

Semantic Theory

Lecture 1 – Introduction

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Information about this course

Contact information:

- Course website: <http://noortjejoost.github.io/teaching/ST16/index.html>
- My email: noortjev@coli.uni-saarland.de

Prerequisites:

- This course assumes basic familiarity with first-order predicate logic

Recommended literature:

- Gamut: Logic, Language, and Meaning, Vol. 2, University of Chicago Press, 1991
- Kamp and Reyle: From Discourse to Logic, Kluwer, 1993

Exercises & exam

Final exam:

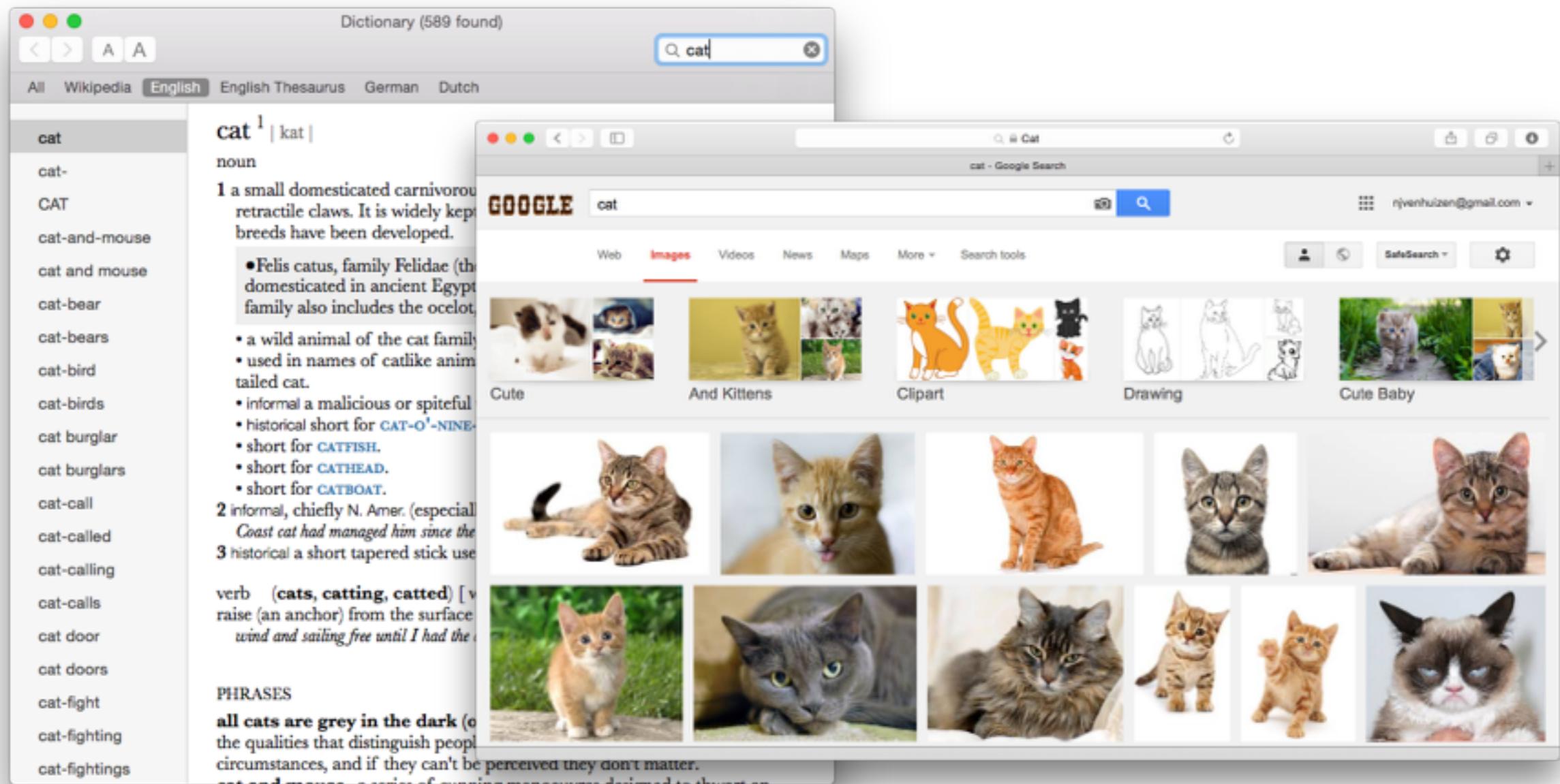
- You have to register: before Monday, July 11th
- Exam date to be confirmed

