Semantic Theory: Discourse Semantics II

Summer 2010

M.Pinkal/ S. Thater

Indefinite NPs and conditionals

- *If a student works, the professor is happy.*

  (1) $\exists x[student(x) \wedge work(x)] \rightarrow happy\_prof$
  (2) $\forall x[student(x) \wedge work(x) \rightarrow happy\_prof]$

- Formulas (1) and (2) are logically equivalent:
  $\exists xA \rightarrow B \Leftrightarrow \forall x[A \rightarrow B]$
  given that x doesn't occur free in B.

Indefinite NPs, Conditionals, and Anaphora

- *If a student works, he will be successful.*

  (1) $\exists x[student(x) \wedge work(x)] \rightarrow successful(x)$
  (2) $\exists x[student(x) \wedge work(x) \rightarrow successful(x)]$
  (3) $\forall x [student(x) \wedge work(x) \rightarrow successful(x)]$
  (1) is not closed
  (2) has wrong truth conditions (much too weak)
  (3) is correct, but how can it be derived compositionally?

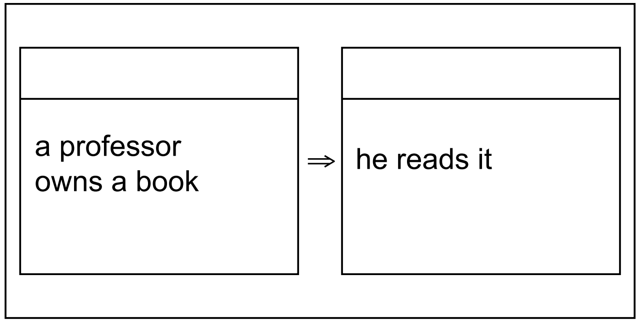
- This is called the donkey sentence problem, after the classical example by P.T. Geach (1967):
  If a farmer owns a donkey, he beats it.

Indefinite NPs and Discourse Structure

- *A car is parked in front of Peter's garage. Peter needs to get to the office quickly. He doesn't know who owns the car. He calls the police, and it is towed away.*
- *Suppose a car is parked in front of Peter's garage. Peter needs to get to the office quickly. He doesn't know who owns the car. Then he will call the police, and it will be towed away.*
- *Let a and b be two positive integers. Let b further be even. Then the product of a and b is even too.*

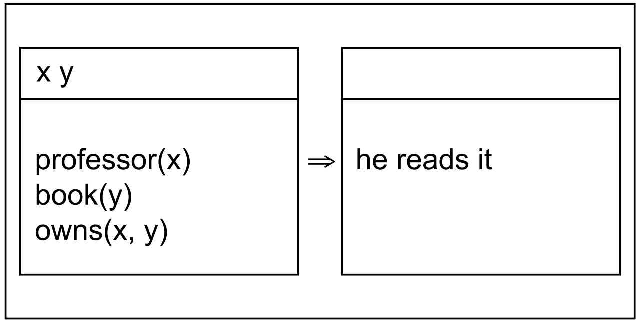
DRS for conditionals: An example

- *If a professor owns a book, he reads it.*



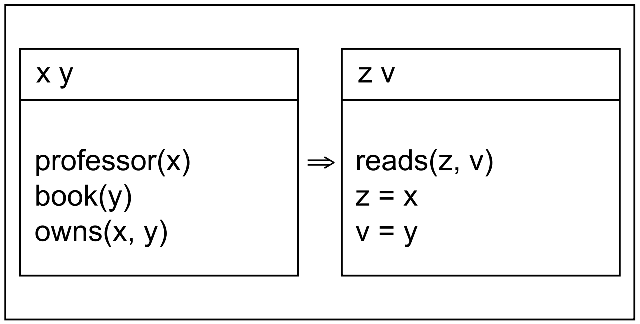
DRS for conditionals: An example

- *If a professor owns a book, he reads it.*



DRS for conditionals: An example

- *If a professor owns a book, he reads it.*



DRS (1st Extension)

- 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
- (Irreducible) conditions:
  - $R(u_1, \ldots, u_n)$ R n-place relation, $u_i \in U_K$
  - $u = v$ $u, v \in U_K$
  - $u = a$ $u \in U_K$, a is a proper name
  - $K_1 \Rightarrow K_2$ K_1 and K_2 DRSes
- Reducible conditions: as before

DRS Construction Rule for Conditionals

- Triggering configuration:
  - α is a reducible condition in DRS K of the form $[_S \text{ if } [_S \beta] \text{ (then) } [_S \gamma]]$
- Action:
  - Remove α from C_K.
  - Add $K_1 \Rightarrow K_2$ to C_K, where
    - $K_1 = \langle \varnothing, \{ \beta \} \rangle$ and
    - $K_2 = \langle \varnothing, \{ \gamma \} \rangle$
- Remark: $K_1 \Rightarrow K_2$ is called a duplex condition; K_1 the "antecedent DRS" and K_2 the "consequent DRS".

