Semantics 1

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Gerhard Jäger

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

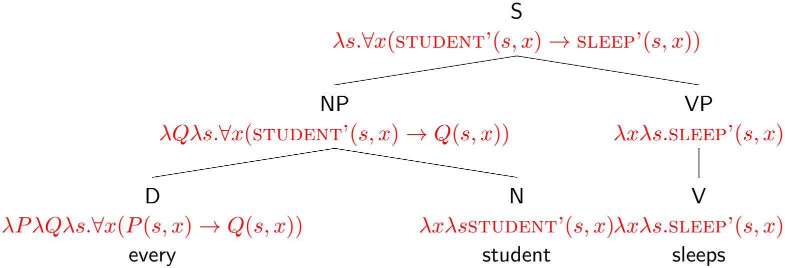
Quantifiers

Determiniers

- Meaning of a determiner is 3-place relation between
  - a situation,
  - two relations between situations and individuals, i.e., the meanings of the NP and the VP respectively
- "logical" determiners:
  - *a, some*: $\lambda P \lambda Q \lambda s \exists x(P(s,x) \wedge Q(s,x))$
  - *every, all*: $\lambda P \lambda Q \lambda s \forall x(P(s,x) \rightarrow Q(s,x))$
  - *no*: $\lambda P \lambda Q \lambda s \neg \exists x(P(s,x) \wedge Q(s,x))$

Quantifiers

Determiner

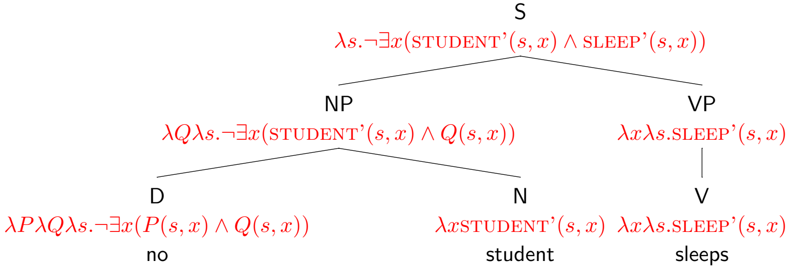


Determiner

- S: $\lambda s.\exists x(\text{STUDENT'}(s,x) \wedge \text{SLEEP'}(s,x))$
  - NP: $\lambda Q \lambda s.\exists x(\text{STUDENT'}(s,x) \wedge Q(s,x))$
    - D: $\lambda P \lambda Q \lambda s.\exists x(P(s,x) \wedge Q(s,x))$
      - a
    - N: $\lambda x \text{STUDENT'}(s,x)$
      - student
  - VP: $\lambda x \lambda s.\text{SLEEP'}(s,x)$
    - V: $\lambda x \lambda s.\text{SLEEP'}(s,x)$
      - sleeps

Quantifiers

Determiner



Quantifiers

Determiners beyond predicate logic

- equivalent notation of the determiners used so far:[1]
  - *every:* $\lambda P \lambda Q \lambda s.(\{x|P(s,x)\} \subseteq \{x|Q(s,x)\})$
  - *a:* $\lambda P \lambda Q \lambda s.(\{x|P(s,x)\} \cap \{x|Q(s,x)\} \neq \emptyset)$
  - *no:* $\lambda P \lambda Q \lambda s.(\{x|P(s,x)\} \cap \{x|Q(s,x)\} = \emptyset)$
- basically, a determiner expresses a 2-place relation between two sets ($\{x|P(s,x)\}$ and $\{x|Q(s,x)\}$)
- similar patterns holds for all determiners:

[1] Note that our meta-language is a mixture of predicate logic and set theory.

