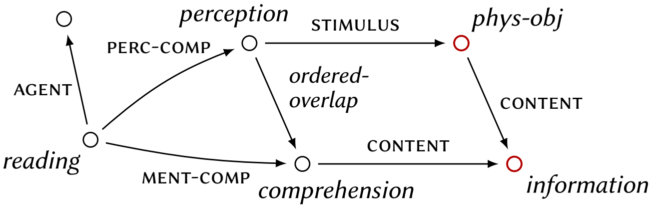
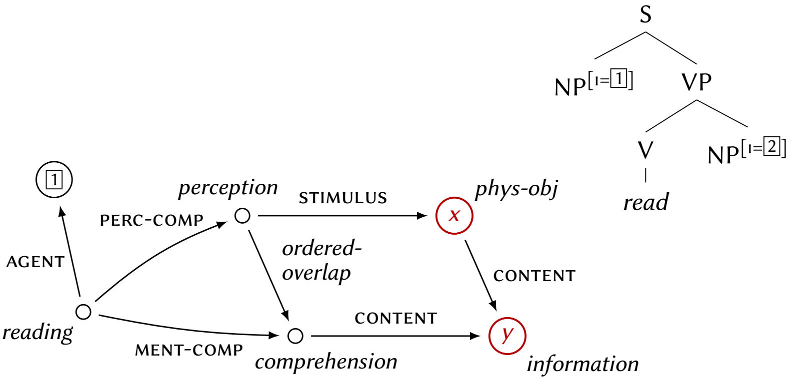


- The argument of ‘read’ can provide either the stimulus of the perception (*phys-obj*) or its content (*information*).

Polysemy, dot objects and coercion

Semantics of ‘read’ and lexical anchoring:



$\boxed{2} \leftrightarrow x \vee \boxed{2} \leftrightarrow y$

Polysemy, dot objects and coercion

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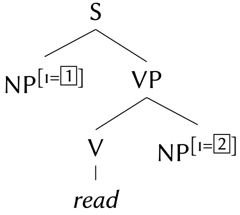

$$
\begin{aligned}
\exists x.\exists y.\boldsymbol{\exists}(\mathit{reading} \wedge \langle \textsc{agent}\rangle \boxed{1} \\
&\wedge \langle \textsc{perc-comp}\rangle\langle \textsc{stimulus}\rangle x \\
&\wedge \langle \textsc{ment-comp}\rangle\langle \textsc{content}\rangle y \\
&\wedge @_x(\mathit{phys\text{-}obj} \wedge \langle \textsc{content}\rangle(\mathit{information} \wedge y)) \\
&\wedge (\boxed{2} \leftrightarrow x \vee \boxed{2} \leftrightarrow y))
\end{aligned}
$$

Compositional derivation of ‘John read the book’ [= (3-a)]

$$
\begin{aligned}
l_0 : \exists x.\exists y.\boldsymbol{\exists}(&\mathit{reading} \wedge \langle \textsc{agent} \rangle \boxed{1} \\
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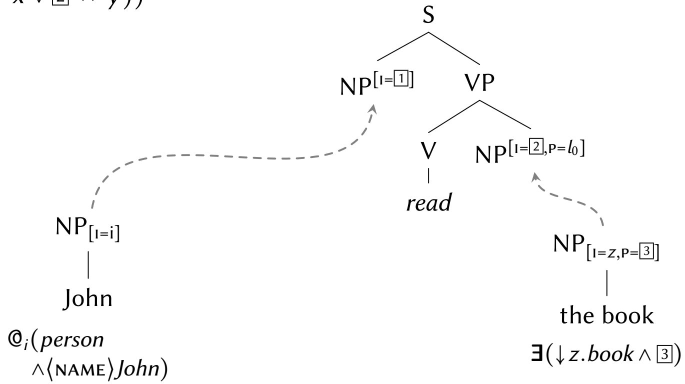

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& l_0 : \exists x.\exists y.\mathbf{E}(\mathit{reading} \wedge \langle \textsc{agent} \rangle i \\
& \qquad \wedge \langle \textsc{perc-comp} \rangle \langle \textsc{stimulus} \rangle x \wedge \langle \textsc{ment-comp} \rangle \langle \textsc{content} \rangle y \\
& \qquad \wedge @_x(\mathit{phys\text{-}obj} \wedge \langle \textsc{content} \rangle (\mathit{information} \wedge y)) \\
& \qquad \wedge (\boxed{2} \leftrightarrow x \vee \boxed{2} \leftrightarrow y)) \\
& @_i(\mathit{person} \wedge \langle \textsc{name} \rangle \mathit{John})
\end{aligned}
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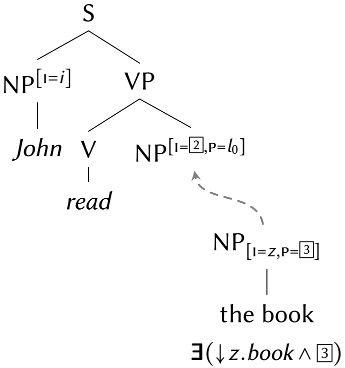