Exercise sheets:

- There will be (approx.) 8 exercise sheets throughout the weeks
- In order to be admitted to the exam, you can miss or fail at most 1 exercise sheet
- Exercises can be done in groups (up to 3 students)

Semantic Theory

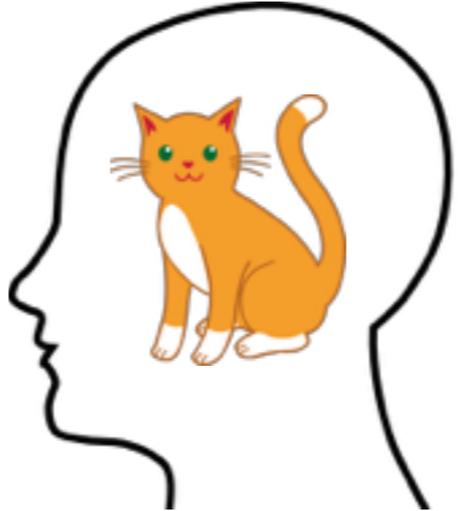
Semantic Theory is the study of linguistic meaning



A philosophical question: What is 'meaning'?

“a small domesticated carnivorous mammal with soft fur, a short snout, and retractile claws”

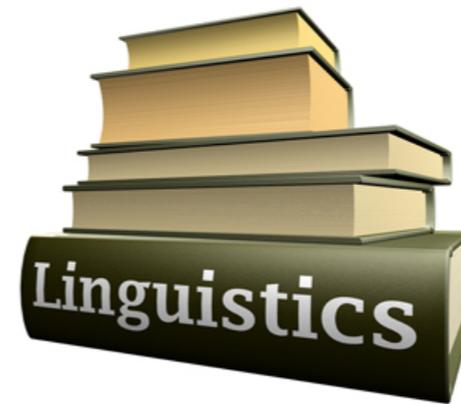
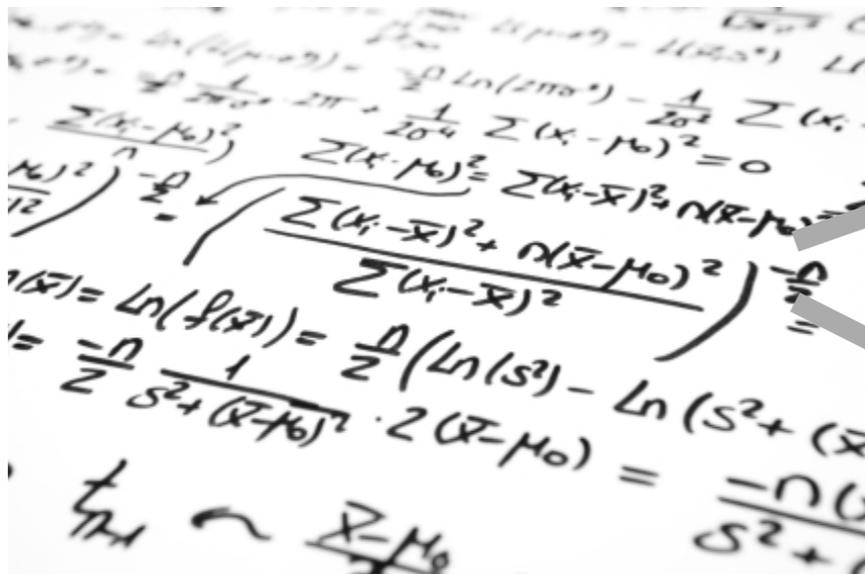
“cat”



Formal semantics

The aim of formal semantics:

Capturing linguistic meaning in a formal (mathematical) system

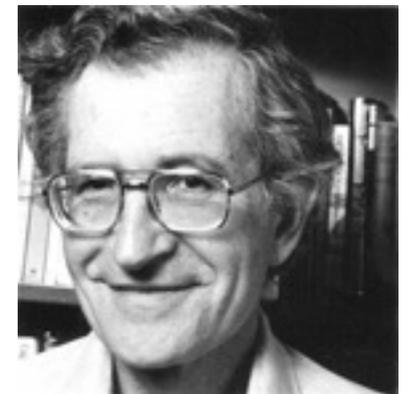


The development of formal semantics

1933 — Bloomfield: “The statement of meanings is [...] the weak point in language-study, and will remain so until human knowledge advances very far beyond its present state.”



