Semantic Theory: Discourse Semantics II

Summer 2009

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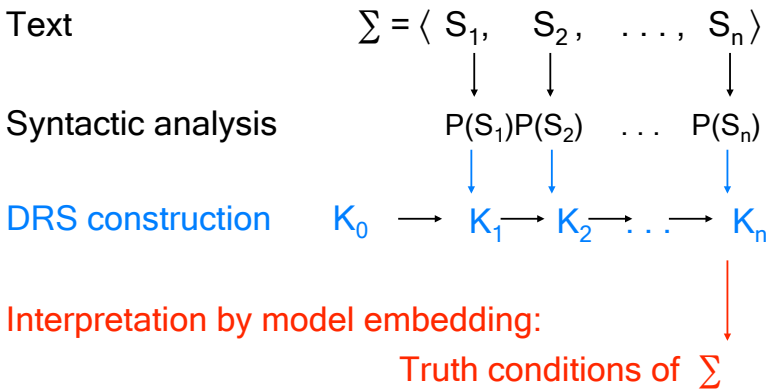
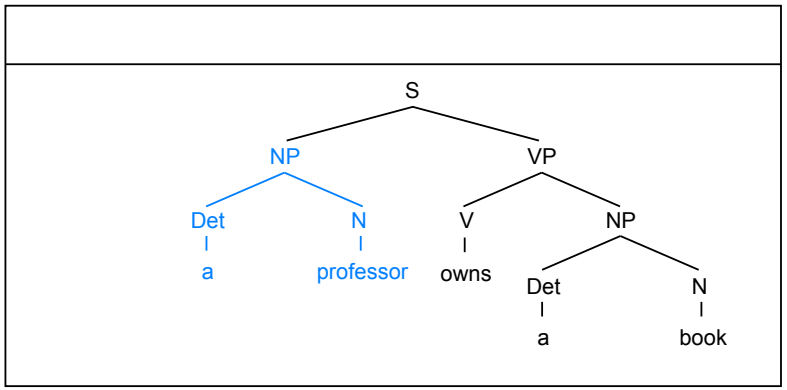
Discourse Representation Theory (DRT)



An example

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



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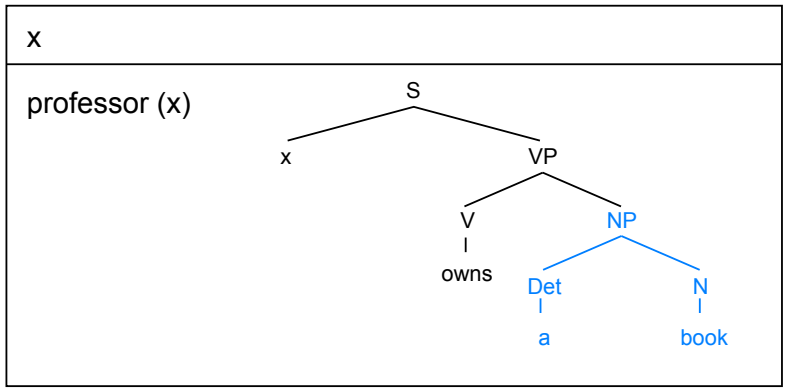

An example

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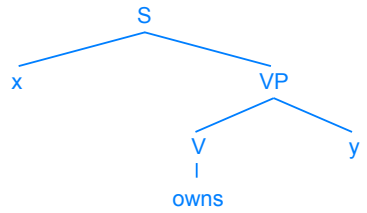
x y
professor(x) book(y) 

An example

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

x y
professor(x) book(y) own(x, y)

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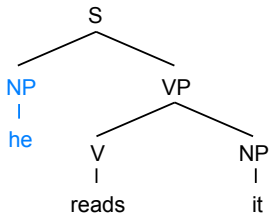
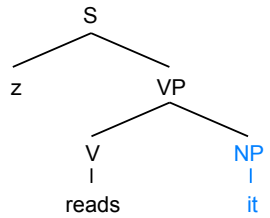
professor(x) book(y) own(x, y) 

