

# **From Formal Semantics to Segmented Discourse Representation Theory**

## **A theory of discourse interpretation**

**10/07**

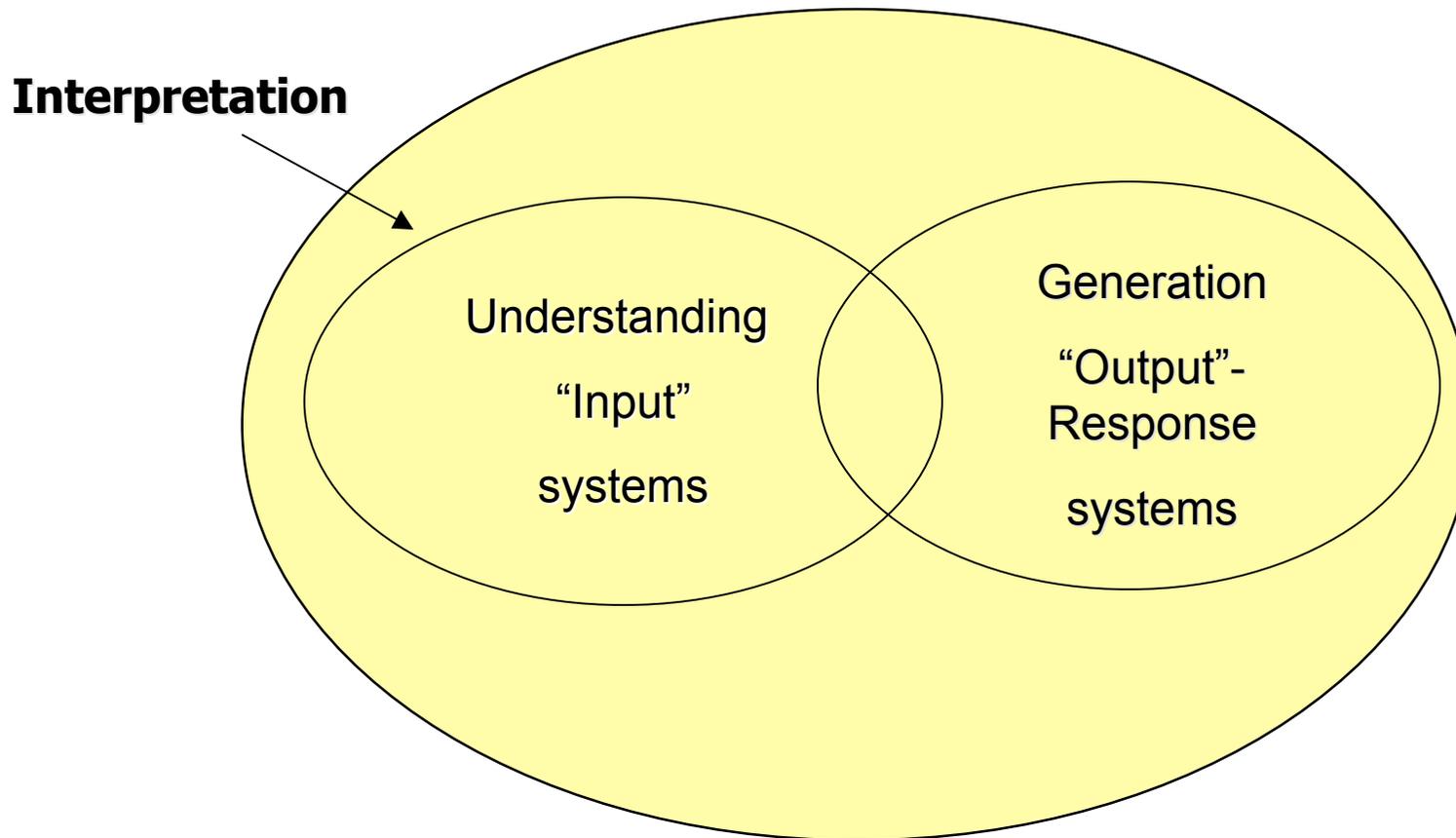
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# The structure of the session

- The placement of computational discourse semantics and SDRT in Natural Language Processing (NLP)
- The need for dynamic semantics in the discourse (inter-)(re-)presentation (Discourse Representation Theory: advantages and drawbacks)
- SDRT-rhetorical relations

# The theory in our mind and in NLP

Macrostructure of semantic “deep” NLP applications



# Computational Discourse Semantics in our mind and in NLP

## **1. Formal Paradigm**

**(Writing a grammar for language as code)**

## **2. Information-Structuring Paradigm**

**(Topic- Comment, Background-Focus)**

## **3. Functional Paradigm**

**(function of language in communication-  
relation between code and use)**

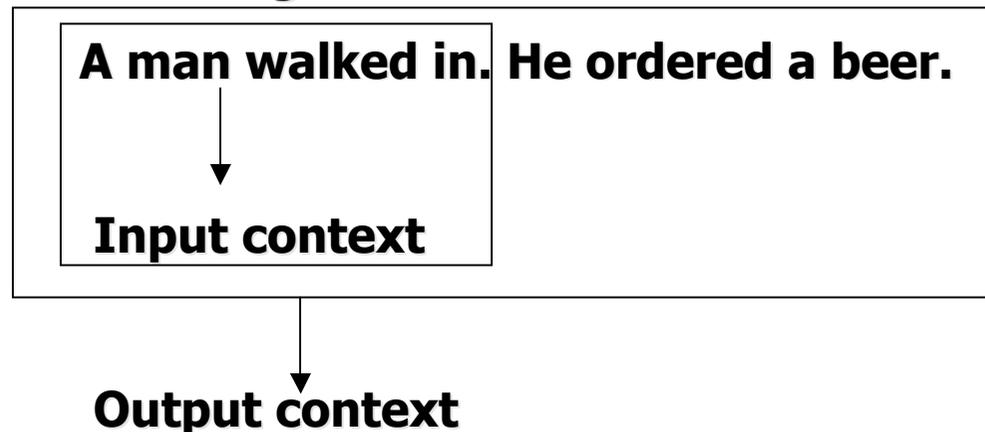
# Computational Discourse Semantics in our mind and in NLP