1957 — Chomsky: “there is little evidence that ‘intuition about meaning’ is at all useful in the actual investigation of linguistic form”



1970 — Montague: “There is in my opinion no important theoretical difference between natural languages and the artificial languages of logicians”



Course Overview

- Part I: Sentence semantics
(compositional semantics)
- Part II: Lexical semantics
- Part III: Discourse semantics



Part I:
Sentence semantics



A basic semantic principle

"For two sentences A and B , if in some possible situation A is true and B is false, A and B must have different meanings."

(M. Cresswell, 1975)

Applied to logical representations:

- For a logical formula α and a sentence A : If in some possible situation corresponding to a model structure M , sentence A is true, and α is not, or vice versa, then α is not an appropriate meaning representation for A .

Sentence meaning

Truth-conditional semantics:

to know the meaning of a (declarative) sentence is to know what the world would have to be like for the sentence to be true:

Sentence meaning = truth-conditions

Indirect interpretation:

1. Translate sentences into logical formulas:

Every student works $\mapsto \forall x(\text{student}'(x) \rightarrow \text{work}'(x))$

2. Interpret these formulas in a logical model:

$\llbracket \forall x(\text{student}'(x) \rightarrow \text{work}'(x)) \rrbracket^{M,g} = 1$ iff $V_M(\text{student}') \subseteq V_M(\text{work}')$

Step 1: from sentence to formula

Propositional logic: Propositions as basic atoms

Syntax: propositions (p, q, \dots), logical connectives ($\neg, \wedge, \vee, \rightarrow, \leftrightarrow$)

Semantics: truth tables — truth conditions, entailment

p	q	$p \& q$	$p \vee q$	$p \rightarrow q$	$p \leftrightarrow q$
T	T	T	T	T	T
T	F	F	T	F	F
F	T	F	T	T	F
F	F	F	F	T	T

Predicate logic: Predicates and arguments

Syntax: predicates & terms ($\text{Love}(j,m), \text{Mortal}(x), \dots$), quantifiers ($\forall x \phi, \exists x \phi$), logical connectives ($\wedge, \vee, \neg, \rightarrow, \leftrightarrow$)

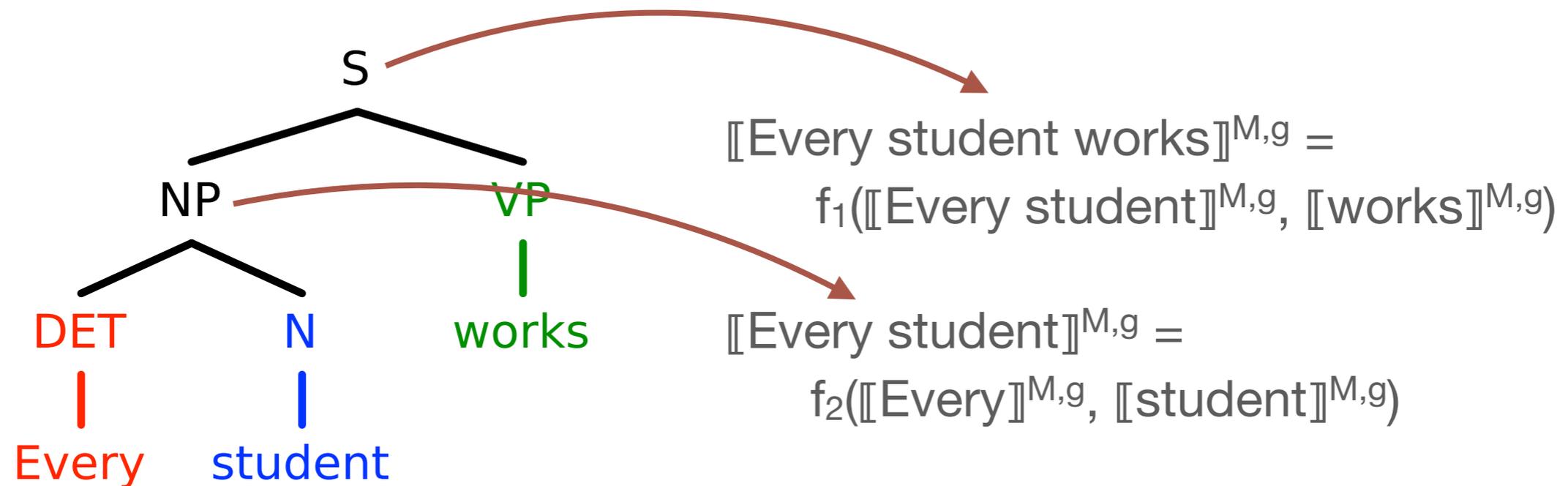
Semantics: model structures and variable assignments