An example

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

x y z
professor(x) book(y) own(x, y) z = x 

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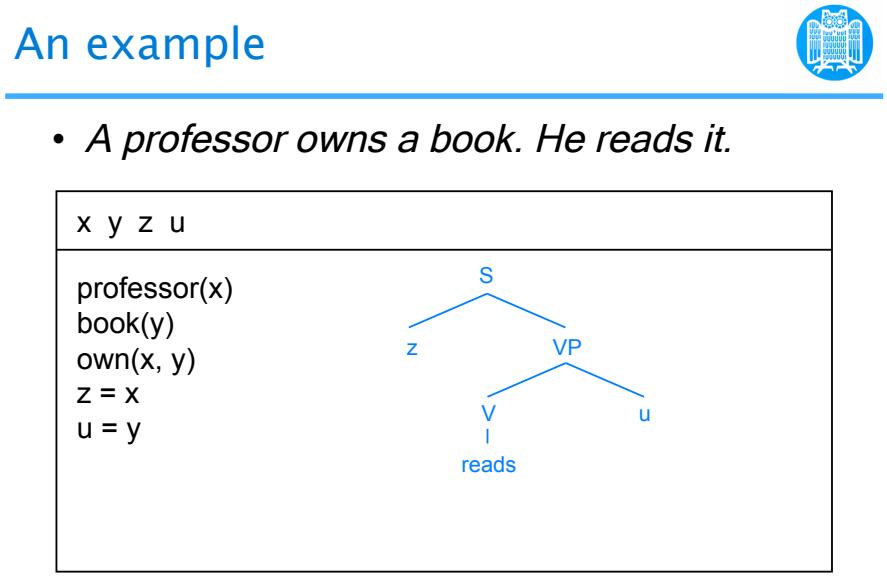


- *A professor owns a book. He reads it.*

x y z u
professor(x) book(y) own(x, y) z = x u = y S z VP V u I reads

An example

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

x y z u
professor(x) book(y) own(x, y) z = x u = y read(z, u)

DRT: Denotational Interpretation

- Let
  - U_D a set of discourse referents,
  - $K = \langle U_K, C_K \rangle$ a DRS with $U_K \subseteq U_D$,
  - $M = \langle U_M, V_M \rangle$ a 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 $U_K \subseteq$ Dom(f).

Verifying embedding

- An embedding f of K in 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 $f(x) = f(y)$

Truth

- Let K be a closed DRS and M be an appropriate model structure for K.
- K is true in M iff there is a verifying embedding f of K in M such that Dom(f) = U_K

Basic features of DRT

- DRT models linguistic meaning as anaphoric potential (through DRS construction) plus truth conditions (through model embedding).
- In particular, DRT explains the ambivalent character of indefinite NPs: Expressions that introduce new reference objects into context, and are truth conditionally equivalent to existential quantifiers.

Translation of DRSes to FOL

- DRS K = $\langle\{x_1, ..., x_n\}, \{c_1, ..., c_k\}\rangle$

$x_1 \ldots x_n$
$c_1 \ldots c_n$

is truth-conditionally equivalent to the following FOL formula:

$\exists x_1 ... \exists x_n [c_1 \wedge ... \wedge c_k]$

Indefinite NPs, Conditionals, and Anaphora

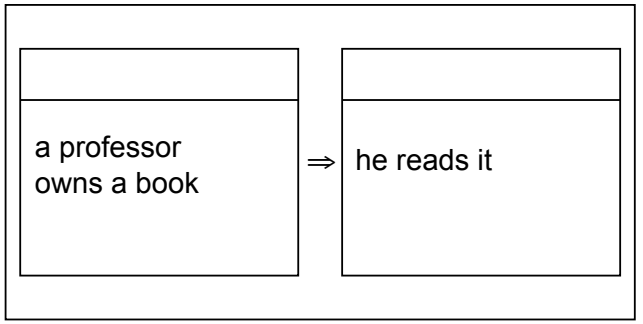
- *If a student works, he will be successful.*
  (1) $\exists x[student(x) \wedge work(x)] \rightarrow successful(x)$
  (2) $\exists x[student(x) \wedge work(x) \rightarrow successful(x)]$
  (3) $\forall x [student(x) \wedge work(x) \rightarrow successful(x)]$
  (1) is not closed
  (2) has wrong truth conditions (much too weak)
  (3) is correct, but how do you derive this compositionally?
- This is called the donkey sentence problem, with reference to 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.*



To be continued.