## Formal Paradigm

- Logic as tool for the representation of discourse
- Montague's papers in 1970's differentiated logical-compositional semantics (semantics on syntax) from LFs (Logical Forms) - interpretive semantics of Chomsky.
- Compositional Semantics developed by Partee's stuff

## 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.



**Dynamic notion of meaning**

**\*Every man<sub>i</sub> walked in. He<sub>i</sub> ordered a beer.**

# 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

# Why DRT and dynamic semantics are not enough

## Drawbacks: no connection to pragmatic factors

- a. John can open Bill's safe.
- b. He is going to have to get the combination changed soon.

# 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.

## 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.

# Temporal phenomena

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

- a. Max entered the room. The room became dark.
- b. 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.

# 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...

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

- a. It provides rhetorical relations (Narration, Elaboration, Parallel, Contrast, Explanation, Background, etc.) - this set would need further refinement
- b. It does not exclude pragmatics or AI techniques for the representation of knowledge...it only formalizes them in a better way and confronts the problems more effectively
- c. It keeps things modular...every source of knowledge is kept separate and interactive

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

- d. And...assumes underspecification appropriate for composition relying on constraint-based frameworks...(HPSG, LFG)
- e. It separates the logic of information content and the logic of information packaging (rhetorical relations bind labels or speech act discourse referents and not propositions)

# Why SDRT?

## Illustration of Last Point:

Goldbach's conjecture

A: There are some unsolvable problems in number theory.

B: Every even number greater than two is expressible as the sum of two primes is undecidable, for instance.

**Conclusion:** Can infer *Elaboration*, even if we don't completely understand the discourse.

Information packaging with ***restricted*** access to content.

A: There are some unsolvable problems in number theory.

B: John is really an idiot, for example.

# 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.

## Rhetorical relations-MDC

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

- a. formalises 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 there are between the segments of text...the more coherent the text meaning is
2. The more anaphoric expressions whose antecedents are resolved...the higher the quality of the coherence of the discourse is
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-semantic effect

How are they to be understood semantically?

The definition of a veridical rhetorical relation

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

$$R(\alpha, \beta) \rightarrow (K\alpha \wedge \beta)$$

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

How is it satisfied?

$$(w, f) [[R(\pi_1, \pi_2)]]_M (w', g) \text{ iff}$$

$$(w, f) [[K\pi_1 \wedge K\pi_2 \wedge \phi_{R(\pi_1, \pi_2)}]]_M (w', g)$$

What does this mean?

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

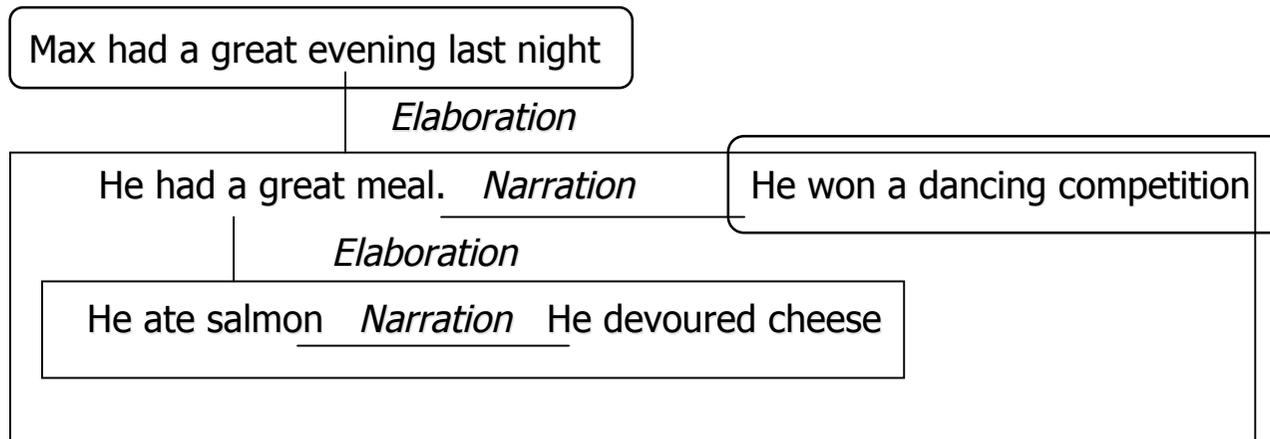
# Semantic underspecification

Underspecified representations are assumed at two levels:

- Sentential level (eliminable labels -after the resolution of the underspecification- within a labelling framework like ULF)
- Intersentential level (where each utterance is connected to other utterances rhetorically...labels are not eliminable, since they act as propositional tokens which represent a certain propositional content or type always).
- Points of underspecification:
  - What kind of rhetorical connection is to be inferred between the current utterance and the past ones or even the future ones?
  - Which are the admissible points or sites for attachment during the discourse update? (Right Frontier Constraint)

# Right Frontier Constraint...what is it?

- a. Max had a great evening last night.
- b. He had a great meal.
- c. He ate salmon.
- d. He devoured lots of cheese.
- e. He then won a dancing competition.



