

Polysemy and coercion.

An approach using (de)compositional frame semantics

Laura Kallmeyer

Heinrich-Heine-Universität Düsseldorf

(joint work with William Babonaud¹, Rainer Osswald² & Sylvain Pogodalla³)
¹ENS Cachan ²HHU ³INRIA Nancy

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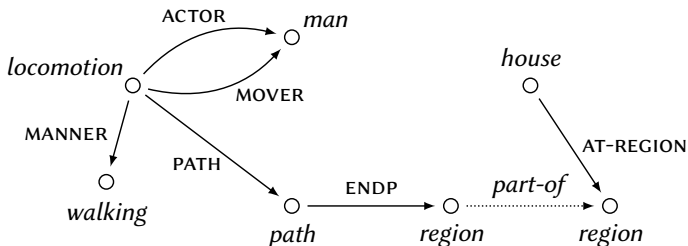
Particularly challenging: **coercion** phenomena, where meaning “changes” in an apparently non-monotonic way, often explained by the presence of some hidden operator.

- (1) a. Mary began the book.
b. John left the party.
c. Mary mastered the heavy book on magic.
d. Peter knocked at the door for ten minutes.

Introduction

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

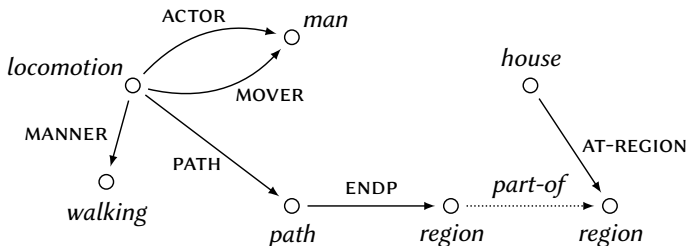
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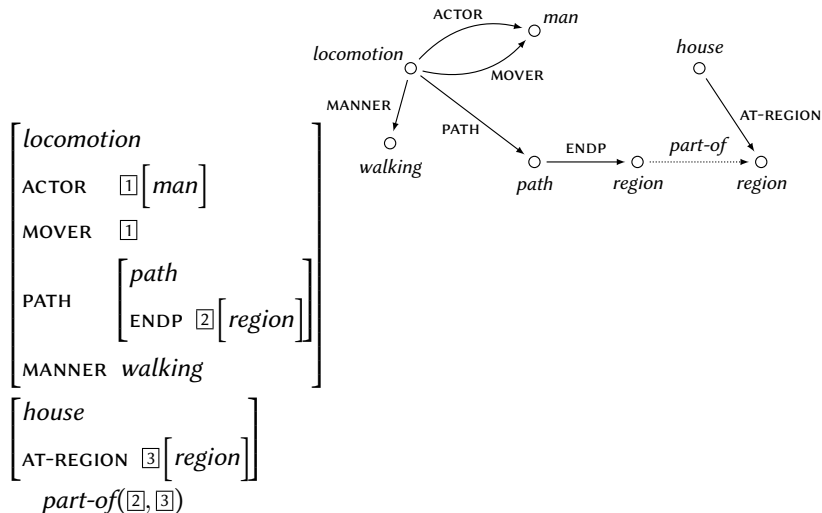
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- Frames in this sense can be formalized as **feature structures** with types and relations (e.g. Kallmeyer & Osswald, 2013).

Introduction

Frame graphs can be represented as attribute-value matrices (AVMs):

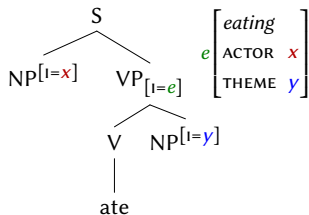


Introduction

In combination with frames, we need a syntactic framework that allows to represent constructions. Our choice: **Lexicalized Tree Adjoining Grammars (LTAG)**.

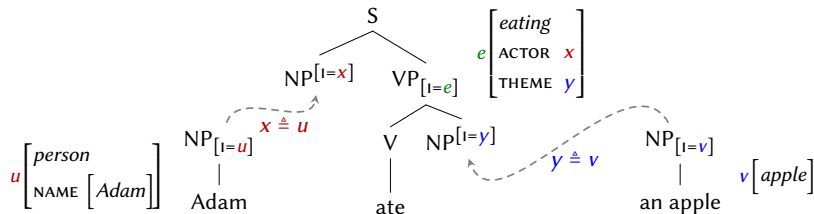
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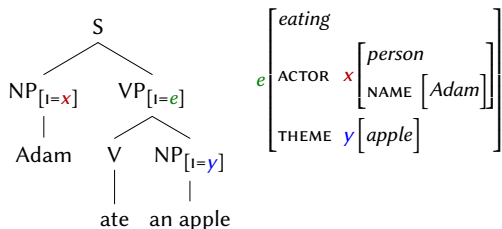
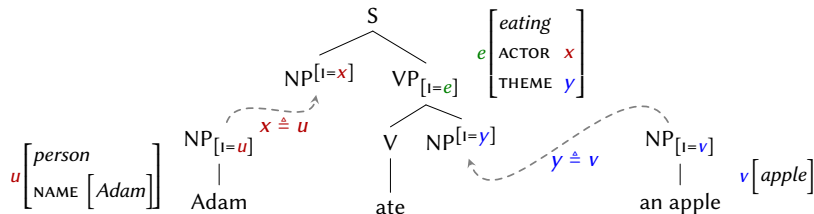
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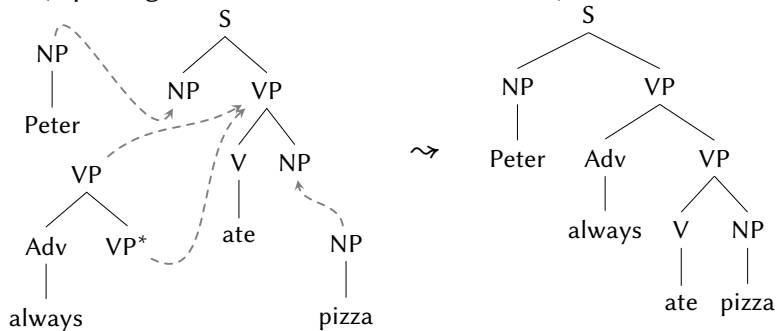
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Introduction