DRS for conditionals: An example

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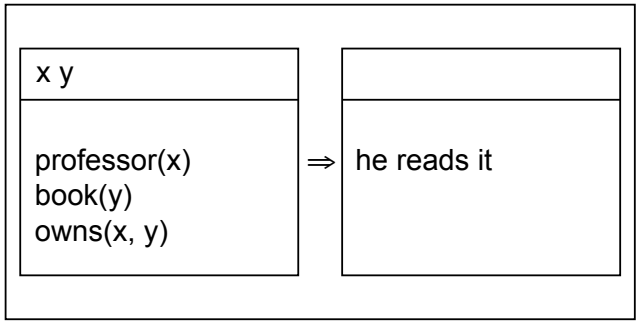

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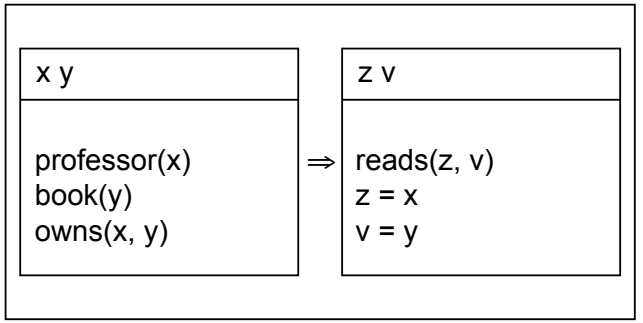

DRS (1st Extension)

- 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 $[_S$ if $[_S \beta]$ (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 $U_K \subseteq$ 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) $f \models_M R(x_1,\ldots, x_n)$ 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. $g \models_M K_1$, we have $g \models_M K_2$
- We write $g \supseteq_U f$ for "$g \supseteq f$ and Dom(g) = Dom(f)∪U"

The definition seems to work ...

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

K1:

K2:		K3:
x y		z v
professor(x) book(y) owns(x, y)	⇒	reads(z, v) z = x v = y

... 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 book (y) owns (x, y)		gives(z,v,w) z = x 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 $\langle f(x_1), \ldots, f(x_n)\rangle \in V_M(R)$

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  (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

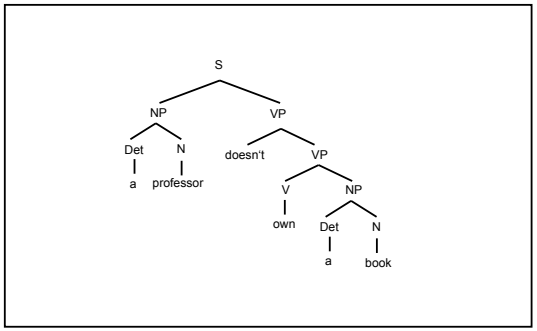
- Triggering configuration:
  - α is a reducible condition in DRS K; α contains a subtree $[_S [_{NP} \beta] [_{VP} \gamma]]$ or $[_{VP} [_V \gamma] [_{NP} \beta]]$
  - β = every δ
- Action:
  - Remove α from C_K.
  - Add $K_1 \Rightarrow K_2$ to C_K, where
    - $K_1 = \langle\{x\}, \{\delta(x)\}\rangle$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



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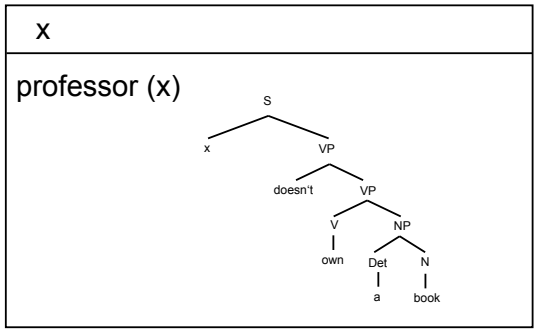