Quantifiers

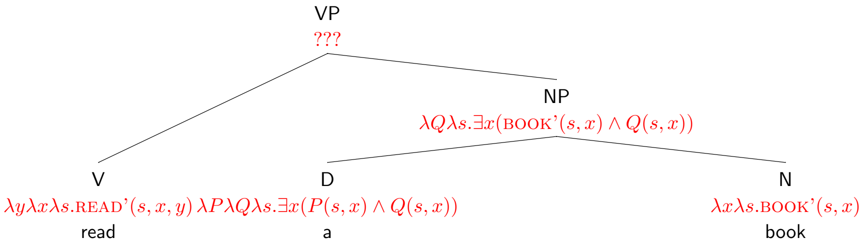
Determiners beyond predicate logic

- *two:* $\lambda P \lambda Q \lambda s.|\{x|P(s,x)\} \cap \{x|Q(s,x)\}| \geq 2$
- *at most two:* $\lambda P \lambda Q \lambda s.|\{x|P(s,x)\} \cap \{x|Q(s,x)\}| \leq 2$
- *exactly two:* $\lambda P \lambda Q \lambda s.|\{x|P(s,x)\} \cap \{x|Q(s,x)\}| = 2$
- *most:*
  $\lambda P \lambda Q \lambda s.|\{x|P(s,x)\} \cap \lambda x.P(s,x)| > |\{x|P(s,x)\} - \{x|Q(s,x)\}|$

[1] $|A|$ is the **cardinality** of the set A, i.e., the number of its elements.

Quantifier Raising

- quantifiers in object position are not interpretable with our current machinery



- both NP and VP denote functions
- domain of $\|$*a book*$\|$: **two**-place relation
- $\|$*read*$\|$ is **three**-place relation
- domain of $\|$*read*$\|$: individuals
- $\|$*a book*$\|$ is not an individual, but a relation

Quantifier Raising

- solution: (one of several possible solutions):
  - syntax tree is modified before compisitional interpretation starts
  - original syntactic structure: **S-structure**
  - derived syntactic structure for semantic interpretation: **Logical Form** (LF)
- transition from S-structure to LF is governed by **transformation rules**

Quantifiers

Excursus: pronouns and variables

- so far, interpretation is always uniquely determined: $\|\alpha\|$ has a unique value
- some expressions, such as pronouns, are **context dependent**

  He sleeps.

- comparable to variables in predicate logic
- different occurrences of a pronoun need not be co-referent

  He sees him.

- desambiguation via **indices**

  He$_i$ *sees him*$_j$.

- indices are natural numbers; equal letters represent equal numbers and different letter for different numbers

Quantifiers

Excursus: Pronomen und Variable

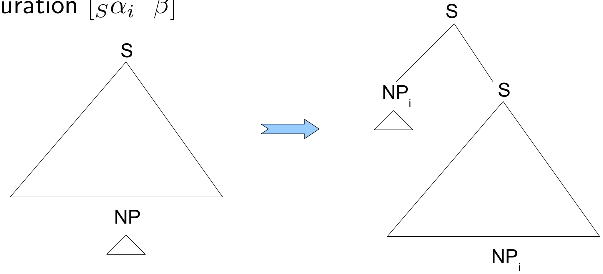
- interpretation rule for pronouns

$$\|he_i\| = x_i$$

$$\|\text{he}_i \text{ sees him}_j\| = \lambda s.\text{SEE'}(s, x_i, x_j)$$

Quantifier Raising

- transformation rule "Quantifier Raising":
  1. replace the NP-node α of a generalized quantifier by NP_i
  2. replace some S-node β that dominates α in S-structure by the configuration $[_S \alpha_i \quad \beta]$



- the lower NP-node is informally called "trace" and the transformation itself "movement" (should be familiar from Syntax 0/Syntax 1)
- sometimes traces are marked by t

Quantifiers

Quantifier Raising

- interpretation of LF
  - If a node NP_i is a leaf (i.e., it is a trace):

$$\|NP_i\| = x_i$$

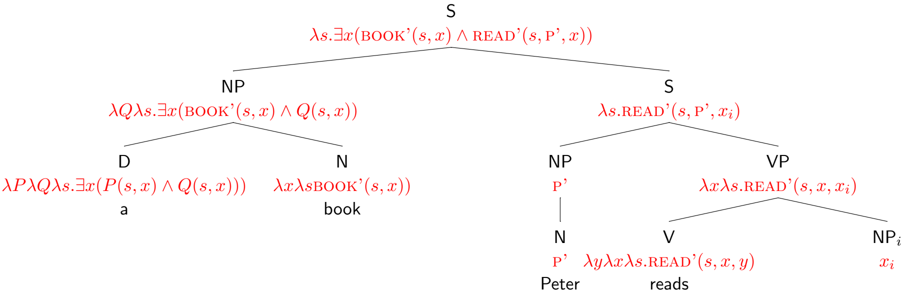
  - If $[_{S_1} NP_i \ \ S_2]$ is a configuration that results from Quantifier Raising:

$$\|S_1\| = \|NP\|(\lambda x_i.\|S_2\|)$$

- Note: This rule is an exception to the principle of type-driven interpretation.