- f. ??It was beautiful pink

# Anaphora resolution

## Observations:

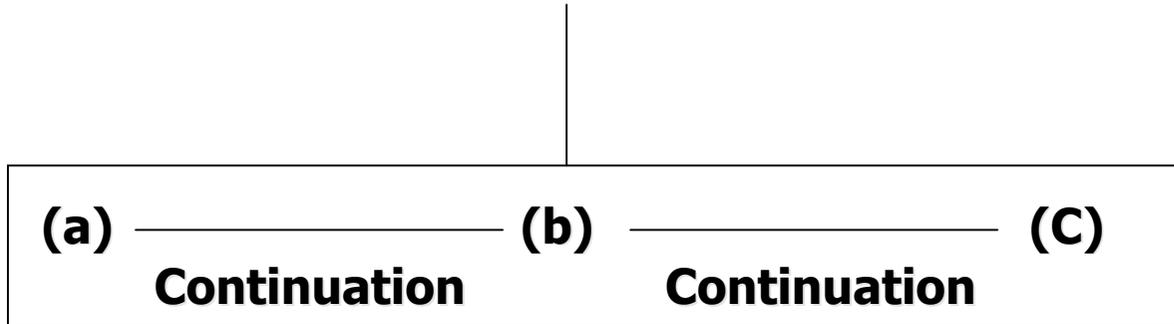
- Right-frontier constraint on the discourse tree (Polanyi, 1985)
- Hierarchical structure in the representation of discourse subordinating, coordinating relations..
- c. Captures successfully the fact that there is incoherence going on in case (f) is added
- d. Different approach to discourse update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

# Anaphora Resolution

- 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.

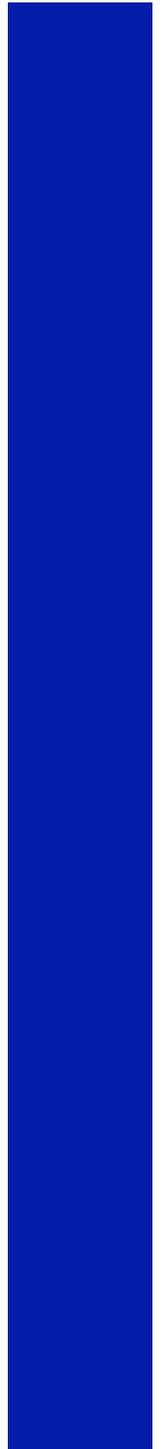
# Anaphora Resolution

**Three plaintiffs make three claims that they are ill-treated**



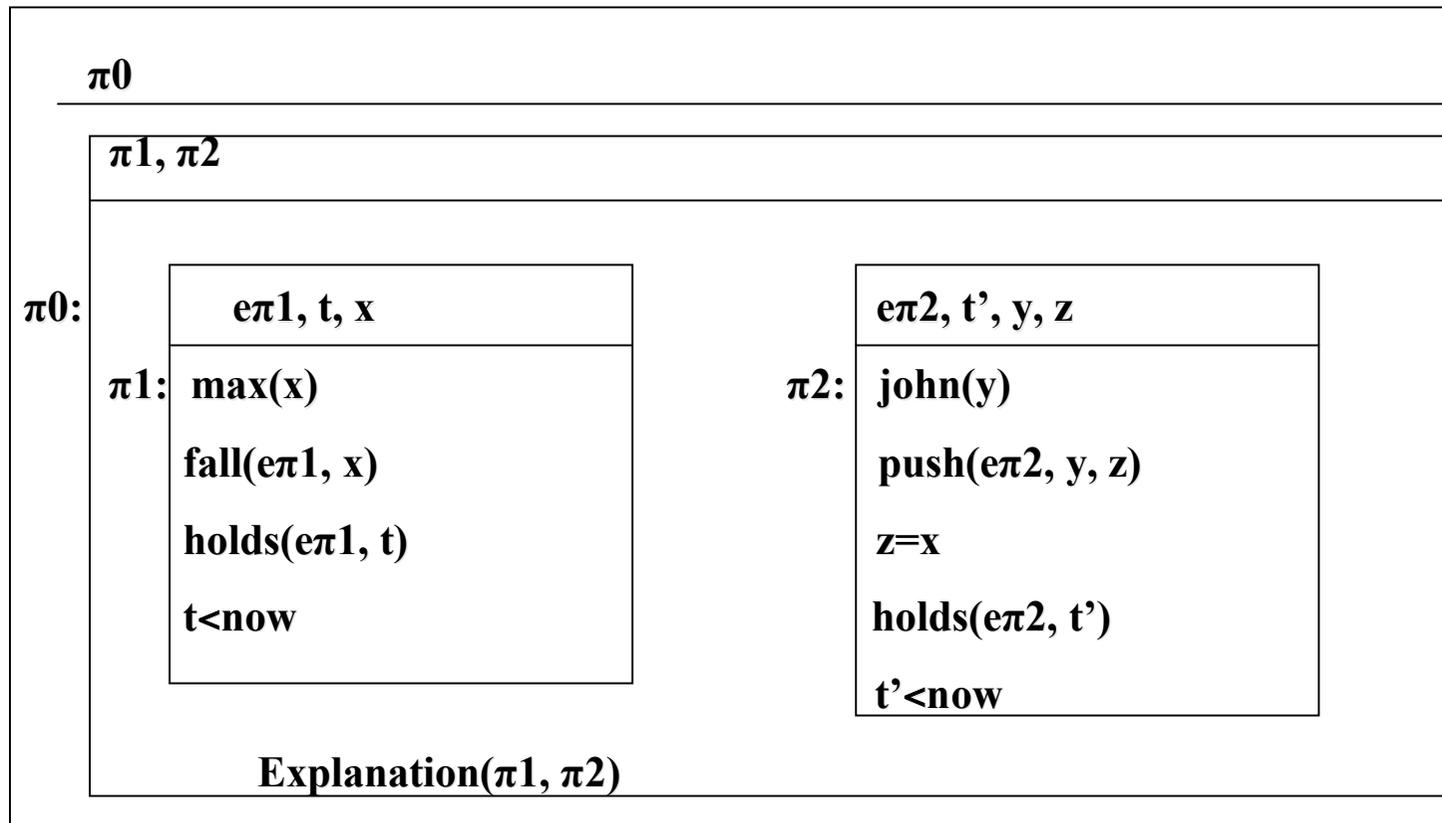
Segmented Discourse Representation Theory