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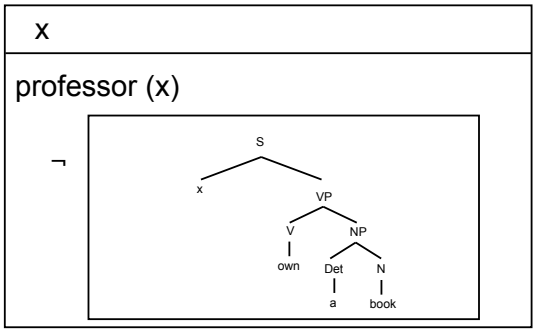

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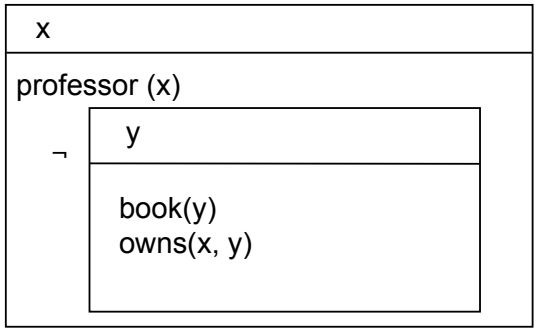

Reminder: The HTC Constraint

- 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

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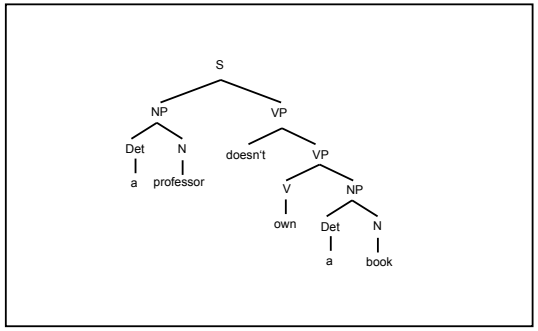

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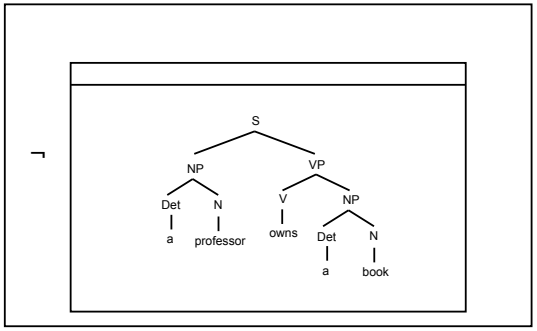

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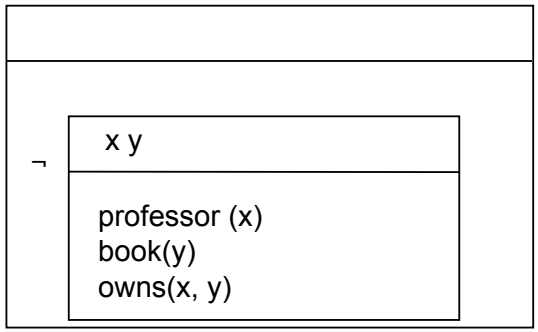
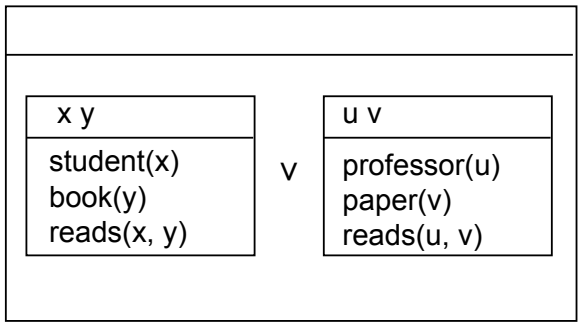


DRS construction rule for clausal disjunction

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

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
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- (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

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

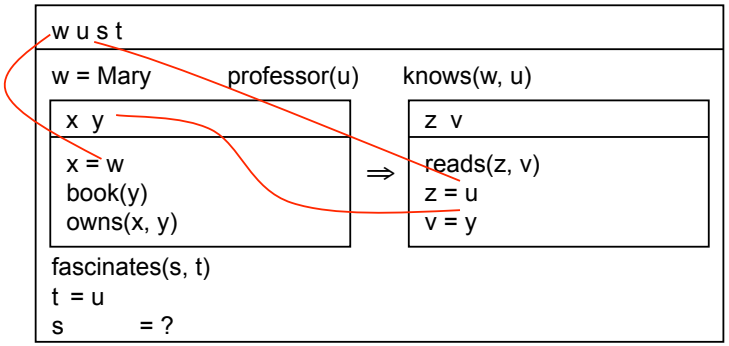
  $T(K_1 \vee K_2) = T(K_1) \vee T(K_2)$

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

  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.