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).



Introduction

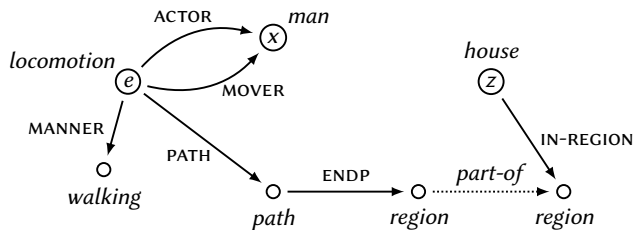
Components of the syntax semantics interface (Kallmeyer & Osswald, 2013; Kallmeyer et al., 2016):

- Semantic representations are linked to entire elementary trees.
- Semantic representations: frames, expressed as typed feature structures, or rather 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.

Introduction

Frames as used in this talk:

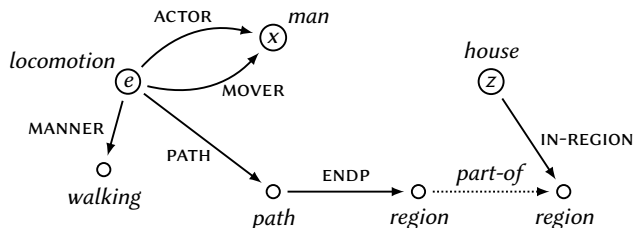
Example



Introduction

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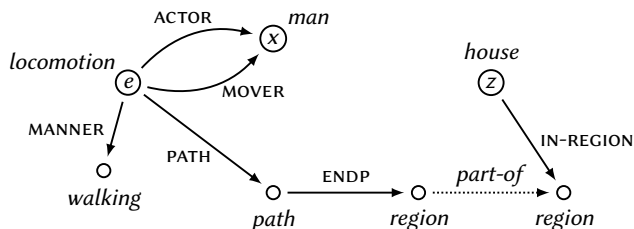
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- Attributes (funct. relations): **ACTOR**, **MOVER**, **PATH**, **MANNER**, **IN-REGION**, ...

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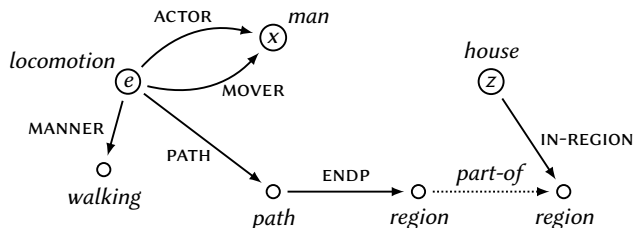
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- Attributes (funct. relations): ACTOR, MOVER, PATH, MANNER, IN-REGION, ...
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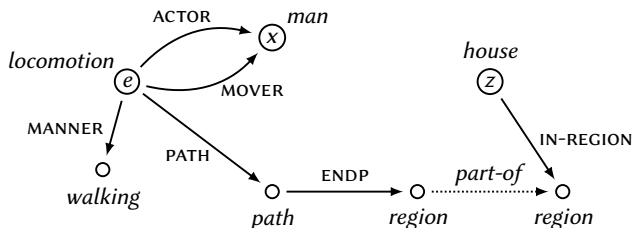
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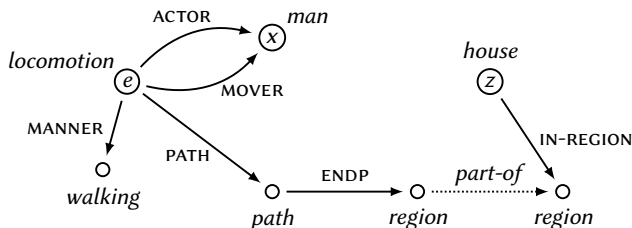
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Example



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Core property

- Every node is reachable from some labeled “base” node via attributes.