Recap: DRT Embeddings

- Let
  - U_D a set of discourse referents,
  - $K = \langle U_K, C_K \rangle$ a DRS with $U_K \subseteq U_D$,
  - $M = \langle U_M, V_M \rangle$ an FOL model structure appropriate for K.
- An *embedding* of K into M is a (partial) function f from U_D to U_M such that $U_K \subseteq \text{Dom}(f)$.

Verifying embeddings (1st extension, preliminary)

- An embedding f of K into M verifies K in M:

  $f \models_M K$ iff f verifies every condition $\alpha \in C_K$.

- f verifies condition α in M ($f \models_M \alpha$):

  (i) $f \models_M R(x_1, \dots, x_n)$ iff $\langle f(x_1), \dots, f(x_n) \rangle \in V_M(R)$

  (ii) $f \models_M x = a$ iff $f(x) = V_M(a)$

  (iii) $f \models_M x = y$ iff $f(x) = f(y)$

  (iv) $f \models_M K_1 \Rightarrow K_2$ iff
  for all $g \supseteq_{U_{K_1}} f$ s.t. $g \models_M K_1$, we have $g \models_M K_2$

- We write $g \supseteq_U f$ for "$g \supseteq f$ and $\text{Dom}(g) = \text{Dom}(f) \cup U$"

The definition seems to work ...

- *If a professor owns a book, he reads it.*

K1:

K2:

x y
professor(x) book(y) owns(x, y)

$\Rightarrow$

K3:

z v
reads(z, v) z = x v = y

$f \models_M K_1 \Rightarrow K_2$ iff
for all $g \supseteq_{U_{K_1}} f$ s.t. $g \models_M K_1$, we have $g \models_M K_2$

... but it doesn't really!

A slightly more complex example:

- *Mary knows a professor.*
  If he owns a book, he gives it to a student.

```
s u
-------------------------------------------
s = Mary      professor(u)
know(s, u)

  x y                    z v w
  ---------              ------------
  x = u           ⇒      gives(z,v,w)
  book (y)               z = x
  owns (x, y)            v = y
                         student(w)
```


Verifying embeddings for conditionals (final)

- An embedding f of K into M verifies K in M:

  $f \models_M K$ iff f verifies every condition $\alpha \in C_K$.

- f verifies condition α in M ($f \models_M \alpha$):

  (i) $f \models_M R(x_1,\ldots, x_n)$ iff $\langle f(x_1), \ldots , f(x_n)\rangle \in V_M(R)$

  (ii) $f \models_M x = a$ iff $f(x) = V_M(a)$

  (iii) $f \models_M x = y$ iff $f(x) = f(y)$

  (iv) $f \models_M K_1 \Rightarrow K_2$ iff for all $g \supseteq_{U_{K_1}} f$ s.t. $g \models_M K_1$ there is a $h \supseteq_{U_{K_2}} g$ s.t. $h \models_M K_2$

DRS construction rule for universal NPs

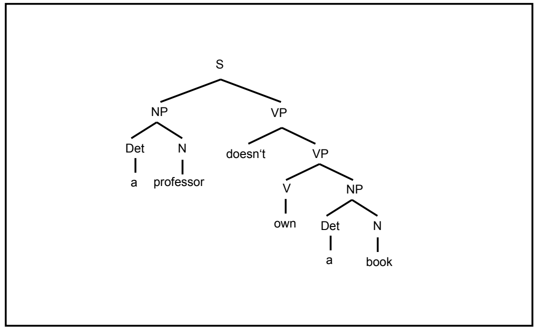
- Triggering configuration:
  - α is a reducible condition in DRS K; α contains a subtree $[_S [_{NP}\, \beta]\, [_{VP}\, \gamma]]$ or $[_{VP} [_V\, \gamma]\, [_{NP}\, \beta]]$
  - β = every δ
- Action:
  - Remove α from C_K.
  - Add $K_1 \Rightarrow K_2$ to C_K, where
    - $K_1 = \langle\{x\}, \{\delta(x)\}\rangle$ and
    - $K_2 = \langle\varnothing, \{\alpha'\}\rangle$
    - obtain α' from α by replacing β by x