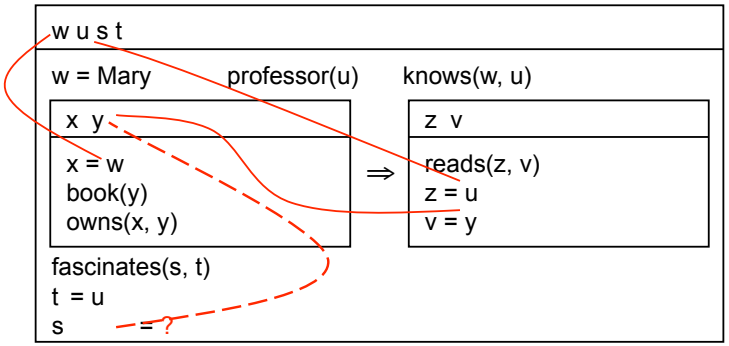
Anaphora and accessibility

- *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^*}.

Is accessibility a truth-conditional property?

- *There is a book that John doesn't own.*
  He wants to buy it.
- *John does not own every book.*
  ?He wants to buy it.
- *One of the ten balls is not in the bag.*
  It must be under the sofa.
- *? Nine of the ten balls are in the bag.*
  It must be under the sofa.

DRT is non-compositional

- DRT is non-compositional on truth conditions: The different discourse-semantic status of the text pairs is not predictable through the (identical) truth conditions of its component sentences.
- Since structural information which cannot be reduced to truth conditions is required to compute the semantic value of texts, DRt is called a representational theory of meaning.

DRT: What about full definite NPs?

- So far, DRT models:
  - Indefinite NPs (*a professor*)
  - Pronouns as a sub-case of definite NPs (*he, she, it*)
  - Proper names (*John, Mary*)
- What about full definite NPs, or „definite descriptions“:
  - *the professor, the book*

Reminder: Definite article in type-theoretic semantics

- Standard type-theoretic representation of definite article:

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

  the sun ⇒ $\lambda G \exists y(\forall x(sun'(x) \leftrightarrow x=y) \wedge G(y))$

  the sun is shining ⇒

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

  the student is working ⇒

  $\exists y(\forall x(student'(x) \leftrightarrow x=y) \wedge work'(y))$???
- Truth conditions – existence of one and only one student - are inadequate.

DRS Construction rule for definite NPs (First attempt)

- Triggering Configuration:
  - Let K* be the main DRS that containing K
  - 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 the definite article
- 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 satisfies δ, and add x = y to C_K.

Similar projection phenomena

- The descriptive content of definite NPs survives negation, as well as other kinds of embeddings
  - *It is not true that the sun is shining.*

    >> There is a sun, and it is not shining.
  - *The sun is shining, or it is dark outside.*
  - ***It is possible** that the student **will** work tomorrow.*
  - *Mary **believes** that John will pass the exam.*

The concept of Presupposition

- The semantic observations about definite noun phrases fit well to the general discourse-semantic view of context-meaning interaction.
- A sentence (containing a definite description) contains meaning information of two different types:
  - One specifies the requirements that the context must satisfy so the utterance can be interpreted at all.
  - The other one expresses the explicitly given additional infomation, in a certain context.
- We call the former the presupposition, the latter the assertion.

Presupposition

- Presupposition is a very general phenomenon in natural language: The projection behaviour under negation(and similar operators) is taken as a standard presupposition test - Presupposition Triggers
- The projection behaviour is more complex than the first guss definite NP rule suggests: Cancellation (and Filtering)
- The contribution of presupposition to the meaning of a discourse is not restricted to establishing the anaphoric link: Accommodation

Some Presupposition Triggers

- Definite noun phrases

  -***The sun*** *is shining*

  ->> There is sun (and it is shining)
- Factive verbs

  -*John* ***regrets*** *that he has married.*

  ->> John has married (and he regrets that)
- Implicative verbs

  -*John* ***forgot*** *to close the door.*

  ->> John intended to close the door (but he forgot to do it)

Presupposition Triggers

- Aspect

  -*John has* ***stopped*** *smoking.*

  ->> John used to smoke (and he has stopped doing it)

  -*John opened the window* ***again****.*

  ->> John had already opened the window before (repetetive)

  ->> The window was open before (restitutive)
- Appositions / non-restrictive relative clauses.