Alex Tantos



# Temporal phenomena

## a. Max fell. John pushed him.



# Temporal phenomena

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

- $\varphi\text{Explanation}(\alpha, \beta) \rightarrow (\neg e\alpha < e\beta)$
- $\varphi\text{Explanation}(\alpha, \beta) \rightarrow (\text{event}(e\beta) \rightarrow e\beta < e\alpha)$

**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:

- a. **No formal way of inferring implicatures**
- b. **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:**

**$\varphi$ Elaboration( $\alpha, \beta$ )  $\rightarrow$  Part-of( $e\alpha, e\beta$ )**

**Properties:**

**1) Transitivity and 2) Distributivity**

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

**2) Elaboration( $\alpha, \beta$ )  $\wedge$  Coord( $\beta, \gamma$ )  $\wedge$  I-outscopes( $\delta, \gamma$ )  $\wedge$   
Elaboration( $\alpha, \delta$ )**

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

# Rhetorical relations...continued

## **Narration—Scalar coherence**

### **Semantic constraints:**

#### **1. Spatiotemporal constraint**

**If Narration( $n_1, n_2$ ), then the poststate of  $e_{n_1}$  must overlap the prestate of  $e_{n_2}$**

- 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( $\alpha, \beta$ )  $\rightarrow$   
overlap(prestate( $e_\beta$ ), Adv $\beta$ (poststate( $e_\alpha$ )))**

# 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.**

$\varphi\text{Narration}(\alpha, \beta) \rightarrow \neg \text{K}(\alpha \sqcap \beta)$

# 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:**

**$\varphi_{\text{Background}}(\alpha, \beta) \rightarrow \text{overlap}(e\beta, e\alpha)$**

**Topic constraint like Narration but in Background the  $e\alpha$  maintains available for anaphoric binding since it is considered the “main story line”**

# Rhetorical relations...continued

## Background

1.  $\pi_1$  **A burglar** broke into Mary's apartment.

$\pi_2$  Mary was asleep.

$\pi_3$  **He** stole the silver.

2.  $\pi_1$  A burglar broke into Mary's apartment.

$\pi_2$  A police woman visited her the next day.

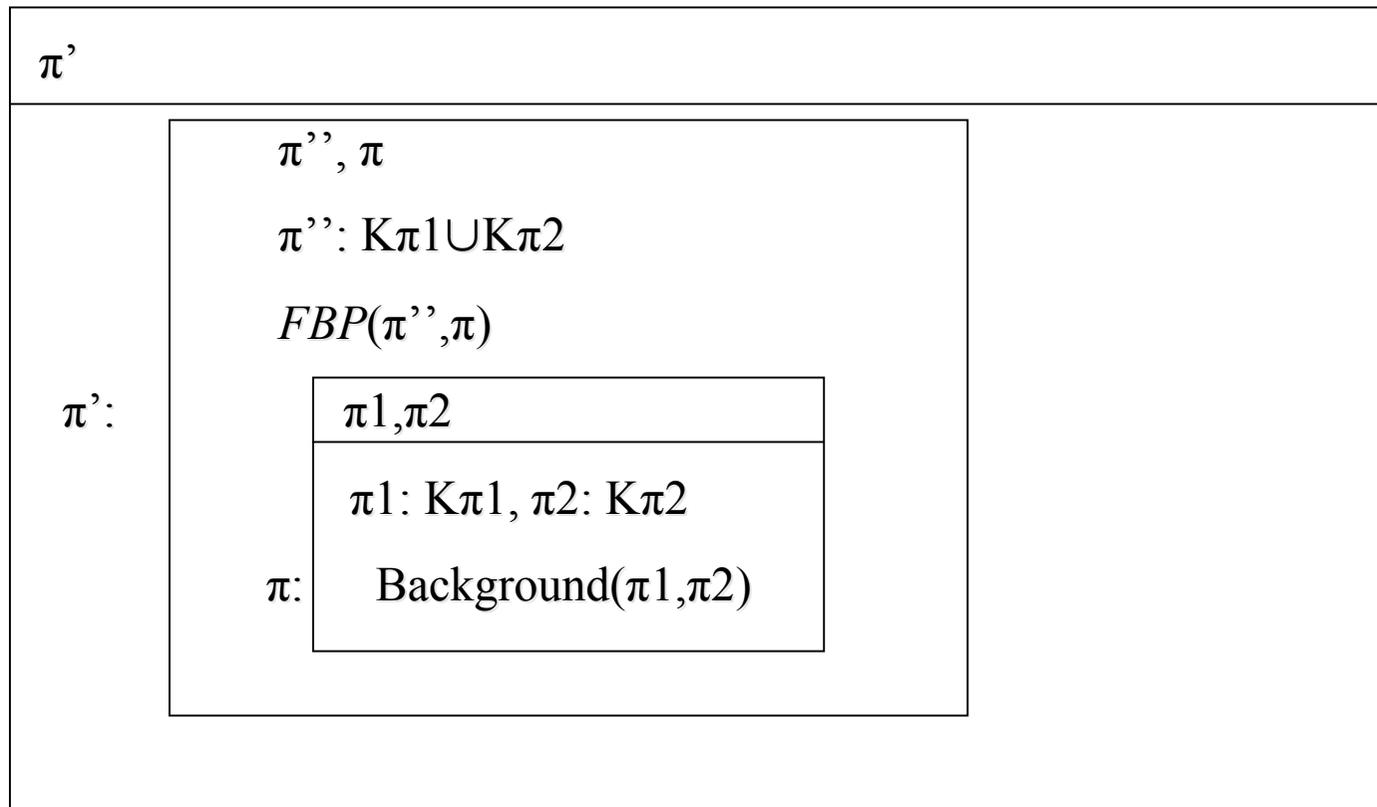
$\pi_3$  ??He stole the silver.