DRS construction rule for negations

- Triggering configuration:
  - α is a reducible condition in DRS K of the form $[_S\, \beta\, [_{VP}$ doesn't $[_{VP}\, \gamma]]]$
- Action:
  - Remove α from C_K .
  - Add $\neg K_1$ to C_K, where $K_1 = \langle\varnothing, \{[_S\, \beta\, [_{VP}\, \gamma]]\}\rangle$,

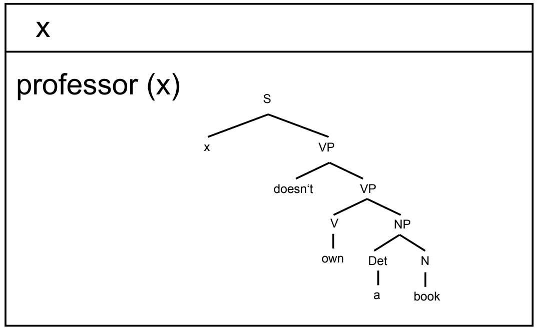
Example

- *A professor doesn't own a book.*



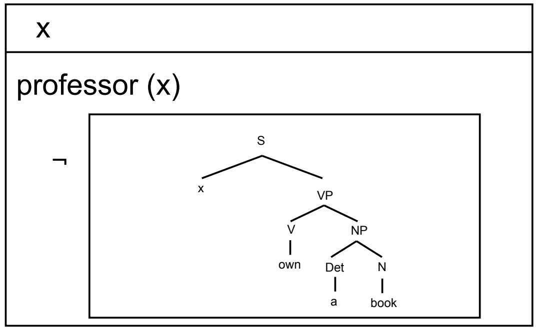
Example

- *A professor doesn't own a book.*



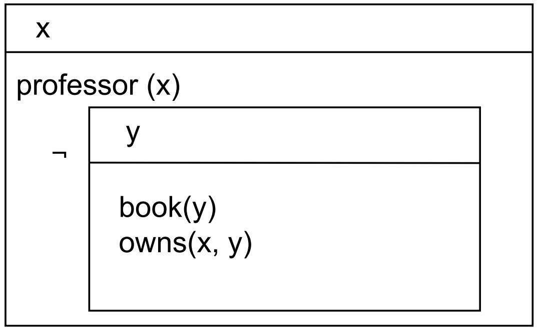
Example

- *A professor doesn't own a book.*



Example

- *A professor doesn't own a book.*

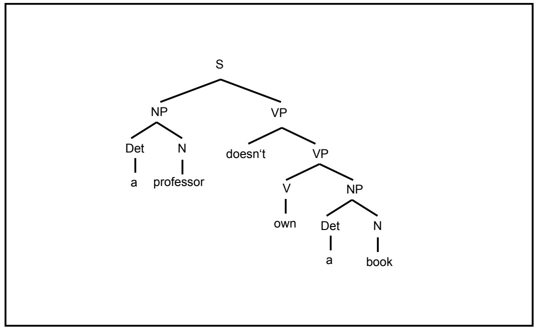


Reminder: The HTC Constraint

- 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.