Quantifiers

Quantifier Raising



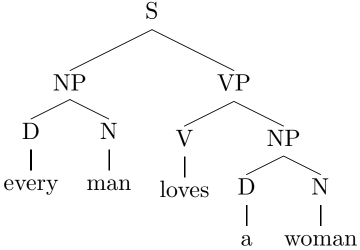
Multiple quantification

- A single sentence may contain more than one quantifier:
  - *Every child bought a cookie.*
  - *Every referee shows some team two red cards.*
- for n quantifiers, we have $n!$ many different ways to perform QR
- up to $n!$ different readings
- simple example

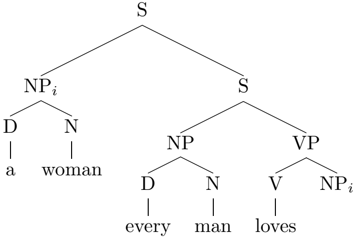
Every man loves a woman.

Multiple quantification

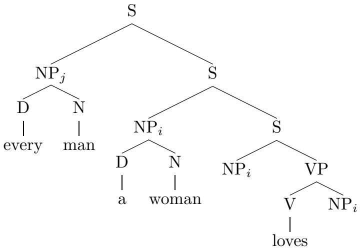
S-structure:



object raising:

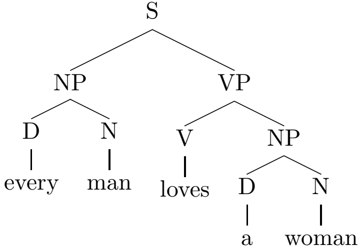


subject raising (= LF 1):

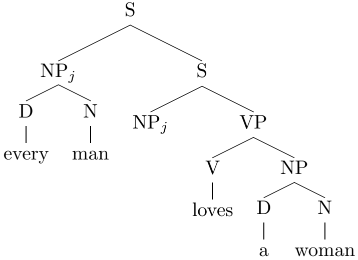


Multiple quantification

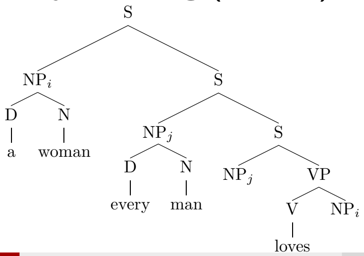
S-structure:



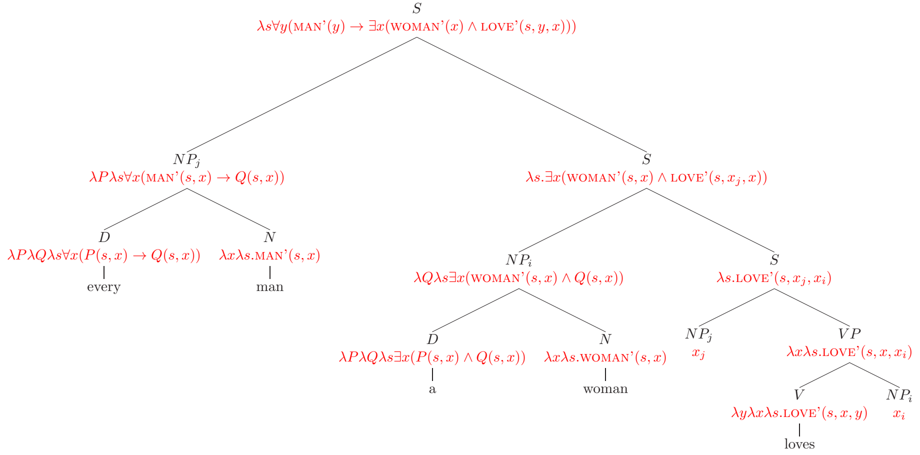
subject raising:



object raising (= LF 2):



Interpretation of LF1:



Multiple quantification

Interpretation of LF2: