

Segmented Discourse Representation Theory

A theory of discourse interpretation

14/05

Course: "Computerlinguistik II"

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The structure of the session

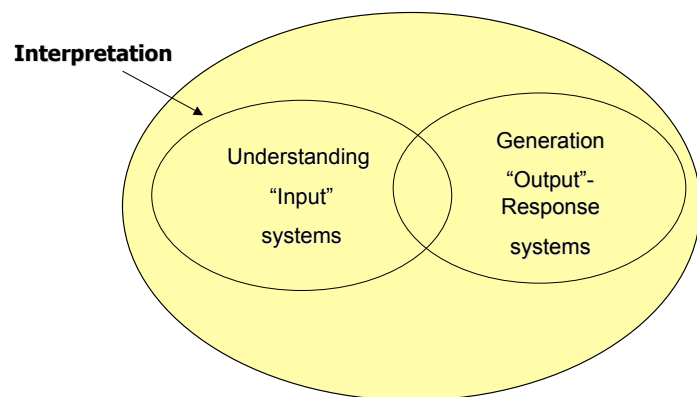
- The placement of computational discourse semantics and SDRT in NLP
- The need for dynamic semantics in the discourse (inter-)(re-)presentation (Discourse Representation Theory: advantages and drawbacks)
- Evidence for SDRT and rhetorical relations
- Possible NLP applications based on such a framework: what comes next?

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The theory in our mind and in NLP

Macrostructure of semantic "deep" NLP applications



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Discourse semantics

Static vs. Dynamic semantics

Prehistory – Static approaches

•Static semantics (sentential level): satisfaction of first-order logical (FOL) formulas in a model with respect to (x-variant) assignment functions

Every boy loves a girl. (2 readings nicely translated by FOL, the one straightforwardly by syntax, the other by Montague's QR or by Cooper's storage, etc..)

1. $\forall x(\text{boy}(x) \rightarrow \exists y(\text{girl}(y) \wedge \text{loves}(x,y)))$
2. $\exists y(\text{girl}(y) \wedge \forall x(\text{boy}(x) \rightarrow \text{loves}(x,y)))$

But how to deal with indefinites and anaphora in general?

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Interpretation of the indefinite „a“

No straightforward translation of „a“ in FOL

1. Scope over coordinates
 - *John introduced [every new student]_i to the chairperson, and Bill introduced him_i to the dean.
 - John introduced [a new student]_i to the chairperson, and Bill introduced him_i to the dean.
2. Donkey sentences-Geach(1962) (Conditionals-When clauses)
 - a. If John owns [a donkey]_i, he beats it_i.
 $(\forall x(\text{donkey}(x) \wedge \text{John}(y) \wedge \text{owns}(y,x)) \rightarrow \text{beats}(y,x))$
 $\forall x(\text{donkey}(x) \wedge (\text{John}(y) \wedge \text{owns}(y,x) \rightarrow \text{beats}(y,x)))$
 - a. When an [Italian is tall]_j, he_j is also blond.

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Intersentential anaphora resolution

Diverse intersentential anaphoric phenomena in NL

Anaphora resolution is processed considering discourse factors.

Until Kamp (1981), Heim (1982) compositional semantics were assigned until the end of the sentence.

“The meaning of a sentence is the set of models it satisfies.”

A man walked in. He was wearing a hat.

Solution...the interpretation is assigned contextually

Kamp (1981) introduced the Context Change Potential (CCP) -- dynamic way of thinking about meaning...

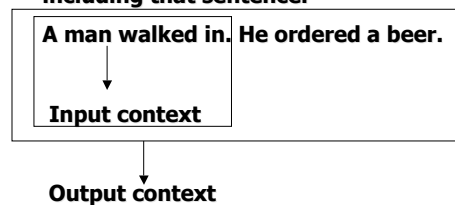
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DRT-CCP

Dynamic notion of meaning

Meaning a *relation* between a set of «input» contexts which represents the content of the discourse prior to the sentence being processed, and a set of «output» contexts which represents the content of the discourse including that sentence.



