

Semantic Theory: Discourse Semantics I

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A simple context theory (Lewis 1970/72)



- Some natural-language expressions, like *I*, *you*, *here*, *this*, vary their meaning with context.
- Model contexts as vectors: sequences of semantically relevant context data with fixed arity.
- Model meanings as functions from contexts to denotations - more specifically, as functions from specific context components to denotations.

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An Example



- Context $c = \langle a, b, l, t, r \rangle$

- <i>a</i> speaker	$[[I]]^{M,g,c} = \text{utt}(c) = a$
- <i>b</i> addressee	$[[you]]^{M,g,c} = \text{adr}(c) = b$
- <i>l</i> utterance location	$[[here]]^{M,g,c} = \text{loc}(c) = l$
- <i>t</i> utterance time	$[[now]]^{M,g,c} = \text{time}(c) = t$
- <i>r</i> referred object	$[[this]]^{M,g,c} = \text{ref}(c) = r$

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Type-theoretic context semantics



- Model structure: $M = \langle U, C, V \rangle$
 - U model universe
 - C context set
 - V value assignment function that assigns non-logical constants functions from contexts to denotations of appropriate type.
- Interpretation:
 - $[[\alpha]]^{M,h,c} = V(\alpha)(c)$, if α non-logical constant,
 - $[[\alpha]]^{M,h,c} = h(\alpha)$, if α Variable,
 - $[[\alpha(\beta_1, \dots, \beta_n)]]^{M,h,c} = [[\alpha]]^{M,h,c}([[\beta_1]]^{M,h,c}, \dots, [[\beta_n]]^{M,h,c})$
 - etc.

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Interpretation: An example



I am reading this book \Rightarrow read'(this-book')(I')

$[[\text{read}'(\text{this-book}')(\text{I}')]]]^{M,h,c} =$

$[[\text{read}']]^{M,h,c}([\text{this-book}]]^{M,h,c}([\text{I}']]^{M,h,c}) =$

$V(\text{read}')(\text{ref}(c))(\text{utt}(c))$

Context-invariant expressions are constant functions:

$V(\text{read}')(\text{c}) = V(\text{read}')(\text{c}') [= V(\text{read}')] \text{ for all } \text{c}, \text{c}' \in \text{C}$

Context Dependence: The Real Story



- Semantic context dependence is a pervasive property of natural language:

Every student must be familiar with the basic properties of FOL

It is hot and sunny everywhere.

John always is late.

Bill has bought an expensive car.

Another one, please!

The student is working.

Two basic classes of context dependent expressions



- Deictic expressions** depend on the physical utterance situation:
I, you, now, here, this
- Anaphoric expressions** refer to linguistic context/ previous discourse:
he, she, it, then
- But there is more ...

Definite NPs: Type-theoretic analysis



- Standard type-theoretic representation of definite article:

the $\Rightarrow \lambda F \lambda G \exists y (\forall x (F(x) \leftrightarrow x=y) \wedge G(y))$

the sun $\Rightarrow \lambda G \exists y (\forall x (\text{sun}'(x) \leftrightarrow x=y) \wedge G(y))$

the sun is shining \Rightarrow

$\exists y (\forall x (\text{sun}'(x) \leftrightarrow x=y) \wedge \text{shine}'(y))$

the student is working \Rightarrow

$\exists y (\forall x (\text{student}'(x) \leftrightarrow x=y) \wedge \text{work}'(y)) ?$

- Definite NPs pick an appropriate object from context.

Context-dependence of definite NPs

- Definite NPs pick an appropriate object from context.