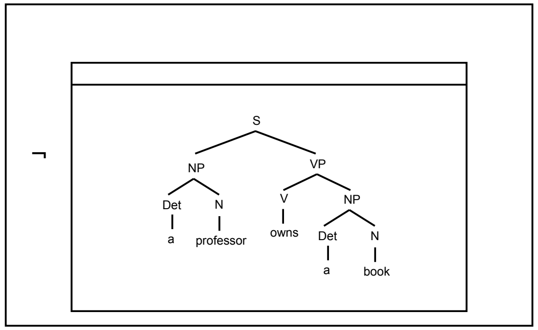
Example: A second reading

- *A professor doesn't own a book.*



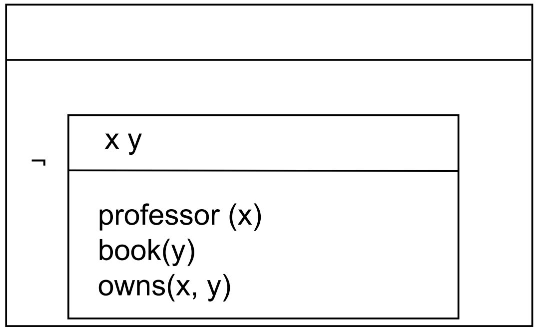
Example: A second reading

- *A professor doesn't own a book.*



Example: A second reading

- *A professor doesn't own a book.*

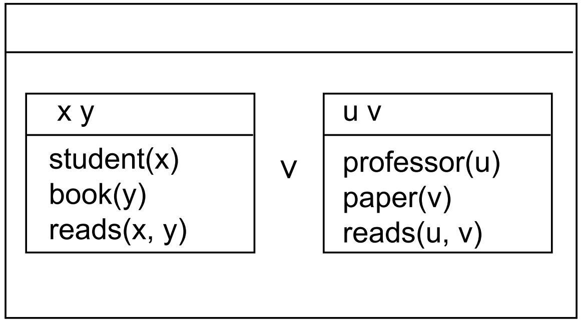


DRS construction rule for clausal disjunction

- Triggering configuration:
  - α is a reducible condition in DRS K of the form $[_S [_S \beta] \text{ or } [_S \gamma]]$
- Action:
  - Remove α from C_K .
  - Add $K_1 \vee K_2$ to C_K, where
    - $K_1 = \langle\emptyset, \{\beta\}\rangle$ and
    - $K_2 = \langle\emptyset, \{\gamma\}\rangle$

An example

- *A student reads a book, or a professor reads a paper.*



DRS (2nd Extension)

- 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
- (Irreducible) conditions:
  - $R(u_1, \ldots, u_n)$ R n-place relation, $u_i \in U_K$
  - $u = v$ $u, v \in U_K$
  - $u = a$ $u \in U_K$, a is a proper name
  - $K_1 \Rightarrow K_2$ K_1 and K_2 DRSs
  - $K_1 \vee K_2$ K_1 und K_2 DRSs
  - $\neg K_1$ K_1 DRS

Verifying embeddings

- f verifies condition α in M ($f \models_M \alpha$):

(i) $f \models_M R(x_1,\ldots, x_n)$ iff $\langle f(x_1), \ldots, f(x_n)\rangle \in V_M(R)$

(ii) $f \models_M x = a$ iff $f(x) = V_M(a)$

(iii) $f \models_M x = y$ iff $f(x) = f(y)$

(iv) $f \models_M K_1 \Rightarrow K_2$ iff for all $g \supseteq_{U_{K_1}} f$ s.t. $g \models_M K_1$ there is a $h \supseteq_{U_{K_2}} g$ s.t. $h \models_M K_2$

(v) $f \models_M \neg K_1$ iff there is no $g \supseteq_{U_{K_1}} f$ s.t. $g \models_M K_1$

(vi) $f \models_M K_1 \vee K_2$ iff there is a $g_1 \supseteq_{U_{K_1}} f$ s.t. $g_1 \models_M K_1$ or there is a $g_2 \supseteq_{U_{K_2}} f$ s.t. $g_2 \models_M K_2$

Translation from DRT to FOL

- DRSs

  $T(\langle\{u_1, \ldots, u_n\}, \{c_1, \ldots, c_n\}\rangle) = \exists u_1 \ldots \exists u_n[T(c_1) \wedge \ldots \wedge T(c_n)]$
- Conditions:

  $T(c) = c$ for atomic conditions c

  $T(\neg K_1) = \neg T(K_1)$

  $T(K_1 \vee K_2) = T(K_1) \vee T(K_2)$

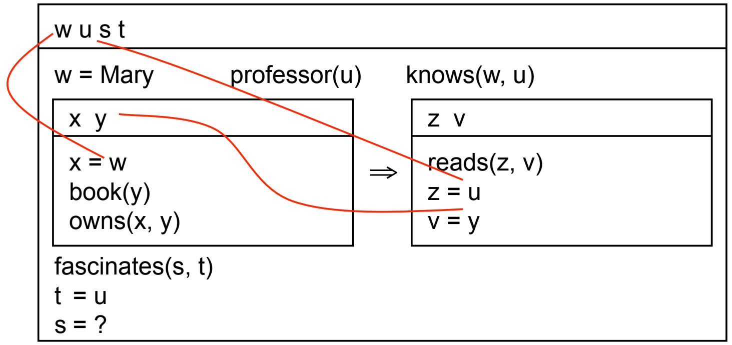
  $T(K_1 \Rightarrow K_2) = \forall u_1 \ldots \forall u_n[(T(c_1) \wedge \ldots \wedge T(c_n)) \rightarrow T(K_2)]$,

  for $K_1 = \langle\{u_1, \ldots, u_n\}, \{c_1, \ldots, c_n\}\rangle$

- For every closed DRS K and every appropriate model M, K is true in M iff T(K) is true in M.