  - *John, a good friend of mine, studies CL.*

  - *John, who is a good friend of mine, studies CL.*

  ->> John is a good friend of mine (and he studies CL).

Presupposition Triggers

- It-Clefts
  -***It was John who*** *ate the cake.*
  ->> Somebody ate the cake (and it was John who did this)
- Focus particles
  -***Only*** *John came to the party*
  ->> John came to the party (and nobody else did).

Presupposition Projection Again

- Presuppositions behave in a uniform way, in that they survive negation and various kinds of embeddings
  - *Either it will stop raining,* ***or*** *the match must be cancelled*
  - >> it is raining.
  - *John* ***possibly*** *regrets that he has married.*
  - >> John has married.
  - *Mary* ***believes*** *that John has stopped smoking.*
  - >> John used to smoke.

Presupposition Cancellation

- In the context of negation, presuppositions can be overwritten or “cancelled” by explicitly claiming that they are false:
- *The king of France isn’t bald. France is a republic.*
- *John possibly regrets that he has married. But possibly, he hasn’t married at all.*

Presupposition Filtering

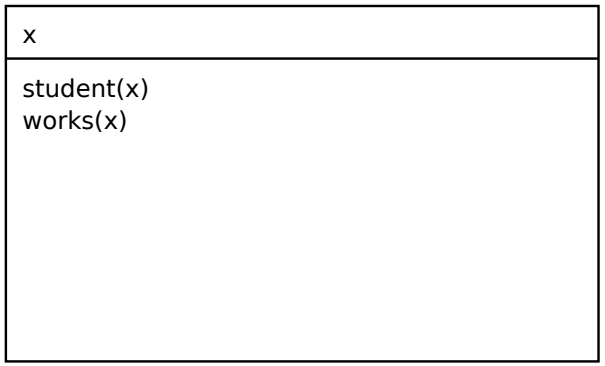
- There are contexts that can “neutralise” or filter some presuppositions: they block projection of these presuppositions.
- *If John is out of town, then* ***his wife*** *is unhappy.*
  - presupposes: John is married / has a wife
- *If John is married, then* ***his wife*** *is unhappy.*
  - does not presuppose: John is married

Accommodation

- *The sun is shining.*
- *Sorry to be late. I couldn‘t start the car.*
- *The king of Samoa will visit Germany in July*.
- Missing discourse referents + NP content can be „accommodated“, if it is not present in the context. Thus, presuppositions are not strict conditions on context, but also a device toconvey additional information.

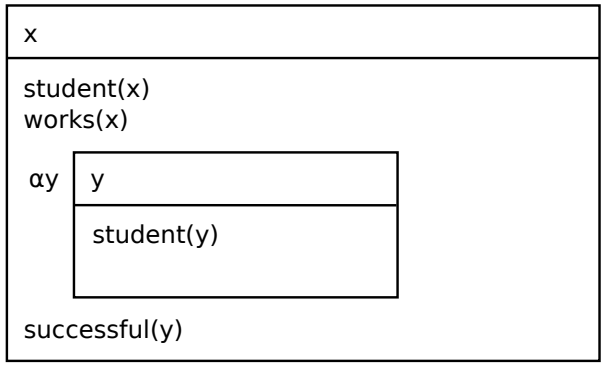
Example: Binding [1]