Introduction

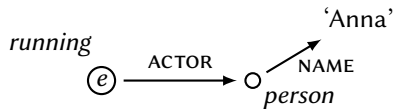
Example

(2) Anna ran

Introduction

Example

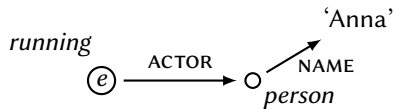
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Introduction

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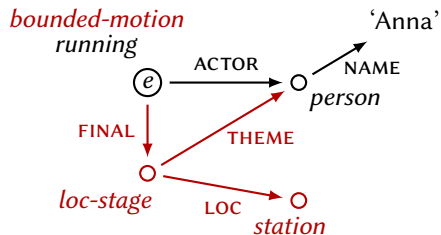
(2) Anna ran **to the station**.



Introduction

Example

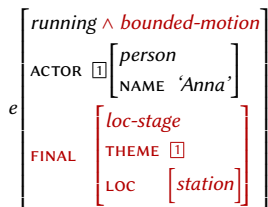
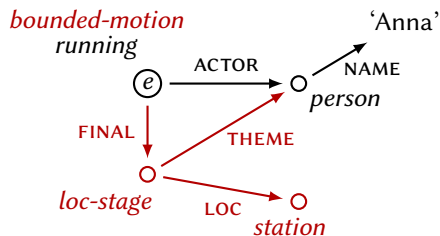
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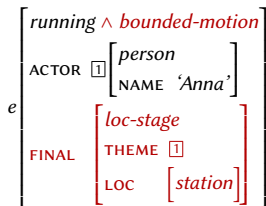
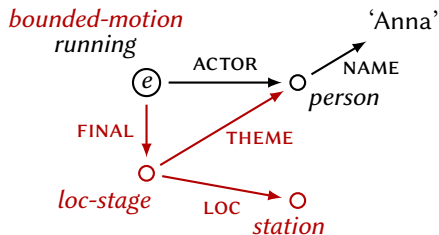
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Introduction

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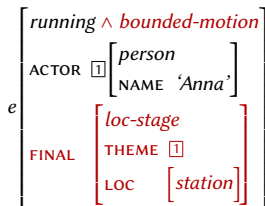
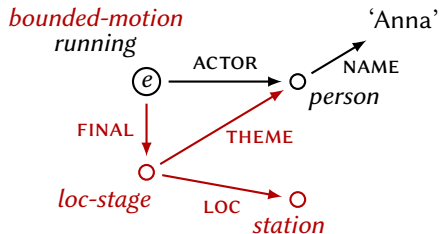
Attribute-value logic

$$e \cdot (\text{running} \wedge \text{bounded-motion} \wedge \text{ACTOR} : (\text{person} \wedge \text{NAME} \hat{=} \text{'Anna'})) \\ \text{ACTOR} \hat{=} \text{FINAL THEME} \wedge \text{FINAL} : (\text{loc-stage} \wedge \text{LOC} : \text{station})$$

Introduction

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Constraints

running \Rightarrow *activity* (short for $\forall e(\text{running}(e) \rightarrow \text{activity}(e))$),
loc-stage \Rightarrow $\text{THEME} : \top \wedge \text{LOC} : \top, \dots$

Polysemy, dot objects and coercion

- (3) 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).

Polysemy, dot objects and coercion

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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).

- (4) 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* (4a).
 - It also enables coercion of its complement from the type *information* (4b) as well as from the type *phys-obj* (4c).

Polysemy, dot objects and coercion

Semantics of the dot object nominal book (Babonnaud et al., 2016):

- Background constraints:

(5) a. *book* \Rightarrow *info-carrier*

b. *info-carrier* \Rightarrow *phys-obj* \wedge *CONTENT: information*

Polysemy, dot objects and coercion

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Consequently: $book \underset{\circ}{\Rightarrow} book \wedge info\text{-}carrier \wedge phys\text{-}obj \underset{\circ}{\xrightarrow{CONTENT}} information \underset{\circ}{}$

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Consequently: $book \circ \Rightarrow \frac{book \wedge info\text{-}carrier \wedge phys\text{-}obj \quad information}{\circ \xrightarrow{CONTENT} \circ}$

- The lexical entry of 'book' only specifies the type *book*.

By (5), 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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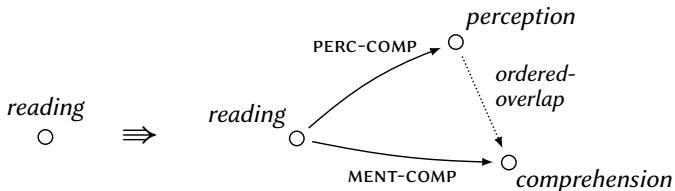
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- The two event components are linked by the (non-functional) temporal relation *ordered-overlap*.