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&\wedge (z \leftrightarrow x \vee z \leftrightarrow y)) \\
@_i&(\mathit{person} \wedge \langle \textsc{name} \rangle \mathit{John}) \\
\boldsymbol{\exists}&(\downarrow z.\mathit{book} \wedge l_0)
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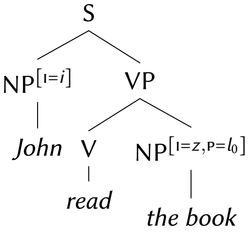

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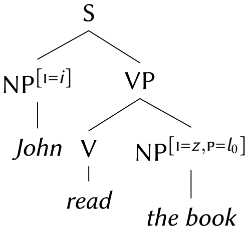

$x \leftrightarrow z$ because of the types

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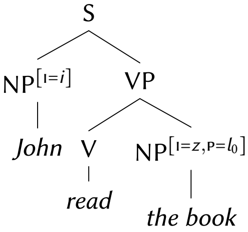

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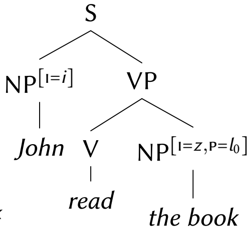

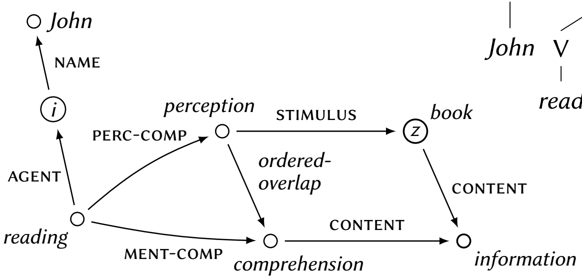

Polysemy, dot objects and coercion

(4) John read the story [= (3-b)]

- Background constraints:

  $\forall(\mathit{story} \rightarrow \mathit{information})$

  $\forall(\mathit{phys\text{-}obj} \rightarrow \neg \mathit{information})$

- Therefore, when combining 'story' as a direct object with the above tree-frame pair for 'read', we obtain $y \leftrightarrow z$.

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- In addition, from the *reading* frame, we infer that there is a physical object that the story is written on and that John perceives this object while comprehending the story.

- In other words, the physical object is not contributed by the lexical entry of 'story' but by coercion, which means in our case by unification and subsequent extension of frames.

Further examples of coercion

(5) John left the party. [= (1-b)]

leaving has a ⟨THEME⟩ attribute whose value is of type *location*.

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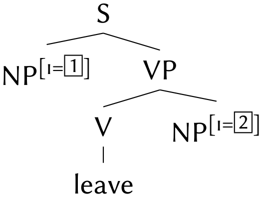
It is either the frame provided by the object NP or the value of the ⟨LOCATION⟩ attribute in that frame.



$$\begin{aligned}\exists x.\boldsymbol{\exists}(&\mathit{leaving} \wedge \langle\textsc{agent}\rangle\boxed{1}\\ &\wedge \langle\textsc{theme}\rangle(\mathit{location} \wedge x)\\ &\wedge (\boxed{2} \leftrightarrow x \vee @_{\boxed{2}}(\langle\textsc{location}\rangle x)))\end{aligned}$$

Further examples of coercion

(6) Mary mastered the heavy book on magic. [= (1-c)]

While both 'heavy' and 'on magic' act as modifiers of 'book', they access different components of the underlying dot object.

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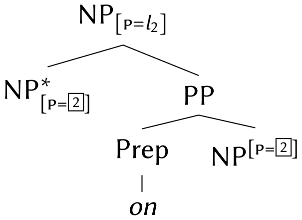
The following (simplified) semantic representation of ‘on’ allows for the modification of the *information* aspect of the modified noun:

$$
\begin{aligned}
l_2 : \boxed{2} \wedge \exists x.(x \vee \langle \textsc{content} \rangle x) \\
\wedge\, @_x(\mathit{knowledge} \wedge \langle \textsc{topic} \rangle \boxed{2})
\end{aligned}
$$



Background constraint:

$$\forall(\mathit{knowledge} \rightarrow \mathit{information} \wedge \langle \textsc{topic} \rangle \top)$$

Conclusion & future work

- We presented a flexible model of the syntax-semantics interface that allows us to account for polysemy and for different coercion phenomena in a monotonic and compositional way without assuming any hidden operators.

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- Possible next step: A more systematic analysis of the various kinds of dot object nouns studied in the literature.

- Many further issues. Example:

  (7) Mary read all the books in the library.

  For (7) to be true, Mary did not necessarily read every physical copy of a book in the library. But she read all the informational contents of the library books (possibly using completely different physical copies).

Thank you very much for your attention!

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