The student is working

- Utterances typically contain several noun phrases referring to different objects:

The student is reading the book in the library

- Noun phrases may refer to different objects of the same type, in one utterance situation:

the book

the blue book

the blue book about discourse semantics

Indefinite NPs

- *A student is working*
- Standard type-theoretic analysis:
 $a \Rightarrow \lambda P \lambda Q \exists x [P(x) \wedge Q(x)]$
 $a \text{ student} \Rightarrow \lambda Q \exists x [\text{student}'(x) \wedge Q(x)]$
 $A \text{ student is working} \Rightarrow \exists x [\text{student}'(x) \wedge \text{work}'(x)]$
- Indefinite noun phrases establish the context for later reference, they introduce new reference objects. Type-theoretic semantics cannot model this effect (without serious changes).
- *A student is working. The student/ She is successful.*
 $she \Rightarrow \lambda PP(x)$
 $She \text{ is successful} \Rightarrow \text{successful}'(x)$
 $A \text{ student is working. She is successful.}$
 $\Rightarrow \exists x [\text{student}'(x) \wedge \text{work}'(x)] \wedge \text{successful}'(x)$

The interaction of definite and indefinite NPs

- Natural-language meaning and context interact in two ways:
 - Context determines the utterance meaning.
 - The semantics of the utterance changes the context.
- The „context change potential“ is part of the meaning of natural-language expressions.

Context dependence: Wrap up

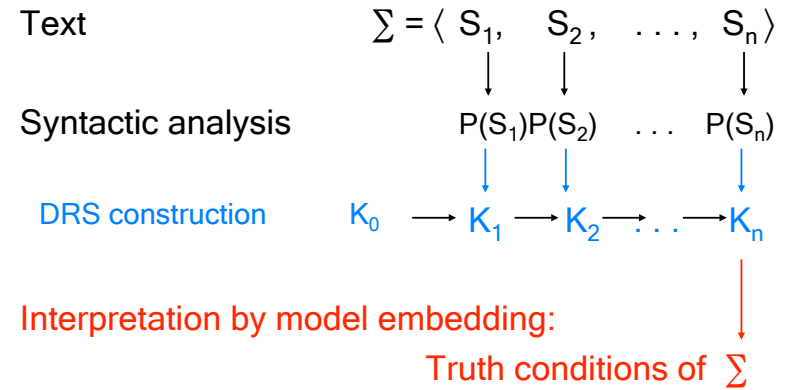
- The interpretation of most context-dependent expressions, e.g., **definite noun phrases**, is determined by context in a complex way.
- Some types of expressions, like **indefinite noun phrases**, introduce new context information, which is available at a later stage of discourse for anaphoric reference. Modelling this kind of **context change potential** is outside the reach of standard type-theoretic semantics, with or without context-semantic extension.
- Reference objects established in discourse need not be real objects:
If you have a pencil or a ballpoint pen, could you please pass it to me?
Someone - whoever that may be - will eventually find out. That person will tell others, and everyone will be terribly upset.

Discourse Semantics



- The basic idea: Meaning as **Context Change Potential**
- Focus on anaphoric use of noun phrases (definite and indefinite, full NPs and pronouns).
- Meaning representation uses **discourse referents** in addition to formulas encoding truth conditions.
- "Division of labor" between definite and indefinite NPs:
 - Indefinite NPs introduce new discourse referents
 - Definite NPs refer to "old" or "familiar" discourse referents (which are already part of the meaning representation)
- Discourse Representation Theory: Hans Kamp (1981), Irene Heim (1980)
- Reading: Hans Kamp/Uwe Reyle: *From Discourse to Logic*, Kluwer: Dordrecht 1993.

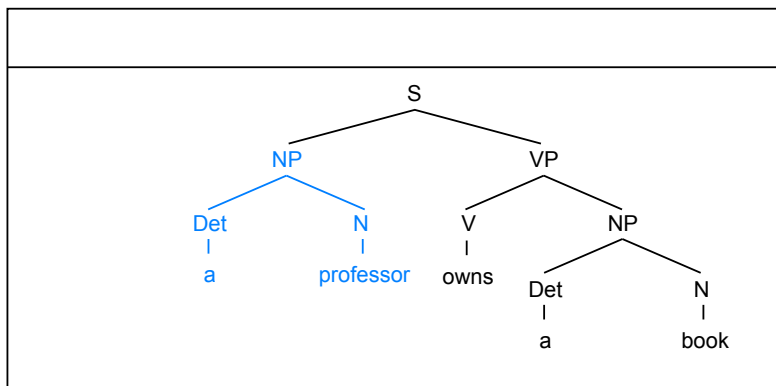
Discourse Representation Theory (DRT)