repeating the common topic...set union of  $\pi_1$ ,  $\pi_2$

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)**

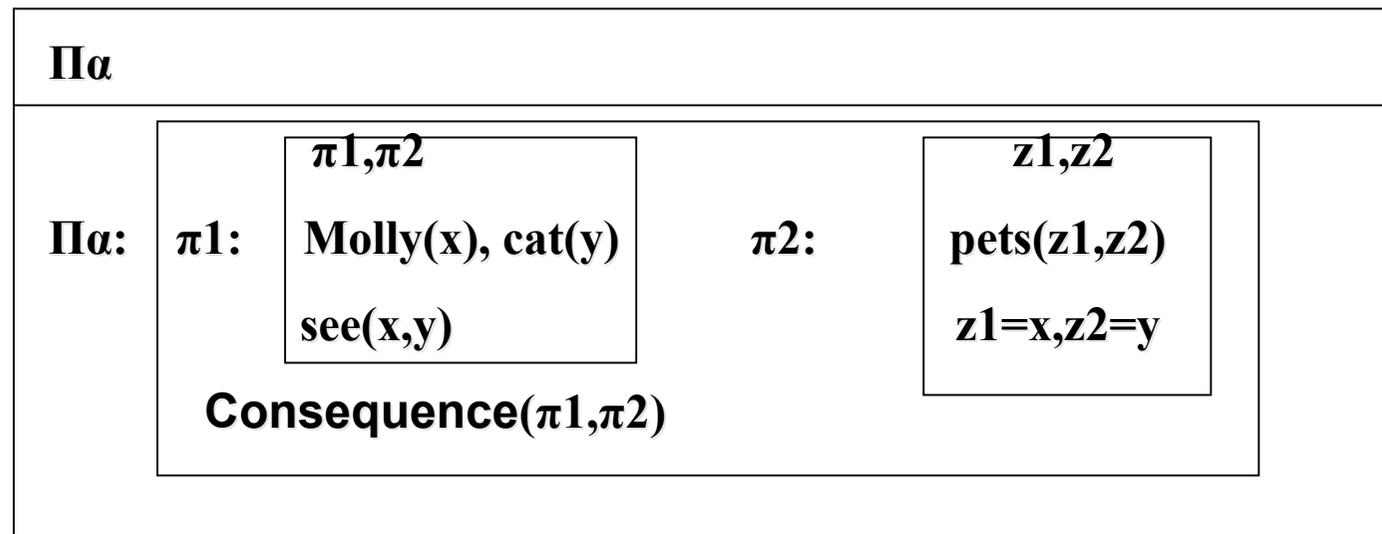
### An example of the second case...