Compositionality

The principle of compositionality:

The meaning of a complex expression is a function of the meanings of its parts and of the syntactic rules by which they are combined (Partee et al., 1993)

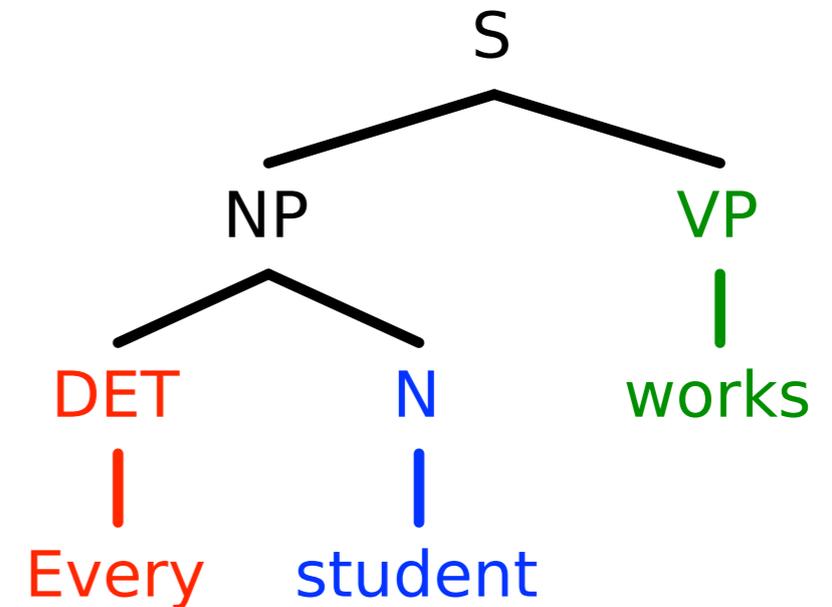
- *Every student works*



Compositional Semantics Construction

Semantic lexicon:

- every $\mapsto \lambda P \lambda Q \forall x (P(x) \rightarrow Q(x))$
- student $\mapsto \text{student}'$
- works $\mapsto \text{work}'$



Semantics construction:

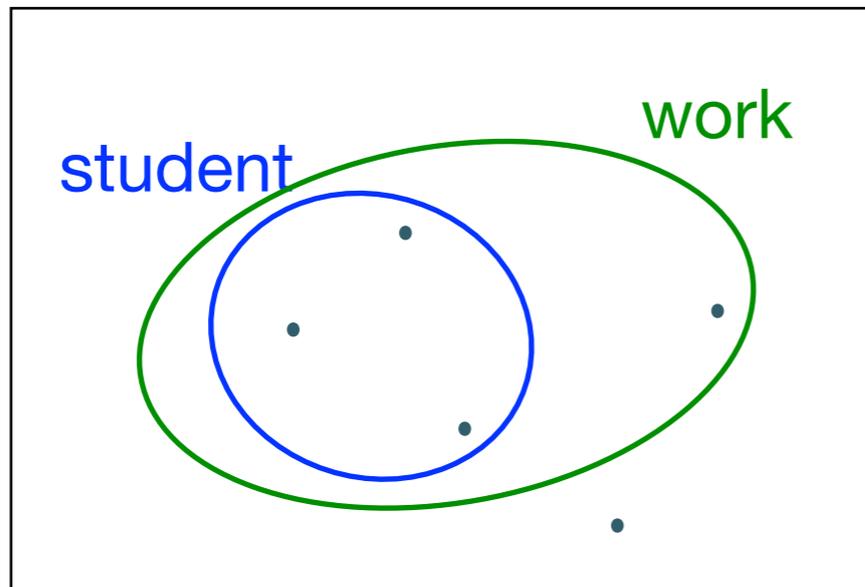
- $\lambda P \lambda Q \forall x (P(x) \rightarrow Q(x))(\text{student}')$ \Rightarrow_{β} $\lambda Q \forall x (\text{student}'(x) \rightarrow Q(x))$
- $\lambda Q \forall x (\text{student}'(x) \rightarrow Q(x))(\text{work}')$ \Rightarrow_{β} $\forall x (\text{student}'(x) \rightarrow \text{work}'(x))$