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DRT-basics

Discourse Representation Structures (DRSs)

DRT-like notation (box representation)

DRSs: formal objects realising the dynamic notion of meaning in the interpretation of discourse

DRSs consist of the universe (entities) and the conditions (relations between entities) supported by an «appropriate» model

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DRT: availability positions

Anaphora resolution according to availability constraints

DRS B1 is accessible from DRS B2 when:

- B1 equals B2
- B1 subordinates B2

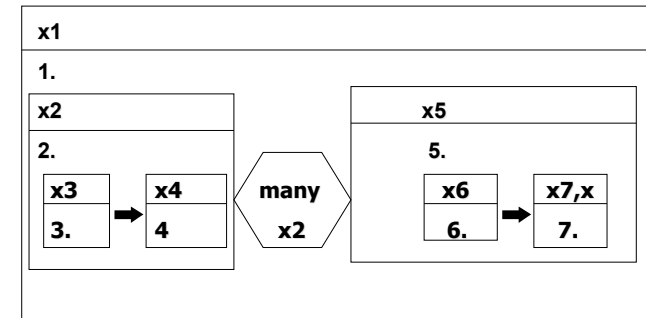
B1 subordinates B2 when:

- B1 immediately subordinates B2
- There is some DRS B such that B1 subordinates B and B subordinates B2

B1 contains a condition of the form $\neg B2$; or
 B1 contains a condition of the form $B2 \vee B$ or $B \vee B2$, for some DRS B; or
 or
 B1 contains a condition of the form $B2 \Rightarrow B$ (or some quantifier), for some DRS B; or
 $B1 \Rightarrow B2$ is a condition in some DRS B.

DRT: availability positions

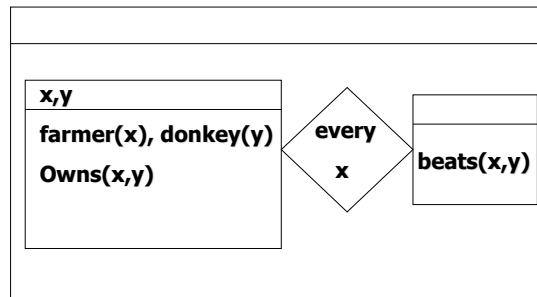
Accessibility constraints



DRT coping with indefinites

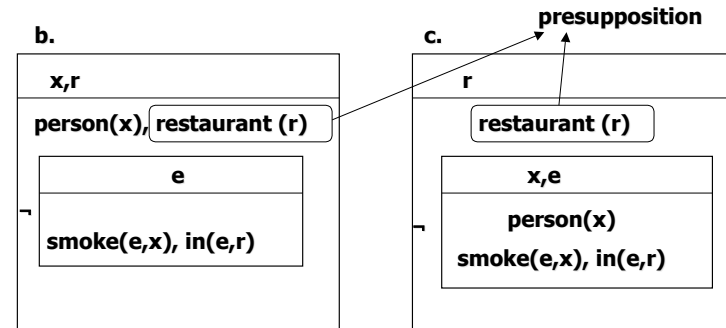
Indefinites as free variables being outscoped by other quantifiers

- a. Every farmer who owns a donkey beats it.



One more example of DRT's representation

- a. Someone didn't smoke in the restaurant.



DRT: what offers

Kamp and Reyle (1993)

- a way to handle intersentential anaphoric phenomena
- a way to handle quantification effectively
- tense and aspect in most of the cases are captured by the theory
- plurals

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Why DRT and dynamic semantics are not enough

Drawbacks: no connection to pragmatic factors

- Constraints on anaphora both overgenerate and undergenerate possible readings
1.
 - a. Max had a great evening last night.
 - b. He had a great meal.
 - c. He ate salmon.
 - d. He devoured cheese.
 - e. He then won a dancing competition.
 - f. ?It was a beautiful pink.