An example



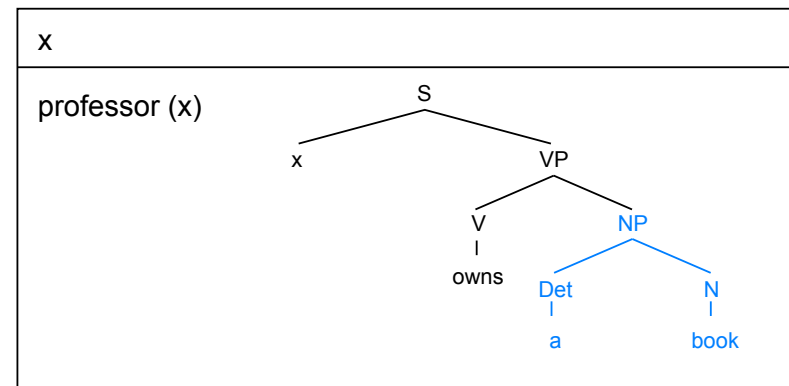
- *A professor owns a book. He reads it.*



An example



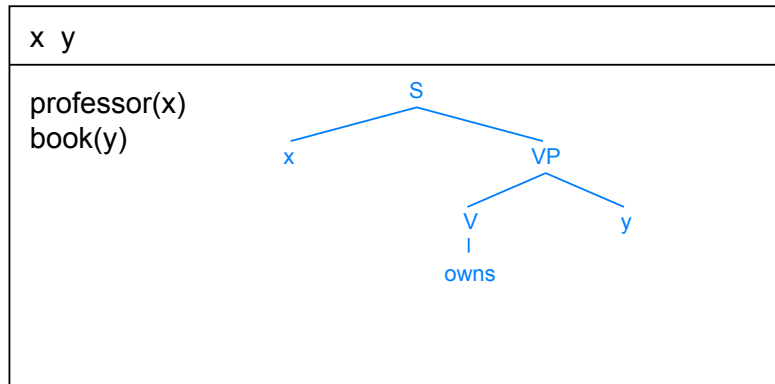
- *A professor owns a book. He reads it.*



An example



- *A professor owns a book. He reads it.*



An example



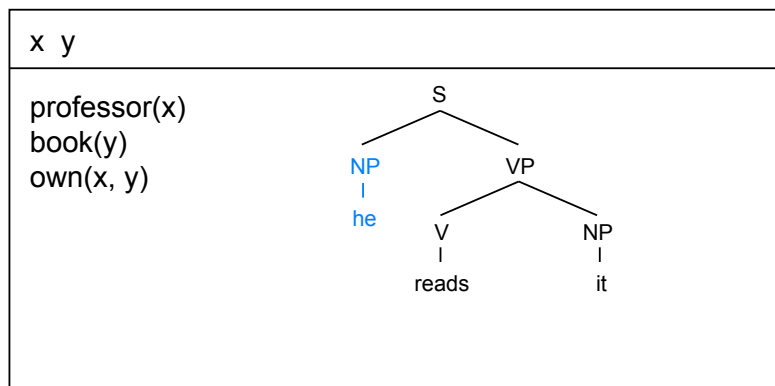
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An example