Step 2: from formula to model

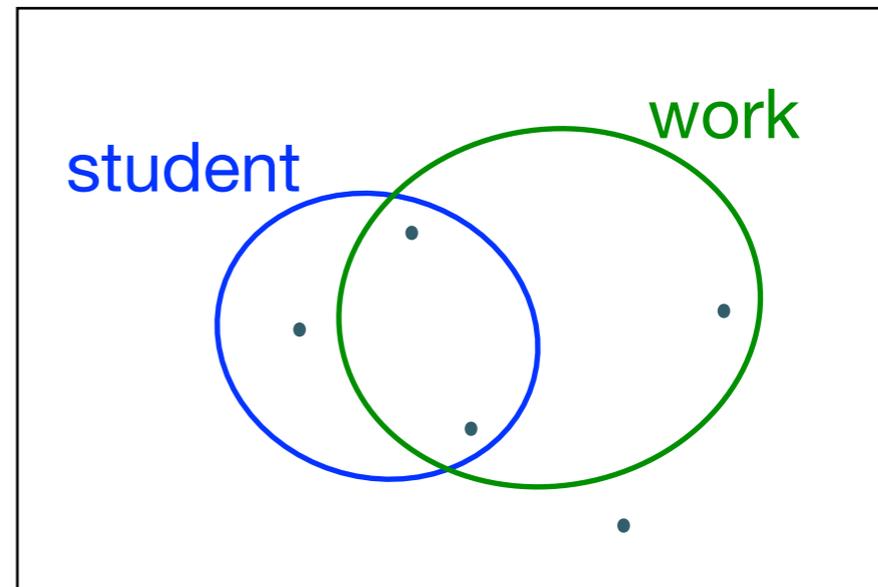
Every student works

$\llbracket \forall x(\text{student}'(x) \rightarrow \text{work}'(x)) \rrbracket^{M,g} = 1$ iff $V_M(\text{student}') \subseteq V_M(\text{work}')$

M1:



M2:



Issues for sentence semantics

Interpretation of adjectives

1. a. Jumbo is a grey elephant \mapsto Jumbo is grey
- b. Jumbo is a small elephant $\not\mapsto$ Jumbo is small

Quantifier scope

2. An American flag was hanging in front of every building
3. Every student speaks two foreign languages
4. A representative of every company saw most samples

Monotonicity and generalised quantifiers

5. All children came home late \mapsto All children came home
6. No children came home late $\not\mapsto$ No children came home

Part II: Lexical semantics



Zooming in: the meaning of words

Lexical semantics revisited:

- student \mapsto **student'** ... what does the ' stand for?



Structured approaches to the lexicon:

Lexical meaning as relations between concepts in a model

- a “student” is someone who studies
- a “bachelor” is a man who is not married

Issues for lexical semantics

Event-denoting expressions

1. a. Bill saw an elephant.
b. Bill saw an accident.
c. Bill saw the children play.

Verb alternatives and semantic roles

2. a. The window broke.
b. A rock broke the window.
c. John broke the window with a rock.