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Dynamic semantics: drawbacks

2.
 - a. One plaintiff was passed over for promotion three times.
 - b. Another didn't get a raise for five years.
 - c. A third plaintiff was given a lower wage compared to males who were doing the same work.
 - d. But the jury didn't believe this.

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Temporal phenomena

Kamp and Reyle (1993) - syntax determines the aktionsart of the sentence

- Max entered the room. The room became dark.
- Max entered the room. The room was dark.

For a: $e \subseteq t$ (the event is within the reference time)

$t' < t$ (for forward movement in narratives)

$t < n$ (past tense)

For b: $t' \subseteq s$ (the state may still be ongoing), $t' < n$

- c. Max fell. John helped him up.
- d. Max fell. John pushed him.

Not even pure default world-knowledge can help us...

Pushings-fallings events...

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Presupposition

Van der Sandt (1992) (constraints on accommodation are too weak)

Beaver (1996) (no precise definition of the “most plausible pragmatic interpretation”)

- a. **If David scuba dives, he will bring his regulator.**
- b. **If David scuba dives, he will bring his dog.**
- c. **I doubt that the knowledge that this seminal logic paper was written by a computer program running on a PC will confound the editors.**

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Lexical disambiguation

- a. The judge demanded to know where the defendant was.
- b. The barrister apologized and said that he was drinking across the street.
- c. The court bailiff found him asleep beneath the bar.

Solutions provided only by data-intensive linguistics (Guthrie, 1991)

$\text{Pr}(\text{sense}(w)=s|C)$

What would they say in case of c' instead of c ?

- c' . But the bailiff found him slumped underneath the bar.

Clearly, we need hybrid approaches where semantic, pragmatic and statistical factors are involved...

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Why SDRT (Asher (1993), Asher and Lascarides (2003)) ?

- a. It provides rhetorical relations (Narration, Elaboration, Parallel, Contrast, Explanation, Background, etc.)
- b. It does not exclude pragmatics or AI techniques for the representation of knowledge...it only formalize them in a better way and face more effectively the problems
- c. It keeps things modular...every source of knowledge is kept separate and interactive
- d. It separates the logic of information content and the logic of information packaging
- e. And...assumes underspecification appropriate for composition relying on constraint-based frameworks...(HPSG, LFG)

But first let's see...what the rhetorical relations look like and what they can do...

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Rhetorical relations..what are they?

- a. **Anaphoric connectors of the discourse**
- b. **Carriers of illocutionary force sourcing from the discourse itself**
- c. **Connectors of labels or *speech act discourse referents* and not of propositions...tokens of propositions and not types (identity criteria, etc..)**
- d. **Validate the defeasibility floating around in language production..**
 - a. **Max fell. John pushed him.**
 - b. **John and Max were at the edge of the cliff. Max felt a sharp blow to the back of his neck. Max fell. John pushed him. Max rolled over the edge of the cliff.**

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Rhetorical relations-MDC

Use of Maximise Discourse Coherence (MDC), the strongest principle of SDRT with monotonic consequences, which:

- a. formalizes the notion of relevance introduced informally [by Sperber and Wilson's Relevance Theory (1986)] by defining "scalar" coherence...
- b. Overrides conflicting world knowledge.

According to MDC:

1. The more rhetorical connections between the segments of text..the more coherent is the text meaning
2. The more anaphoric expressions are resolved the higher the quality
3. Some relations are inherently scalar..(Narration, Contrast)..we are looking for the interpretation that maximises the quality of the relation under question

Rhetorical relations

How are semantically to be understood?