- 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

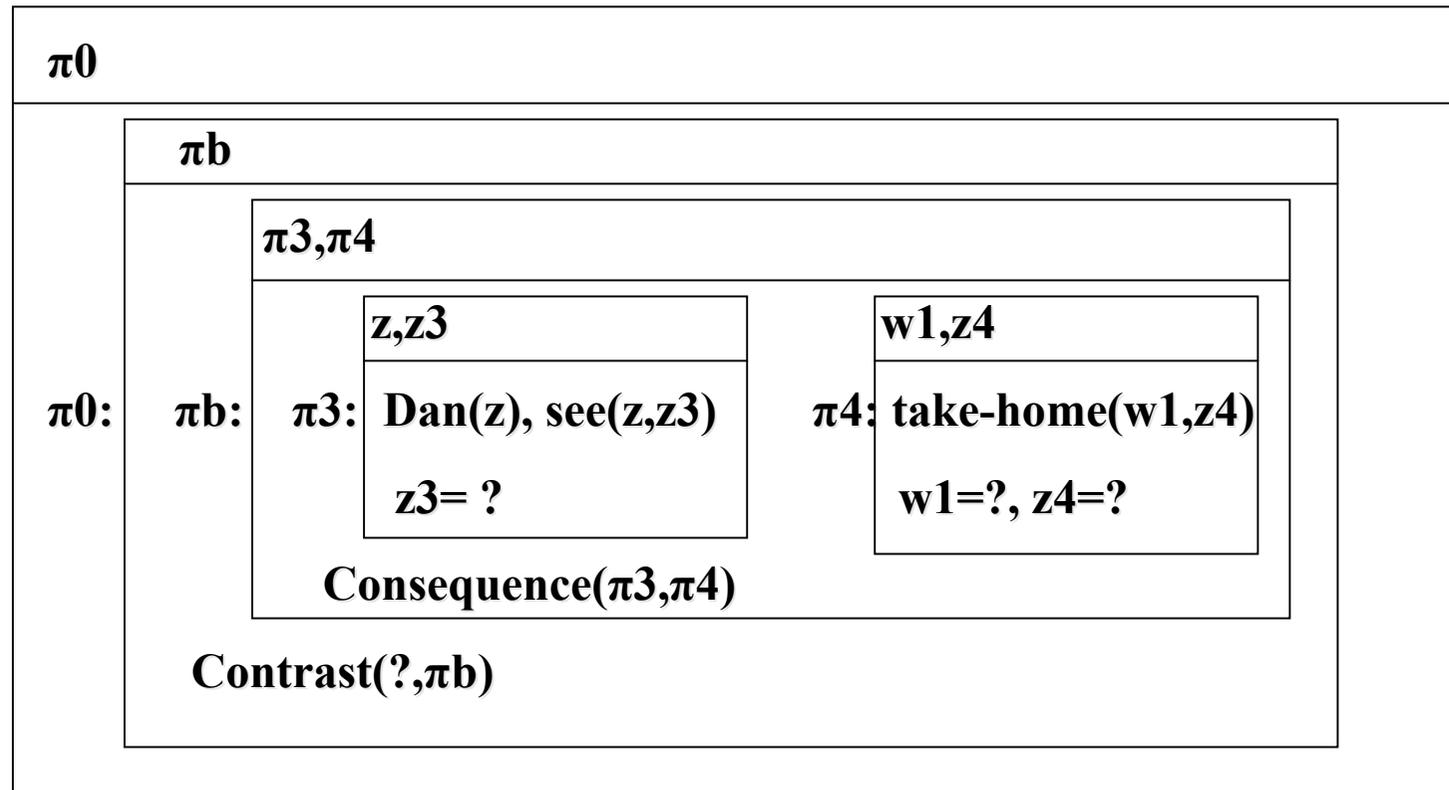
a.



# Rhetorical relations...continued

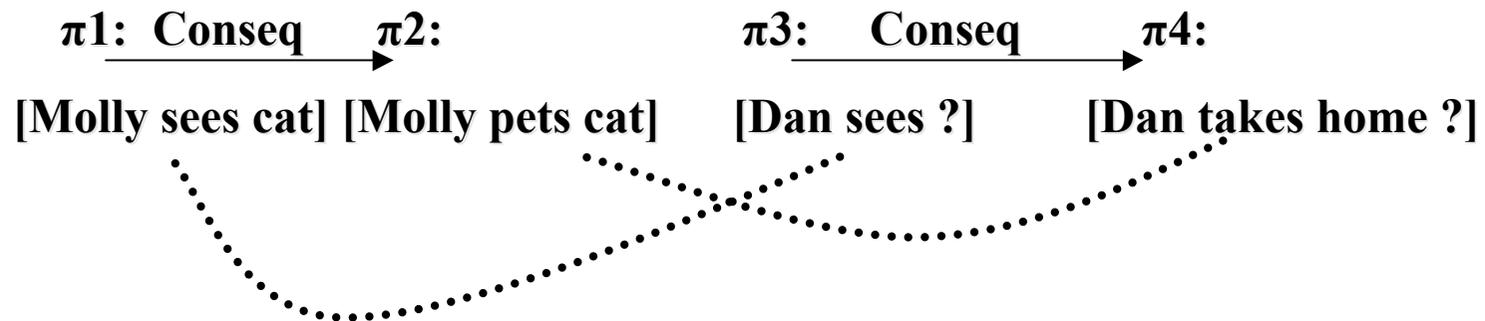
## Contrast-Evidence

b.