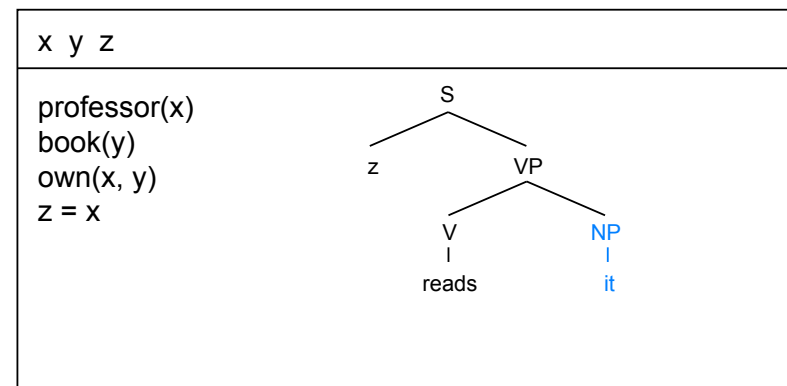
- *A professor owns a book. He reads it.*



An example



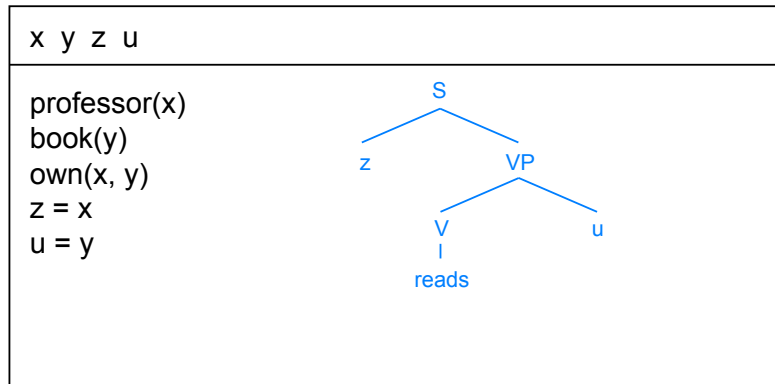
- *A professor owns a book. He reads it.*



An example



- *A professor owns a book. He reads it.*



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An example



- *A professor owns a book. He reads it.*



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DRS (Basic Version)



- A discourse representation structure (DRS) K is a pair $\langle U_K, C_K \rangle$, where
 - U_K is a set of **discourse referents**
 - C_K is a set of **conditions**
- (Fully reduced) conditions:
 - $R(u_1, \dots, u_n)$ R n -place relation, $u_i \in U_K$
 - $u = v$ $u, v \in U_K$
 - $u = a$ $u \in U_K$, a is proper name
- **Reducible conditions**: Conditions of form α or $\alpha(x_1, \dots, x_n)$, where α is a context-free parse tree.

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DRS (Basic Version)



- A discourse referent (DR) u is free in DRS $K = \langle U_K, C_K \rangle$, if u is free in one of K 's conditions, and $u \notin U_K$.
- A DRS K is closed in K iff no DR occurs free in K .
- A reducible (fully reduced) DRS is a DRS which contains (does not contain) reducible conditions.

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DRS Construction Algorithm



- Input:
 - a text $\Sigma = \langle S_1, \dots, S_n \rangle$
 - a DRS $K_0 (= \langle \emptyset, \emptyset \rangle)$, by default
- Repeat for $i = 1, \dots, n$:
 - Add parse tree $P(S_i)$ to the conditions of K_{i-1} .
 - Apply DRS construction rules to reducible conditions of K_{i-1} , until no reduction steps are possible any more. The resulting DRS is K_i , the discourse representation of text $\langle S_1, \dots, S_i \rangle$.

DRS Construction Rule for Indefinite NP



- Triggering Configuration:
 - α is reducible condition in DRS K , containing $[_{S} [_{NP} \beta] [_{VP} \gamma]]$ or $[_{VP} [_{V} \gamma] [_{NP} \beta]]$ as a substructure.
 - β is $\varepsilon\delta$, ε indefinite article
- Action:
 - Add a new DR x to U_K .
 - Replace β in α by x .
 - Add $\delta(x)$ to C_K .