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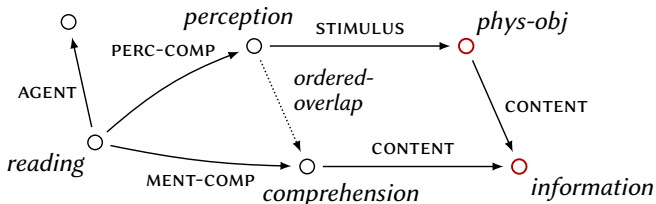
(6) *reading* \Rightarrow (PERC-COMP: *perception* \wedge MENT-COMP: *comprehension* \wedge [PERC-COMP, MENT-COMP]: *ordered-overlap*)



Polysemy, dot objects and coercion

Semantics of 'read' (continued):

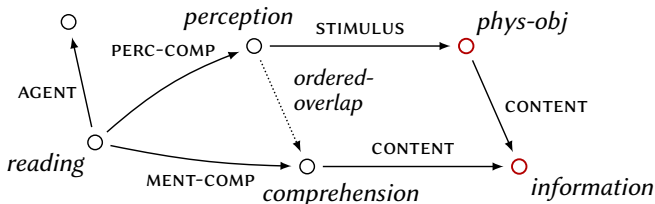
- The *perception* component has an attribute **STIMULUS** of type *phys-obj* and the *comprehension* node has an attribute **CONTENT** whose value is the *information* that is being read and which coincides with the **CONTENT** of the *STIMULUS*.



Polysemy, dot objects and coercion

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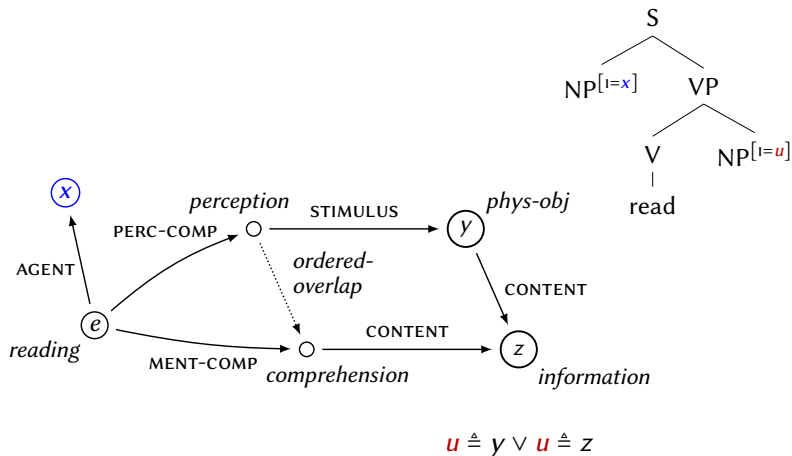
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- The argument of 'read' can provide either the stimulus of the perception (*phys-obj*) or its content (*information*).

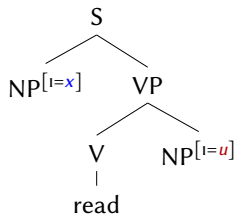
Polysemy, dot objects and coercion

Elementary construction anchored by 'read':



Polysemy, dot objects and coercion

Elementary construction anchored by 'read':



$e \cdot \text{reading} \wedge \text{AGENT} \hat{=} x$

$\wedge \text{PERC-COMP STIMULUS} \hat{=} y$

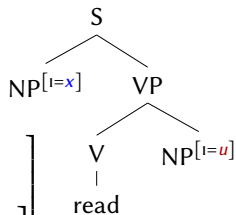
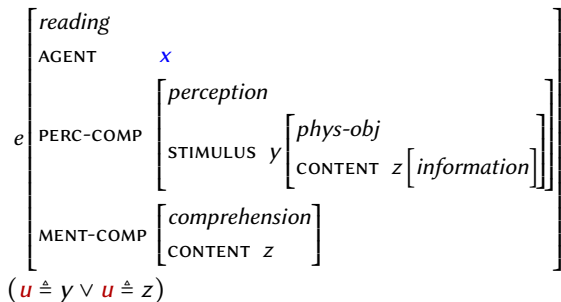
$\wedge \text{MENT-COMP CONTENT} \hat{=} z$

$\wedge y \cdot (\text{phys-obj} \wedge \text{CONTENT} : z \cdot \text{information})$