The definition of a veridical rhetorical relation

A relation R is veridical iff the following axiom is valid:

$$R(_ _) \rightarrow (K \wedge _)$$

\wedge is to be understood dynamically and not as logical conjunction

How is it satisfied?

$$(w, f) [[R(n1, n2)]]_M (w', g)$$

$$(w, f) [[Kn1 \wedge Kn2 \wedge _R(n1, n2)]]_M (w', g)$$

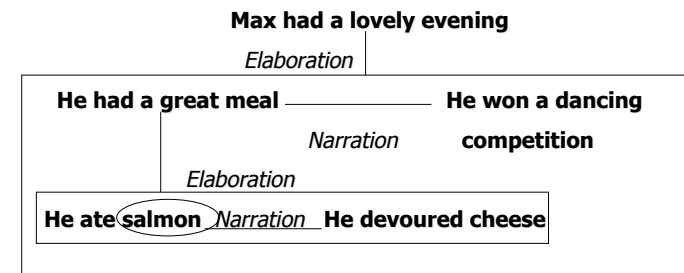
What does this mean?

- a. They change context...they are interpreted as speech acts..

Anaphora resolution

- a. Max had a great evening last night.
- b. He had a great meal.
- c. He ate salmon.
- d. He devoured cheese.
- e. He then won a dancing competition.
- f. ?It was a beautiful pink.

Anaphora resolution



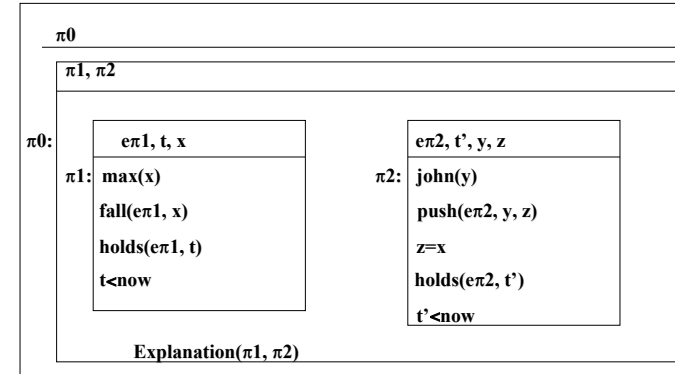
Anaphora resolution

Observations:

- **Right-frontier constraint on the discourse tree (Polanyi, 1985)**
- **Hierarchical structure in the representation of discourse subordinating, coordinating relations..**
- c. **Captures successfully the fact that there is incoherence going on in case (f) is added**
- d. **Different approach to discourse update process from that of DRT (which is simple amending DRs)...take a look at the copy...**

Temporal phenomena

a. Max fell. John pushed him.



Temporal phenomena

By the semantics of Explanation...we have..

- $_Explanation(_)_ \rightarrow (\neg e_<e_)$
- $_Explanation(_)_ \rightarrow (event(e_)_ \rightarrow e_<e_)$

Let's take a look at where we are...check the copy..

Cognitive plausibility matters

Pragmatics (Grice (1975), Searle (1969), Sperber and Wilson(1986,1995)) and AI techniques (Hobbs et al. (1993), Grosz and Sidner(1993)):

Direct interpretation of "intended" meaning both in pragmatics and AI...

Pragmatics

Meaning is what speakers intend to say under what they express

Full access to the cognitive state of the speaker

AI

Hobbs et al. (1993) unmodular architecture of the information flow between the participants in the conversation..

Cognitive plausibility matters

Obvious Drawbacks:

- No formal way of inferring implicatures
- Static full access to the logic of cognitive states, which apparently complicates the interpretation task and base the inference
- c. Computability issue
- d. Fail to provide explanation about the dramatic changes in the interpretation provided by small changes in the surface (no contact to linguistic evidence-dynamic semantics)

Rhetorical relations...continued

Elaboration

- Blair has caused chaos in Iraq. He sent his troops and killed the hopes of the people there.

Temporal consequence of Elaboration:

$_Elaboration(_)_ \rightarrow Part-of(e_e_)$

Properties:

1) Transitivity and 2) Distributivity

1) $Elaboration(n1, n2) \wedge Elaboration(n2, n3) \rightarrow Elaboration(n1, n3)$

2) $Elaboration(_)_ \wedge Coord(_)_ \wedge I-outscopes(_)_ \wedge Elaboration(_)_$

Check at the first classical example with the salmon...