- *A student works.*



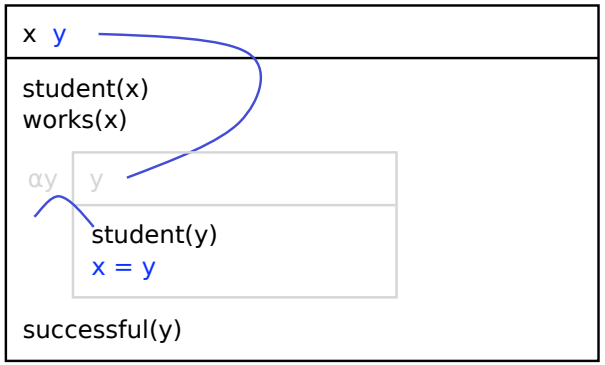
Example1: Construction of Proto-DRS

- *A student works. The student is successful.*



Example1: Binding

- *A student works. The student is successful.*



Example1: Binding

- *A student works. The student is successful.*

x y
student(x) works(x) student(y) x = y successful(y)

Example2: Construction of Proto-DRS

- The king of Samoa is visiting.

αx | x king-of-samoa(x) visit(x)

Example2: Accommodation

- The king of Samoa is visiting.

x
αx | x king-of-samoa(x) visit(x)

Example2: Accommodation

- The king of Samoa is visiting.

x
king-of-samoa(x) visit(x)

(Proto-)DRSes

- A (proto-) DRS is a triple $\langle U_K, C_K, A_K \rangle$ such that
  - U_K is a set of discourse referents
  - C_K is a set of (atomic or complex) conditions
  - A_K is a set of "anaphoric" (α-) DRSs of the form αzK', where z is a discourse referent and K' is a proto-DRS.

DRSConstruction for Definite NPs

- The DRS construction rules for all definite noun phrase types introduce α-DRSs:
  - Definite descriptions ("the woman")

    αy | y
    woman(y)
  - pronouns

    αx | x
  - proper names ("Mary")

    αx | x
    x = Mary

Complex Alpha-DRSs

"his book"

αy | y
book(y)
of(y, z)
αz | z

"the book of a professor"

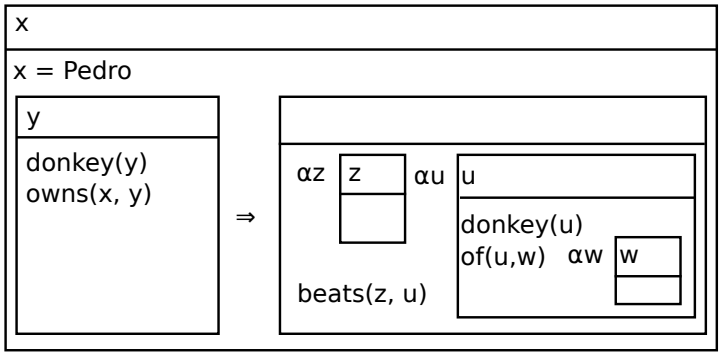
αy | y z
book(y)
of(y, z)
professor(z)

Resolution by Binding

- Let K, K', K_t DRSs, K' ≤ K, K_t ≤ K and
  - γ = αxK_S ∈ K', K_S is α-free
  - y ∈ U_{Kt} a DR that is accessible and suitable for γ
- Remove γ from K' and extend K_t with U_{Ks}, C_{Ks}, and the condition x = y.
- Note: The content of an α-DRS is released into the DRS of the discourse referent, which it is bound to.
- Note: Because K_s must be α-free, complex Alpha-DRSs are always resolved from the inside out.

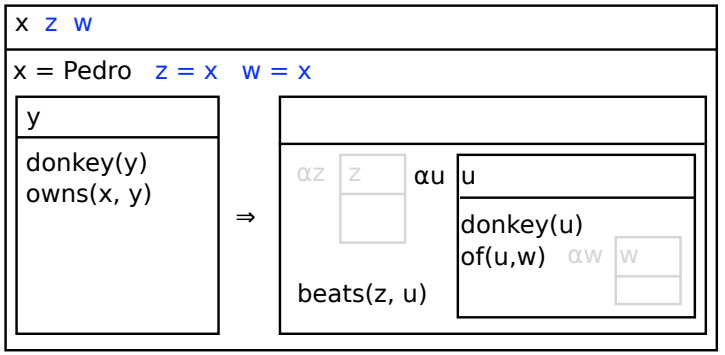
Example: Binding [1]

- If Pedro owns a donkey, he beats his donkey.



Example: Binding [2]

- If Pedro owns a donkey, he beats his donkey.