$\wedge (u \hat{=} y \vee u \hat{=} z)$

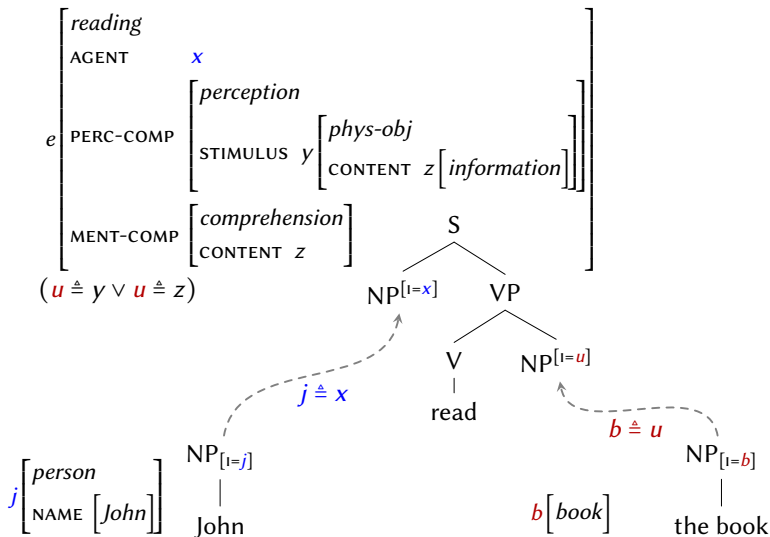
Polysemy, dot objects and coercion

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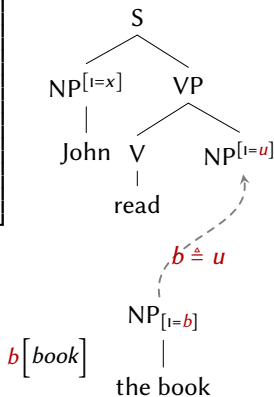
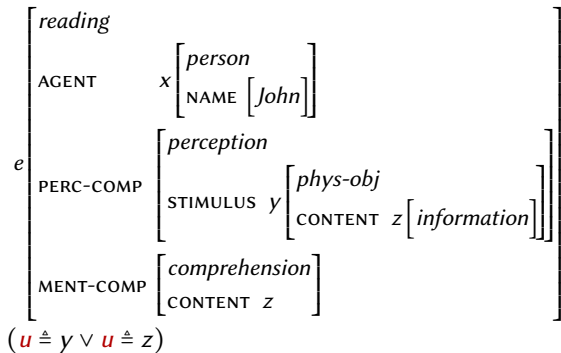
Polysemy, dot objects and coercion

Compositional derivation of 'John read the book' [= (4a)]



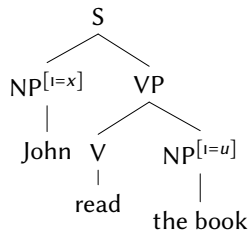
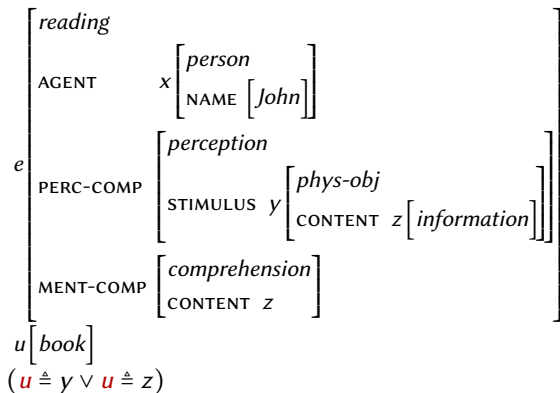
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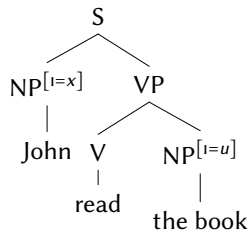
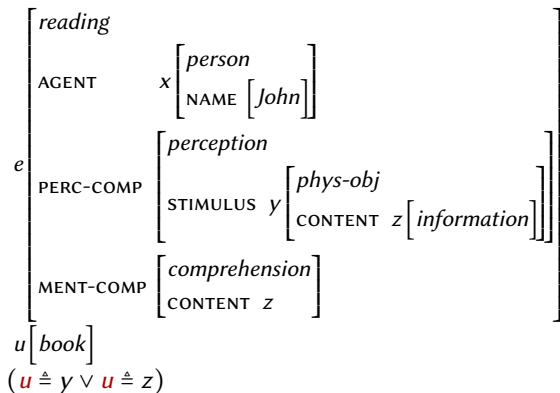
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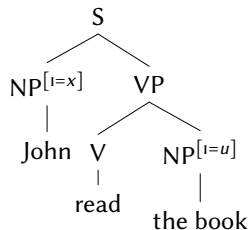
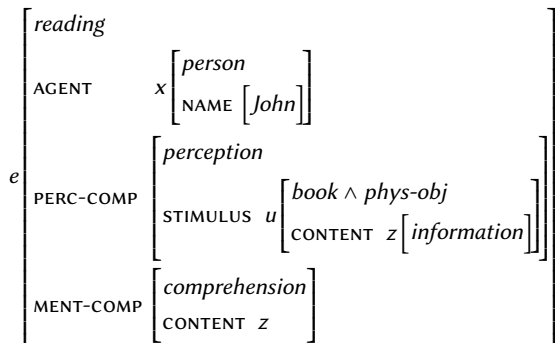
Compositional derivation of 'John read the book' [= (4a)]



$u \triangleq y$ because of the types

Polysemy, dot objects and coercion

Compositional derivation of 'John read the book' [= (4a)]



Polysemy, dot objects and coercion

(7) John read the story [= (4b)]

- Background constraints:

(8) a. *story* \Rightarrow *information*

b. (*phys-obj* \wedge *information*) $\Rightarrow \perp$

- Therefore, when combining ‘story’ as a direct object with the above tree-frame pair for ‘read’, we obtain $u \triangleq z$.

Polysemy, dot objects and coercion

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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.