Rhetorical relations...continued

Narration—Scalar coherence

Semantic constraints:

1. Spatiotemporal constraint

If $Narration(n1, n2)$, then the poststate of e_{n1} must overlap the prestate of e_{n2}

- a. The terrorist Blair planted a mine near the bridge. 20m south, he planted another.
- b. The terrorist Blair planted a mine near the bridge. Then he planted another.

$Narration(_)_ \rightarrow overlap(prestate(e_), Adv_(poststate(e_)))$

Rhetorical relations...continued

Narration—Scalar coherence

Semantic constraints:

2. Common Topic

Both the speech act discourse referents must indicate a common topic

- a. My car broke down. Then the sun set.
- b. My car broke down. Then the sun set and I knew I was in trouble.

$_Narration(_)_ \rightarrow \neg \clubsuit(K_][K_)$

Rhetorical relations...continued

Background

- Max entered the room. It was pitch dark. (Background)
- Max switched off the light. It was pitch dark. (Narration)

Temporal consequence of Background:

$_Background(_,_)\rightarrow overlap(e_e_)$

Topic constraint like Narration but in Background the $e_$ maintains available for anaphoric binding since it is considered the "main story line"

Rhetorical relations...continued

Background

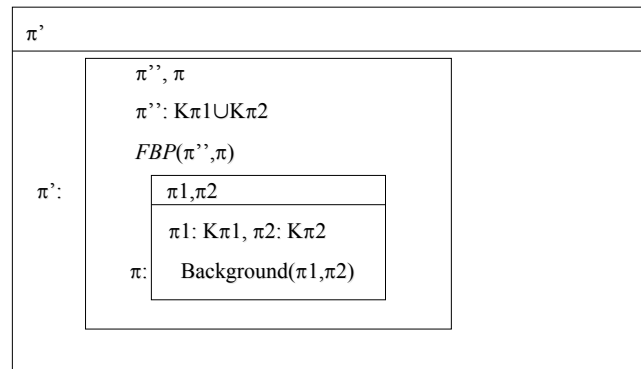
1. $n1$ (A burglar) broke into Mary's apartment.
 $n2$ Mary was asleep.
 $n3$ (He) stole the silver.
2. $n1$ A burglar broke into Mary's apartment.
 $n2$ A police woman visited her the next day.
 $n3$??He stole the silver.

repeating the common topic...set union of $n1, n2$

Introduce *Foreground-Background Pair* subordinate relation (FBP)

Rhetorical relations...continued

Background



Rhetorical relations...continued

Contrast-Evidence

Ducrot (1984)

- a. John speaks French. Bill speaks German. (formal contrast)
- b. John loves sport. (But) he hates football. (violation of expectation)

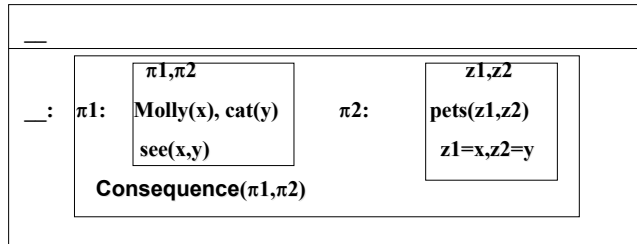
An example of the second case...

- a. If Molly sees a stray cat, she pets it.
- b. But if Dan sees it, he takes it home.

Rhetorical relations...continued

Contrast-Evidence

a.



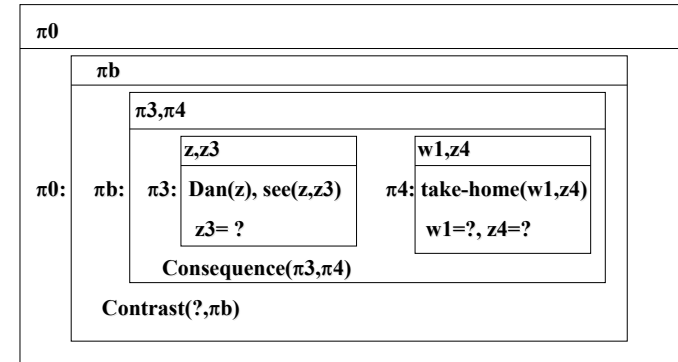
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Rhetorical relations...continued

Contrast-Evidence

b.