DRS Construction Rule for Personal Pronoun



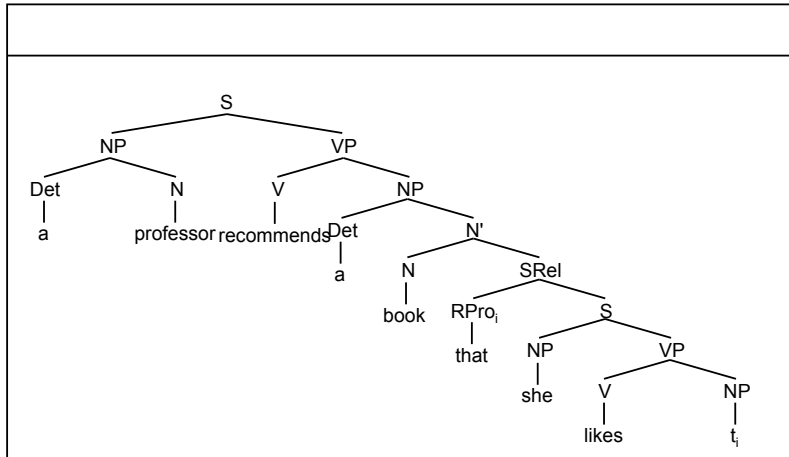
- Triggering Configuration:
 - α is reducible condition in DRS K ; α contains $[_{S} [_{NP} \beta] [_{VP} \gamma]]$ or $[_{VP} [_{V} \gamma] [_{NP} \beta]]$ as substructure.
 - β is a personal pronoun.
- Action:
 - Add a new DR x to U_K .
 - Replace β in α by x .
 - Select an appropriate DR $y \in U_K$, and add $x = y$ to C_K .

DRS Construction Rule for Proper Names

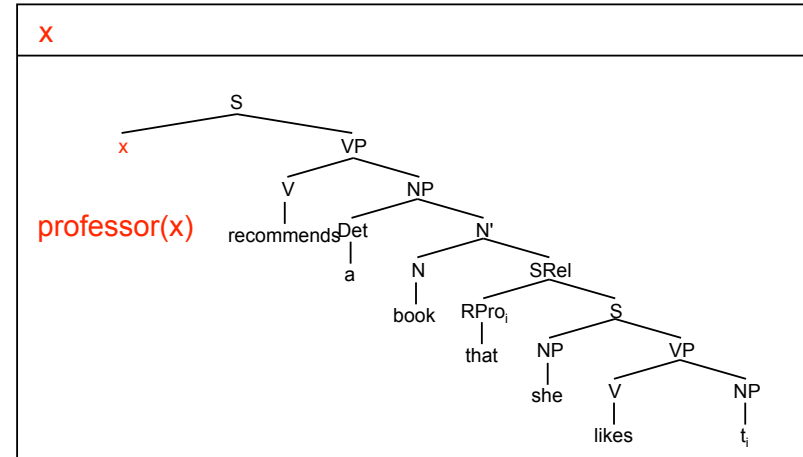


- Triggering Configuration:
 - α is reducible condition in DRS K ; α contains $[_{S} [_{NP} \beta] [_{VP} \gamma]]$ or $[_{VP} [_{V} \gamma] [_{NP} \beta]]$ as substructure.
 - β is a proper name.
- Action:
 - Add a new DR x to U_K .
 - Replace β in α by x .
 - Add $x = \beta$ to C_K .