Polysemy, dot objects and coercion

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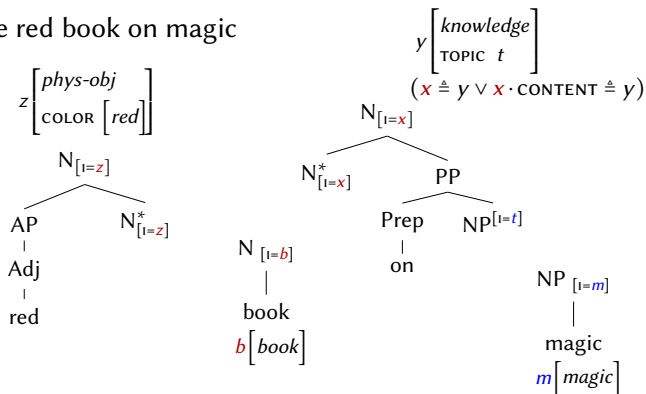
b. (*phys-obj* \wedge *information*) $\Rightarrow \perp$

- Therefore, when combining ‘story’ as a direct object with the above tree-frame pair for ‘read’, we obtain $u \triangleq z$.
- 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.

Polysemy, dot objects and coercion

Copredication: combination of different predicates applying to the same argument while targeting different meaning facets

(9) the red book on magic



(10) $knowledge \Rightarrow (information \wedge TOPIC : T)$

therefore $x \cdot CONTENT \triangleq y$

Quantification and polysemous nouns

The “**Quantification Puzzle**” (Asher & Pustejovsky, 2005, 2006)

- (11) a. Mary carried off every book in the library.
b. Mary read every book in the library.

Quantification and polysemous nouns

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Issues related to the analysis of (11b):

- Usually there is **no one-to-one correspondence** between the physical books in the library and the book contents.
- Moreover, (11b) may be true even if **no physical copy** from the library has been ever used by Mary.

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Asher’s (2011) proposal:

- Reification of dot type objects; the different aspects of a dot object are accessed via functors (using a category theoretic approach).

Quantification and polysemous nouns

Our proposal:

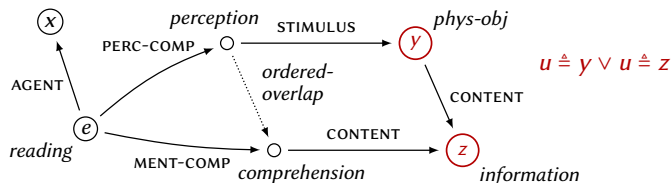
- Keep the frame structure of books as physical information carriers.
- Keep the frame for *reading* events.
- Modify the way the two frames are combined.

Quantification and polysemous nouns

Our proposal:

- Keep the frame structure of books as physical information carriers.
- Keep the frame for *reading* events.
- Modify the way the two frames are combined.

Analysis we had so far (u is the interface feature at the direct object):



a) the *book* node unifies with y and b) its informational content unifies with z because of the functionality of the CONTENT attribute.

Quantification and polysemous nouns

Question: Does the *reading* frame really take the *phys-obj* node as an argument if there is such a node?

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Quantification and polysemous nouns

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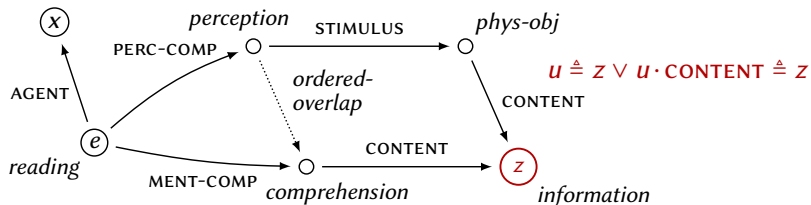
- (12) Did you read this book?
can be answered “yes” even if the physical object in question was not involved in the reading event.
- (13) Mary read the heavy book on magic. She read part of it on her ebook reader for convenience.

Variability of the physical carrier while reading a single book (understood as an informational object).

Quantification and polysemous nouns

Revised analysis:

The informational content involved in the reading event is either contributed by the direct object or it is the CONTENT value of the direct object frame.

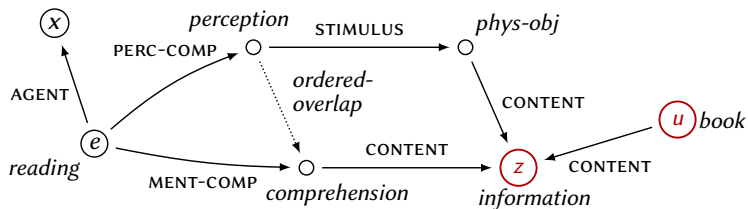


(*u* is the interface feature at the direct object)

Quantification and polysemous nouns

(14) John read the book

leads then to the following frame:



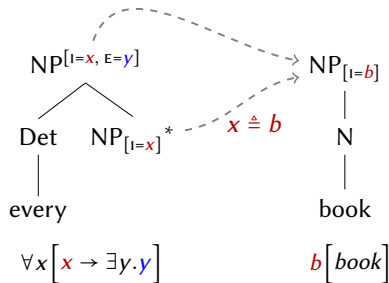
This does neither exclude nor enforce equality of the *book* node u and the *phys-obj* node.