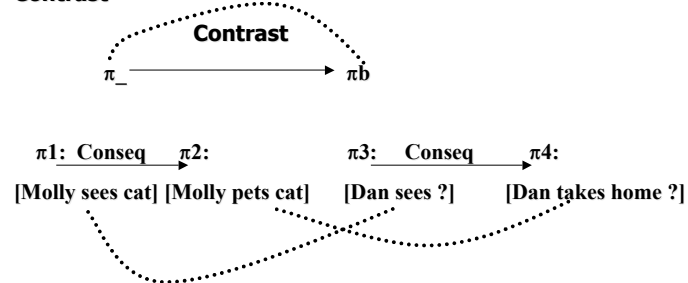


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Rhetorical relations...continued

Contrast



For the mapping between the ns see Asher (1993)

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Rhetorical relations...continued

Microstructure

Some words about the connectives between two fully specified formulas:

→, ∨, ∧...DRT's truth functional approach

In SDRT, they are represented by rhetorical relations...

Consequence, Alternation and no conjunction...conjunction is too poor...

What does it mean that the compositional semantics of two clauses are true and nothing more?

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Rhetorical relations...continued

Microstructure

A 3rd connector...

>: means defeasible consequence...or conditional of normality (normally if...then..)

Used heavily in the logic of information packaging, where defaults are placed and defeated when new information comes to play...

An example on applying the relational-dynamic semantics of SDRT on an intentional model...

$M = \langle A, W, *, I \rangle$

Tasha is a cat.

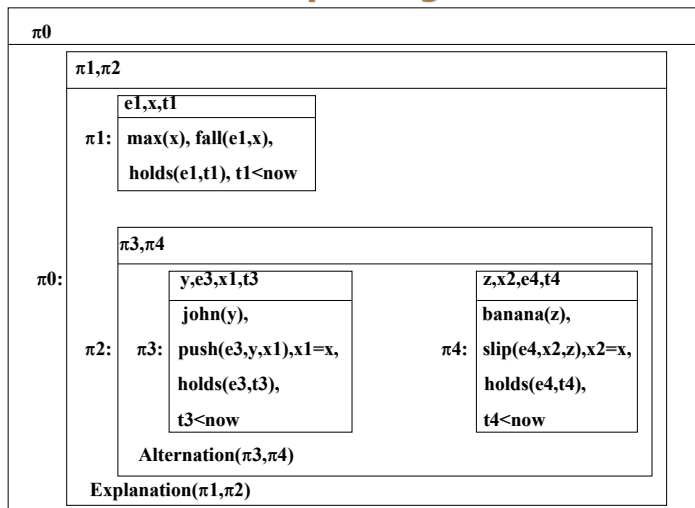
$*_w([[n]])$

The SDRS K_n for the sentence...under the special element $*_w$ gives us all the output contexts where the cat is a normal one..(has a tail, four legs, two eyes...)

Unpacking truth conditions:

- Max fell.
- Either John pushed him or
- He slipped on a banana peel.

Unpacking truth conditions:



Unpacking truth conditions:

Use of the satisfaction schema and recursively unpacking:

$(w, f)[[Explanation(n1, n2)]]_M(w, g)$ iff

$(w, f)[[Kn1 \wedge Kn2 \wedge Explanation_{(n1, n2)}]]_M(w, g)$

By the semantics of \wedge there are variable assignment functions h and i such that:

- $(w, f)[[Kn1]]_M(w, h)$
- $(w, h)[[Kn2]]_M(w, i)$; and
- $(w, i)[[Explanation_{(n1, n2)}]]_M(w, g)$

Let's take the first condition:

(a) Holds only if:

- $Dom(h) = dom(f) \cup \{e1, x, t1\}$ and (w, h) satisfies the SDRSs conditions..
- $\langle h(x) \rangle \in I_M(max)(w)$, $\langle h(e1), h(x) \rangle \in I_M(fall)(w)$, etc..