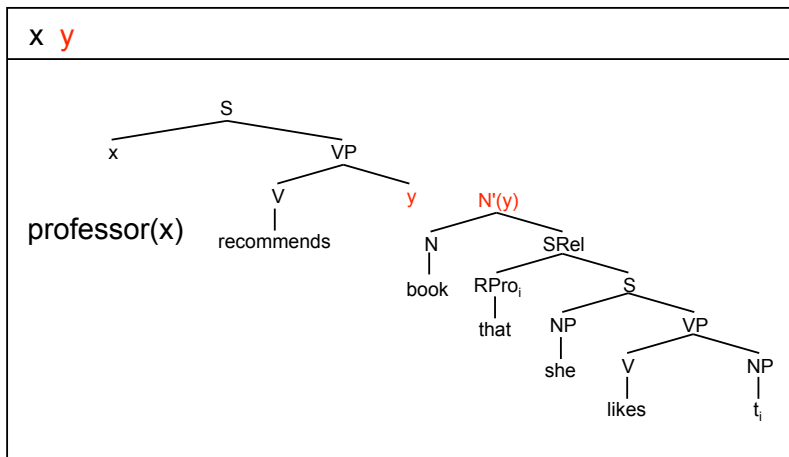
A more complex example



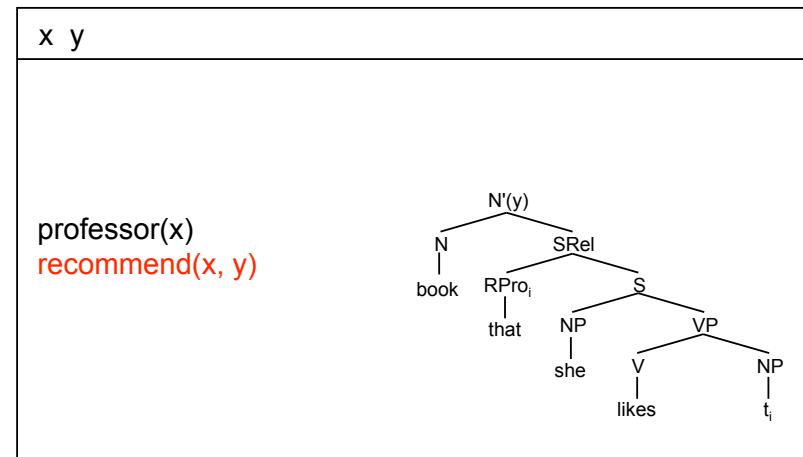
Indefinite NP rule



Indefinite NP rule



Flattening



DRS-CR for Relative Clauses



- Triggering configuration:
 - $\alpha(x)$ is reducible condition in DRS K ; α contains $[_{NP} [_{NP} \beta]$ $[_{S_{Rel}} \gamma]]$ as a substructure
 - γ is relative clause of the form $\delta\varepsilon$, where δ is a relative pronoun and ε a sentence with an NP gap t , δ and t are co-indexed.
- Actions:
 - Remove $\alpha(x)$ from C_K .
 - Add $\beta(x)$ to C_K .
 - Replace the NP gap in ε by x , and add the resulting structure to C_K .

Relative Clause Rule



x y

$\text{professor}(x)$
 $\text{recommend}(x, y)$
 $\text{book}(y)$

```

graph TD
    S --> NP1[NP]
    S --> VP[VP]
    NP1 --> she[she]
    VP --> V[V]
    VP --> NP2[NP]
    V --> likes[likes]
    NP2 --> y[y]
            
```

Personal Pronoun Rule



x y z

$\text{professor}(x)$
 $\text{recommend}(x, y)$
 $\text{book}(y)$
 $z = x$

```

graph TD
    S --> NP1[NP]
    S --> VP[VP]
    NP1 --> z[z]
    VP --> V[V]
    VP --> NP2[NP]
    V --> likes[likes]
    NP2 --> y[y]
            
```

Fully reduced DRS after Flattening



x y z

$\text{professor}(x)$
 $\text{recommends}(x, y)$
 $\text{book}(y)$
 $z = x$
 $\text{likes}(z, y)$

A constraint on the DRS construction algorithm



- A problem: The basic DRS construction algorithm can derive DRSes for both of the following sentences, with the indicated anaphoric binding
 - *[A professor]_i recommends a book that she_i likes*
 - **She_i recommends a book that [a professor]_i likes*

The Highest Triggering Configuration Constraint



- If two triggering configurations of one or two different DRS construction rules occur in a reducible condition, then first apply the construction rule to the highest triggering configuration.
- The highest triggering configuration is the one whose top node dominates the top nodes of all other triggering configurations.

Discourse Representation Theory (DRT)