Quantification and polysemous nouns

Question: How can we integrate quantifiers into frames?

Our current choice: quantification in the underlying logic, not in the frame structures themselves.

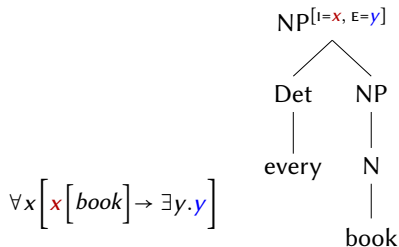
(15) John carried off every book



Quantification and polysemous nouns

Question: How can we integrate quantifiers into frames?

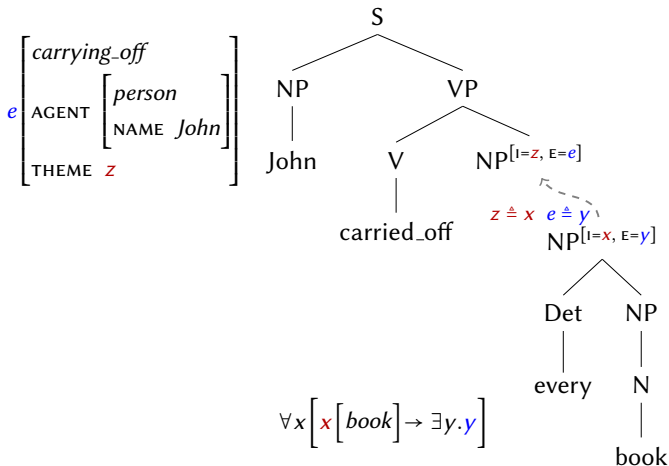
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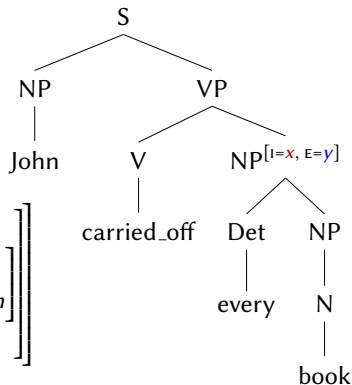


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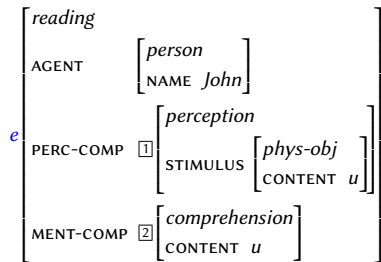
Our current choice: quantification in the underlying logic, not in the frame structures themselves.

$$\forall x \left[x \left[\text{book} \right] \rightarrow \exists y. y \left[\begin{array}{l} \text{carrying_off} \\ \text{AGENT} \left[\begin{array}{l} \text{person} \\ \text{NAME } \textit{John} \end{array} \right] \\ \text{THEME } x \end{array} \right] \right]$$



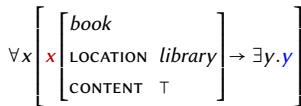
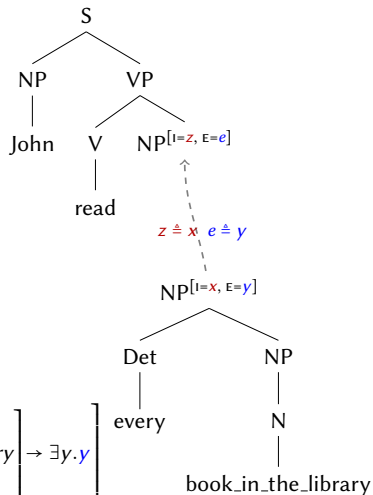
Quantification and polysemous nouns

(16) John read every book in the library



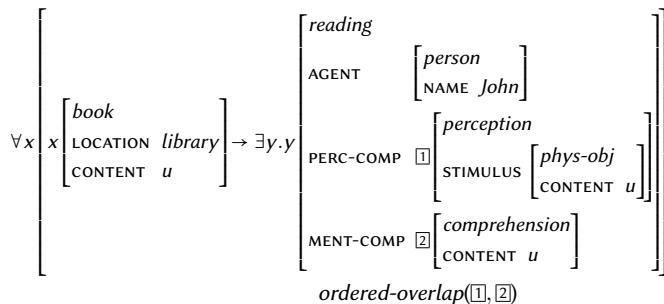
ordered-overlap([1], [2])

$u \triangleq z \vee z$ [CONTENT u]



Quantification and polysemous nouns

(16) John read every book in the library



Atelicity and telicity and *for*-adverbials

Analysis largely based on Kallmeyer et al. (2016)

(17) Peter swam for one hour

(18) Peter knocked at the door for one hour

- In (17), the verb denotes an activity and is thus immediately compatible with the *for*-adverbial.
- In (18), the verb denotes a punctual event, and, hence, calls for additional adjustments in order to be compatible with *for*-adverbials.

⇒ (18) is interpreted as describing a sequence or iteration of knockings.