# Rhetorical relations...continued

**Contrast**



**For the mapping between the ns see Asher (1993)**

# Rhetorical relations...continued

## Microstructure

**Some words about the connectives between two fully specified formulas:**

**$\rightarrow, \vee, \wedge$ ...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?**

# Rhetorical relations...continued

## Microstructure

### A 3<sup>rd</sup> 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...**

**$M = \langle A_\mu, W_\mu, *_\mu, I_\mu \rangle$**

**Tasha is a cat.**

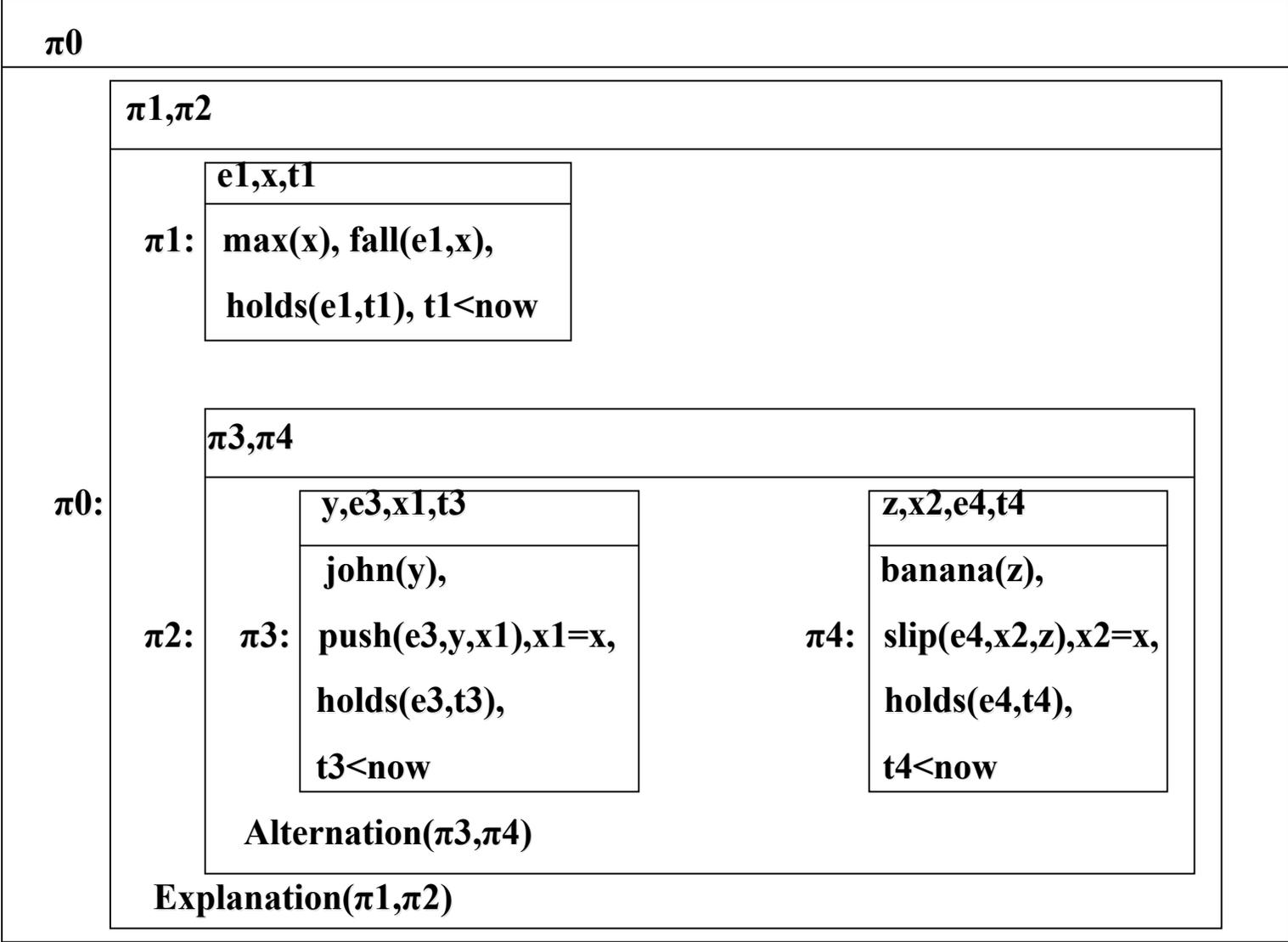
**$*_\mu(w, [[n]])$**

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

# Unpacking truth conditions:

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

# Unpacking truth conditions:



# Unpacking truth conditions:

Use of the satisfaction schema and recursively unpacking:

$(w,f)[[\text{Explanation}(n1,n2)]]_M(w,g)$  iff

$(w,f)[[K_{n1} \wedge K_{n2} \wedge \text{Explanation}_{(n1,n2)}]]_M(w',g)$

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

- a)  $(w,f)[[K_{n1}]]_M(w,h)$
- b)  $(w,h)[[K_{n2}]]_M(w,i)$ ; and
- c)  $(w,i)[[\text{Explanation}_{(n1,n2)}]]_M(w,g)$

Let's take the first condition:

(a) Holds only if:

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

# Unpacking truth conditions:

**Condition (b) for  $K_{n2}$  contains a complex SDRS containing an Alternation relation...**

**So either  $e_3$  happens or  $e_4$  in the  $K_{n2}$ :**

**$(w,h)[[Alternation(n_3,n_4)]]_M(w,i)$  iff  
 $(w,h)[[K_{n3} \vee K_{n4}]]_M(w,i)$**

**Reminder:  $K_{n1}$  is connected to  $K_{n2}$  and not to  $K_{n3}$  or to  $K_{n4}$ .  $K_{n2}$  is dependent on the truth conditions of  $K_{n3}$  and  $K_{n4}$ .**

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

**$\varphi_{Explanation}(\alpha,\beta) \rightarrow (\neg e_{\alpha} < e_{\beta})$**

# 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?**

**Contact me...Alexandros.Tantos@uni-konstanz.de**

# 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...**

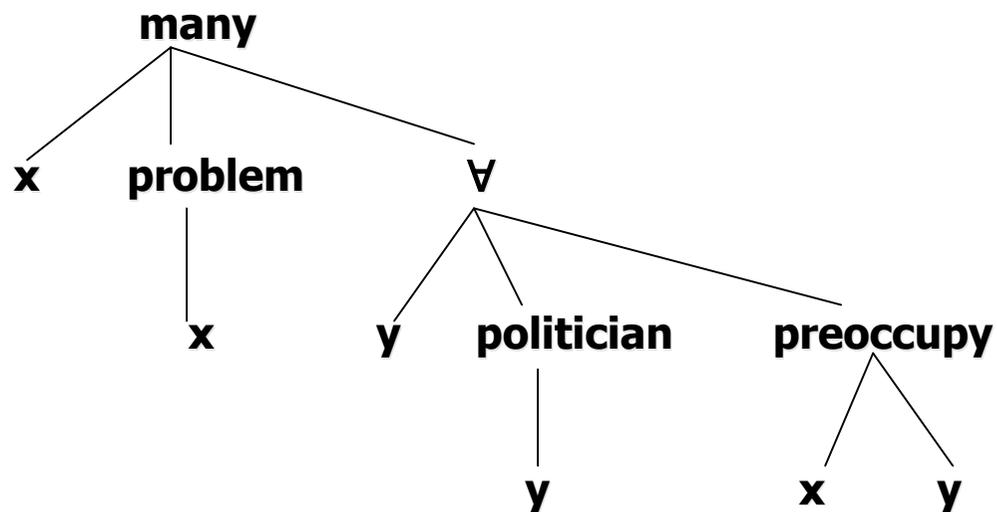
**Approaches of underspecification: [Reyle(1993), Bos(1995), Bos et al. (1996), Asher and Fernando(1997), Egg et al.(2001) and Copestake et al.(1999)]**

**To the point with “labels”...**

# Some words about Underspecification

Many problems preoccupy every politician.