Plurals and collective predicates

3. Bill and Mary met \neq Bill met
4. Five students carried three pianos upstairs.

Part III: Discourse semantics



Beyond the sentence boundary

Limitations of sentence-level semantics:

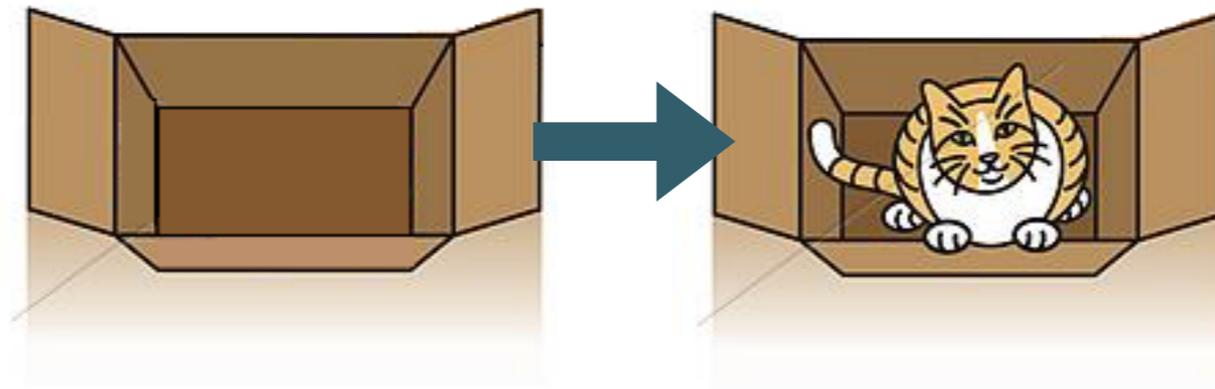
- Anaphora
 1. John hit Bill. He hit him back.
 2. If a farmer owns a donkey, he feeds it.
- Discourse relations
 3. John fell. Mary helped him up.
 4. John fell. Mary pushed him.
- Presuppositions
 5. a. Bill regrets that his cat has died.
 - b. Bill doesn't regret that his cat has died

Dynamic Semantics

Revisiting the idea of meaning as truth-conditions

- There is more to meaning than truth-conditions
- Meaning is context-dependent
- Meaning is dynamic: it keeps changing

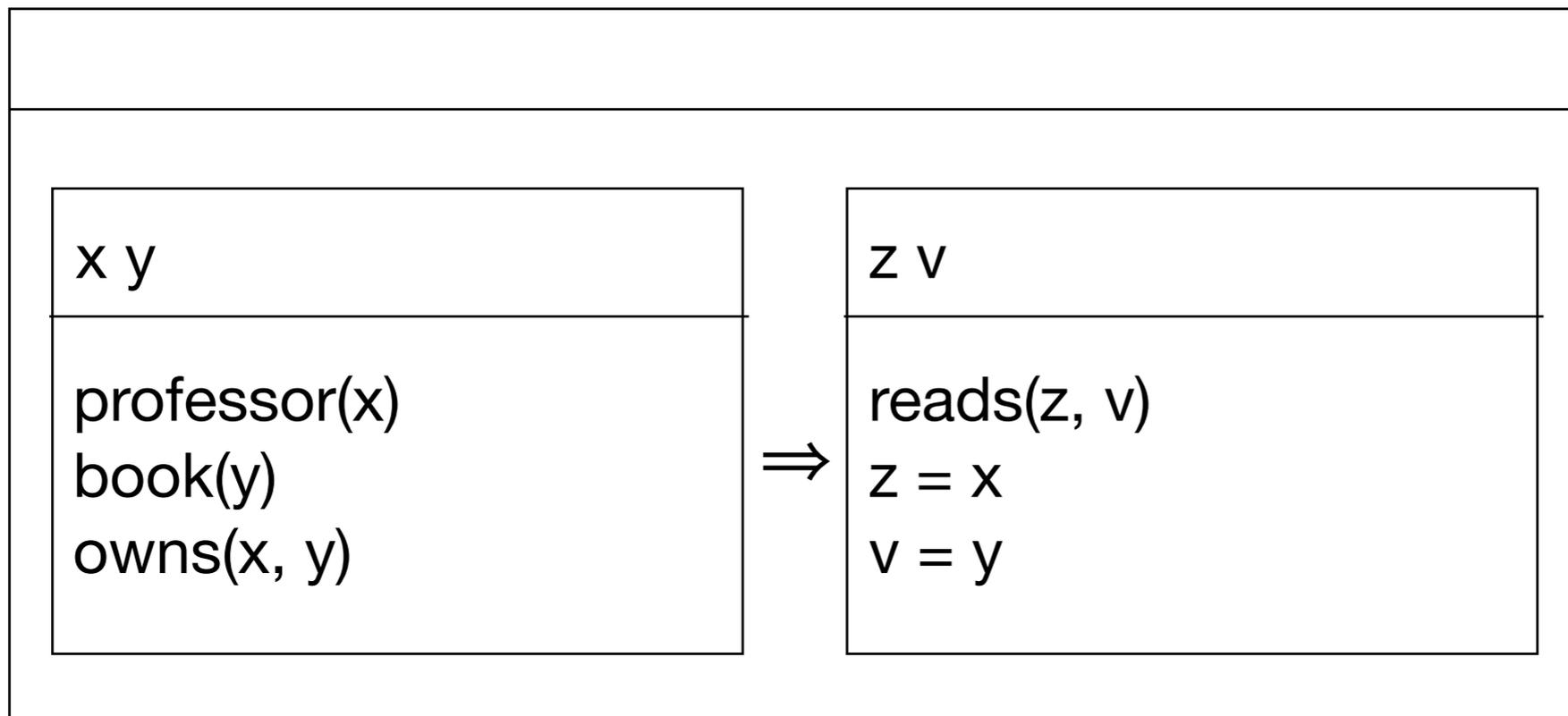
Solution: Meaning = context-change potential