Atelicity and telicity and *for*-adverbials

Semantics of *for*-adverbials following Champollion (2013):

$$(19) \lambda P \lambda I [AT(P, I) \wedge hours(I) = 1 \wedge \forall J [J \in \mathcal{R}_I^{short(I)} \rightarrow AT(P, J)]]$$

In other words, a *for*-adverbial can only apply to an event P if we can fix a partition of the entire time interval I such that in each of the smaller intervals J , P holds as well.

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- In the case of *knock*, one has to apply an iteration operator first ($*knock$), and the result can then become the argument of (19).

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Goal of our work: provide an analysis with a similar semantics for *for*-adverbials that avoids the assumption of an independent, separately applying iteration operator.

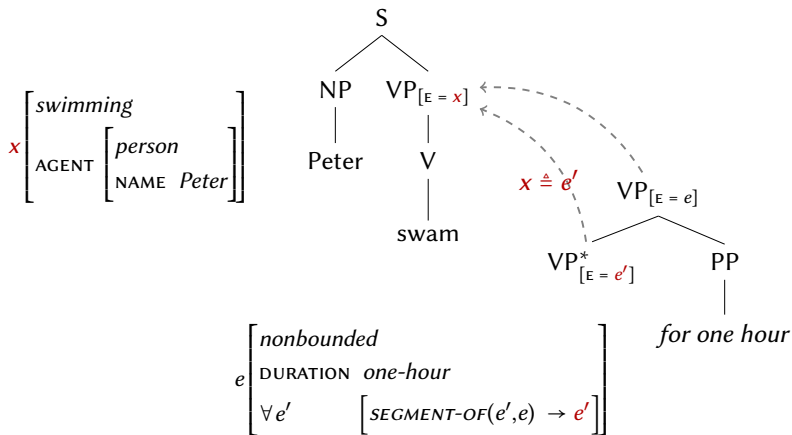
Atelicity and telicity and *for*-adverbials

Our proposal:

- The result of the modification with the *for*-adverbial is either a *progression* or an *iteration*, depending on the modified event.
- More generally, it yields a non-bounded event that has a DURATION of one hour and that is such that its segments are events of the type characterized by the modified verb.
- Crucially, the overall event e need not be of the type characterized by the modified event. In the case of a *progression*, it is, in the case of an *iteration* it is not of this type.

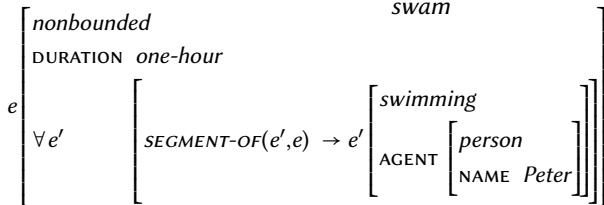
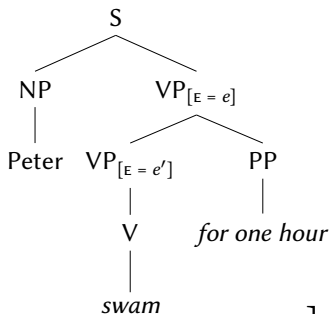
Atelicity and telicity and *for*-adverbials

(20) Peter swam for one hour



Atelicity and telicity and *for*-adverbials

(20) Peter swam for one hour



Atelicity and telicity and *for*-adverbials

(21) Peter knocked at the door for one hour

In a way similar to the derivation of (20), we can derive the following semantics for (21):

(22)
$$e \left[\begin{array}{l} \textit{nonbounded} \\ \text{DURATION } \textit{one-hour} \\ \forall e' \left[\text{SEGMENT-OF}(e', e) \rightarrow e' \left[\begin{array}{l} \textit{knocking} \\ \text{AGENT } \left[\begin{array}{l} \textit{person} \\ \text{NAME } \textit{Peter} \end{array} \right] \\ \text{PATIENT } \textit{door} \end{array} \right] \end{array} \right] \end{array} \right]$$

Atelicity and telicity and *for*-adverbials

In order to make the meanings of (20) (swimming) and (21) (knocking) more explicit, we need additional general constraints.

- (23) a. *nonbounded* \Rightarrow (*iteration* \vee *progression*)
b. (*iteration* \wedge *progression*) $\Rightarrow \perp$

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(24) a. $\forall e[\exists e'(\textit{segment-of}(e, e') \wedge e' \cdot \textit{iteration}) \rightarrow e \cdot \textit{bounded}]$

b. *punctual* \Rightarrow *bounded*

c. *knocking* \Rightarrow *punctual*

d. $\forall e[\exists e'(\textit{segment-of}(e, e') \wedge e' \cdot \textit{progression}) \rightarrow e \cdot \textit{nonbounded}]$

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(25) $\forall e[e \cdot progression \rightarrow segment-of(e, e)]$

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Applying these constraints yields a $progression \wedge swimming$ reading for (20) and an $iteration$ reading for (21).

Conclusion

- 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.
- We used frames for a fine-grained representation of lexical meaning. Furthermore, the types in frames, in combination with frame constraints that capture world knowledge, restrict unification and enforce coercion.

Danke!

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