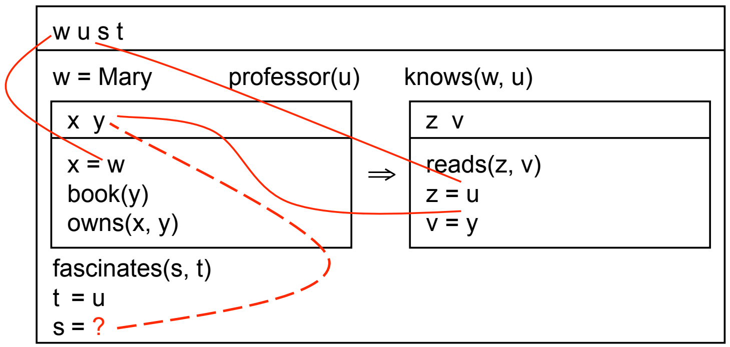
Anaphora and accessibility

- *Mary knows a professor. If she owns a book, he reads it. It fascinates him.*



Anaphora and accessibility

- *Mary knows a professor. If she owns a book, he reads it. ?It fascinates him.*



Accessible discourse referents

- The following discourse referents are accessible for a condition:
  - DRs in the same local DRS
  - DRs in a superordinate DRS
  - DRs on the top level of an antecedent DRS, if the condition occurs in the consequent DRS.

Accessible discourse referents

- Cases of non-accessibility:
  - *If a professor owns a book, he reads it. It has 300 pages.*
  - *It is not the case that a professor owns a book. He reads it.*
  - *Every professor owns a book. He reads it.*
  - *If every professor owns a book, he reads it.*
  - *Peter owns a book, or Mary reads it.*
  - *Peter reads a book, or Mary reads a newpaper article. It is interesting.*

Subordination

- A DRS K_1 is an immediate sub-DRS of a DRS $K = \langle U_K, C_K \rangle$ iff C_K contains a condition of the form $\neg K_1$, $K_1 \Rightarrow K_2$, $K_2 \Rightarrow K_1$, $K_1 \vee K_2$ or $K_2 \vee K_1$.
- K_1 is a sub-DRS of K (notation: $K_1 \leq K$) iff
  (i) K_1 = K or
  (ii) K_1 is an immediate sub-DRS of K or
  (iii) there is a DRS K_2 s.t. $K_2 \leq K_1$ and K_1 is an immediate sub-DRS of K.
  (i.e. reflexive, transitive closure)
- K_1 is a proper sub-DRS of K iff $K_1 \leq K$ and $K_1 \neq K$.

Accessibility

- Let K, K_1, K_2 be DRSes s.t. $K_1, K_2 \leq K$, $x \in U_{K_1}$, $\gamma \in C_{K_2}$
- x is accessible from γ in K iff
  (i) $K_2 \leq K_1$ or
  (ii) there are $K_3, K_4 \leq K$ s.t. $K_1 \Rightarrow K_3 \in C_{K_4}$ and $K_2 \leq K_3$

Revised DRS Construction rule for Pronouns

- Triggering Configuration:
  - Let K* be the main DRS that containing K
  - α a reducible condition in DRS K, containing $[_S [_{NP}\ \beta]\ [_{VP}\ \gamma]]$ or $[_{VP} [_V\ \gamma]\ [_{NP}\ \beta]]$ as substructure
  - β a personal pronoun.
- Action:
  - Add a new DR x to U_K.
  - Replace β in α by x.
  - Select an appropriate DR y that is accessible from α in K*, and add x = y to C_K.

DRS Construction Rule for Proper Names

- Triggering Configuration:
  - Let K* be the main DRS that containing K
  - α a reducible condition in DRS K, containing $[_S [_{NP}\ \beta]\ [_{VP}\ \gamma]]$ or $[_{VP}\ [_V\ \gamma]\ [_{NP}\ \beta]]$ as substructure.
  - β a proper name

- Action:
  - Add a new DR x to U_{K*}.
  - Replace β in α by x.
  - Add x = β to C_{K*}.