Discourse Representation Theory

If a professor owns a book, he reads it.

- $\forall x \forall y [\text{professor}(x) \wedge \text{book}(y) \wedge \text{own}(x, y) \rightarrow \text{read}(x, y)]$



Applications of DRT

The image shows a web browser window displaying a document analysis interface. The browser address bar shows `gmb.let.rug.nl`. The page title is "Document 88/0480 - GMB Explorer". The interface includes a navigation menu with links like "explore", "challenges", "semantic lexicon", "search", "news feed", "statistics", "warnings", and "users". A user is logged in as "noortje (Master Annotator)". The document is identified as "Document 481 of 10102, ID: 88 / 0480". The status is "accepted". The interface also shows a "Change to:" dropdown set to "accepted" and a "Comment:" field. Below the document information, there are tabs for "metadata", "raw", "tokens", "sentences", "discourse", "8 bits of wisdom", and "0 warnings".

Overlaid on the browser window is a terminal window titled "PDRT - ghc - 114x39". The terminal shows the following code and output:

```
Prelude Data.DRS> DRS [DRSRef "x"] [Rel (DRSRel "Luke") [DRSRef "x"]]  
size: 3 sentences  
last processed: 14 April 2015, 17:16:53  
C&C tools: 2554  
Update to latest version of the document | report issue  
Filter by part:   
Filter by status: accepted  
Filter by subcorpus:   
Warnings:   
Prelude Data.DRS> DRS [DRSRef "y"] [Rel (DRSRel "father") [DRSRef "y"], Rel (DRSRel "of") [DRSRef "x", DRSRef "y"], Neg (DRS [] [Rel (DRSRel "like") [DRSRef "x", DRSRef "y"]])]  
y  
father(y)  
of(x,y)  
like(x,y)  
Prelude Data.DRS> printMerge luke doesntlikehisfather  
x y  
Luke(x) + father(y) of(x,y) = Luke(x) father(y)  
of(x,y) of(x,y) of(x,y)  
like(x,y) like(x,y)
```

The diagram illustrates a logical derivation. It shows a sequence of steps: a box labeled "x" containing "Luke(x)", followed by a plus sign, a box labeled "y" containing "father(y) of(x,y)", an equals sign, and a box labeled "x y" containing "Luke(x) father(y) of(x,y)". Below these, a box labeled "like(x,y)" is shown with a tilde symbol (~) next to it, indicating a negation or a specific relationship.



Current issues in Semantic Theory

- Where is the border between semantics and pragmatics?
- What do (or: can) formal semantic theories say about the way meaning is stored and created in the human brain?
- How can we use formal semantics for practical purposes (for example to improve machine translation)?

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