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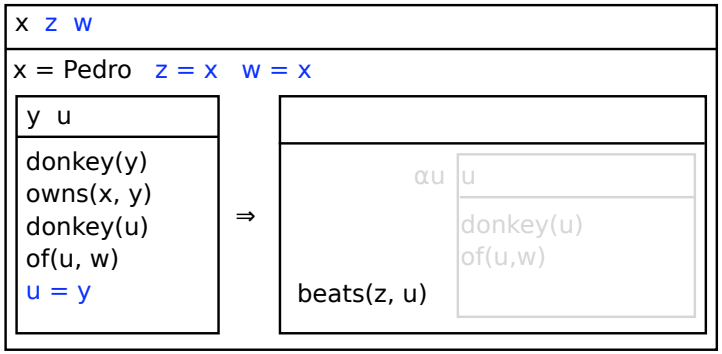

Example: Binding [2]

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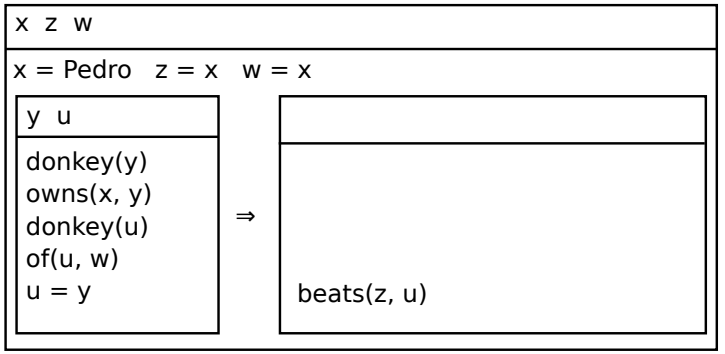

Resolution by Accommodation

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  - γ = αxK_s ∈ K', K_s is α-free
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- Remove γ from K' and extend K_t with U_{Ks} and C_{Ks}.

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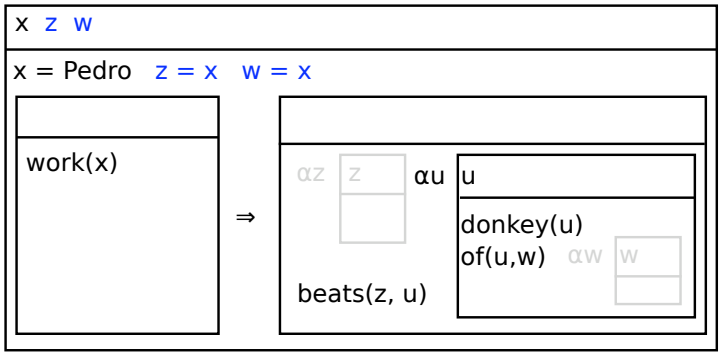

Example: Accommodation [1]

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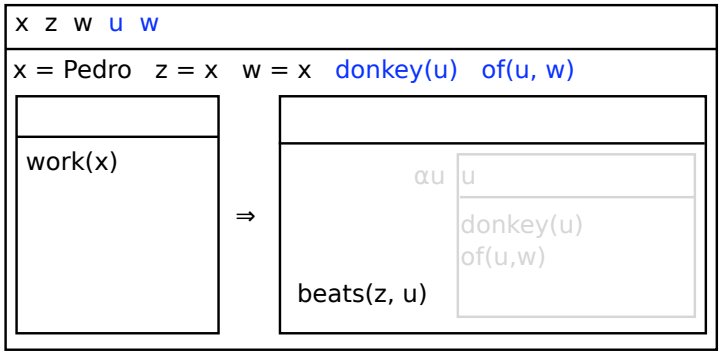

Presupposition Projection:Constraints and Preferences

- The two resolution rules specify possible sites where α-DRSs can be bound or accommodated.
- But so far, they are highly non-deterministic: We can bind or accommodate almost anywhere!
- We need constraints or preferences for binding and accommodation.

Preference Principles

- Binding is preferred over accommodation.
- Binding works “upwards” along the accessibility relation: The “closest” possible antecedent is preferred.
- Accommodation works “downwards” along the accessibility relation. It is preferred to accommodate into the highest possible DRS.