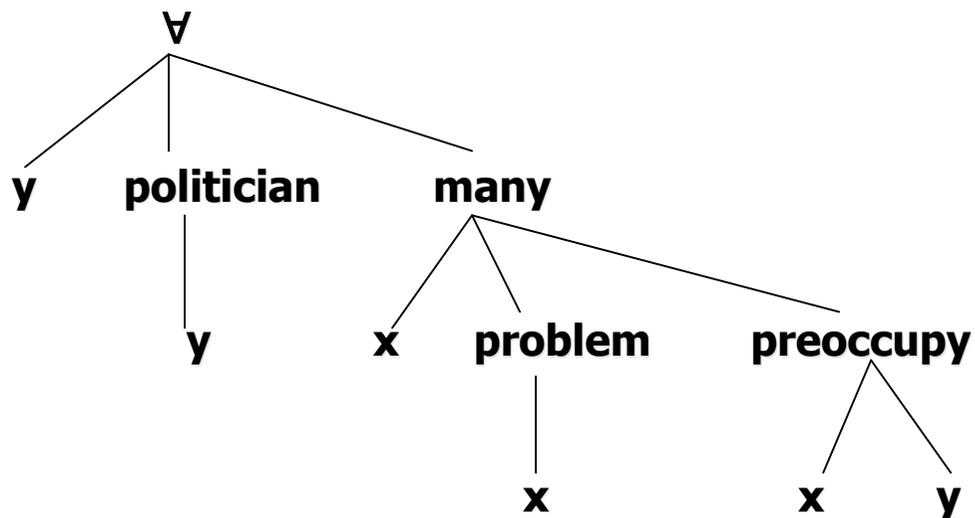
- $\text{many}(x, \text{problem}(x), \forall(y, \text{politician}(y), \text{preoccupy}(x, y)))$
- $\forall(y, \text{politician}(y), \text{many}(x, \text{problem}(x), \text{preoccupy}(x, y)))$



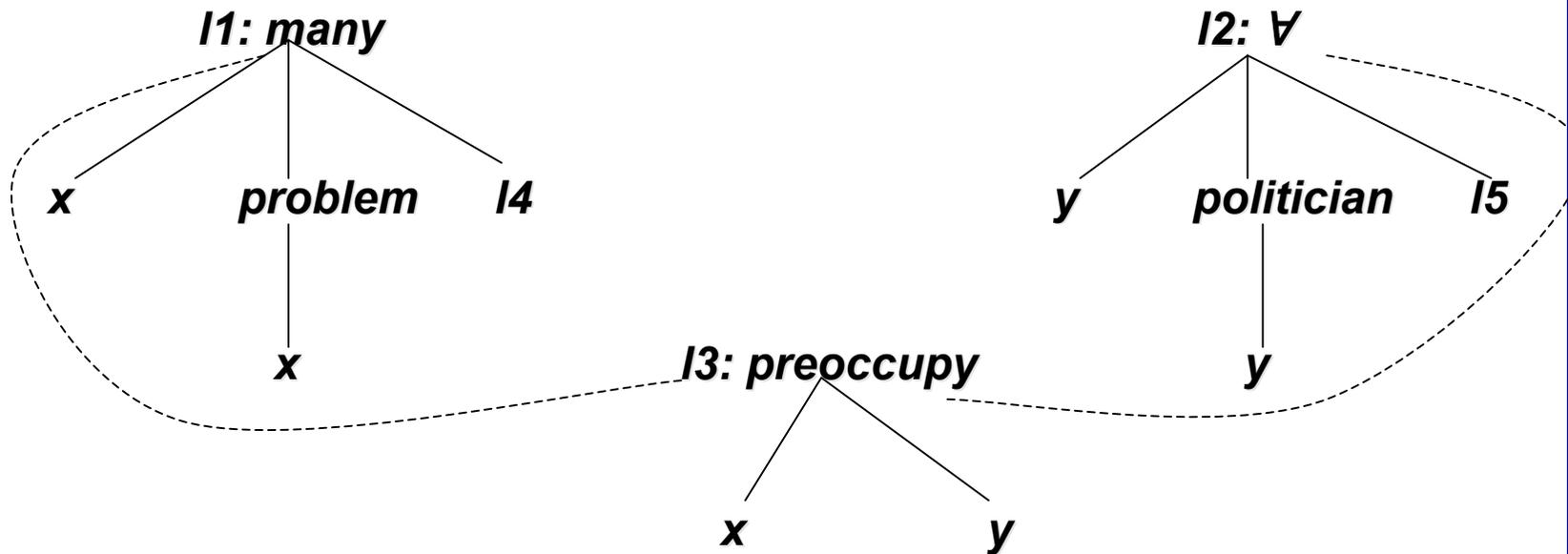
# Some words about Underspecification

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



# Some words about Underspecification



$\exists I4 \exists I5 ( I1: \text{many}(x, \text{problem}(x), I4) \wedge$   
 $I2: \forall(y, \text{politician}(y), I5) \wedge$   
 $I3: \text{preoccupy}(x, y) \wedge$   
 $\text{outscopes}(I1, I3) \wedge \text{outscopes}(I2, I3))$