Unpacking truth conditions:

Condition (b) for Kn2 contains a complex SDRS containing an Alternation relation...

So either e3 happens or e4 in the Kn2:

$(w,h)[[Alternation(n3,n4)]]M(w,i)$ iff
 $(w,h)[[Kn3 \vee Kn4]]_M(w,i)$

Reminder: Kn1 is connected to Kn2 and not to Kn3 or to Kn4. Kn2 is dependent on the truth conditions of Kn3 and Kn4.

For the condition (c)...the meaning postulate of explanation must hold...

$_Explanation(_,_)\rightarrow(-e_<e_)$

Some words about Underspecification

What is underspecification?

A way to deal with ambiguity phenomena unable to be covered by the grammar...the most classic one:

scope ambiguities

What does underspecification really do?

Keeps "labels" or "holes" in the semantic representation and fills them with the adequate candidates..

In essence, it is a way of delaying things until the bits of information have been provided...

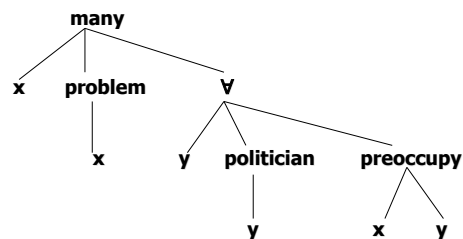
Approaches of underspecification: [Reyle(1993), Bos(1995), Bos et al. (1996), Asher and Fernando(1997), Egg et al.(2001) and Copestake et al.(1999)]

To the point with "labels"...

Some words about Underspecification

Many problems preoccupy every politician.

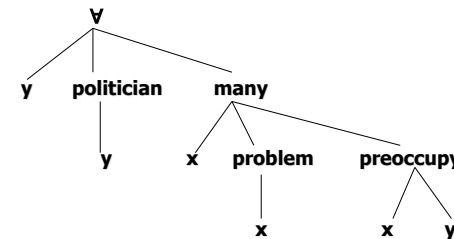
- $many(x,problem(x),\forall(y,politician(y),preoccupy(x,y)))$
- $\forall(y,politician(y),many(x,problem(x),preoccupy(x,y)))$



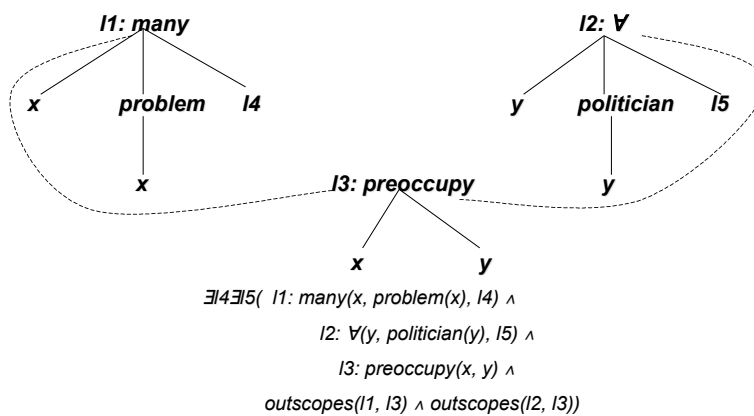
Some words about Underspecification

Many problems preoccupy every politician.

- $many(x,problem(x),\forall(y,politician(y),preoccupy(x,y)))$
- $\forall(y,politician(y),many(x,problem(x),preoccupy(x,y)))$



Some words about Underspecification



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What is next?

SDRT is a new theory..it does not include...

- Implicatures that follow from social status, gender and so on
- The contents of dialogues where discourse participants have different communicative agendas
- The repair strategies that occur when dialogue participants realise they have interpreted the dialogue differently

Do you want some more?

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