Semantic Theory
Lecture 1 – Introduction

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Summer 2018

Information about this course

Contact information:

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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:

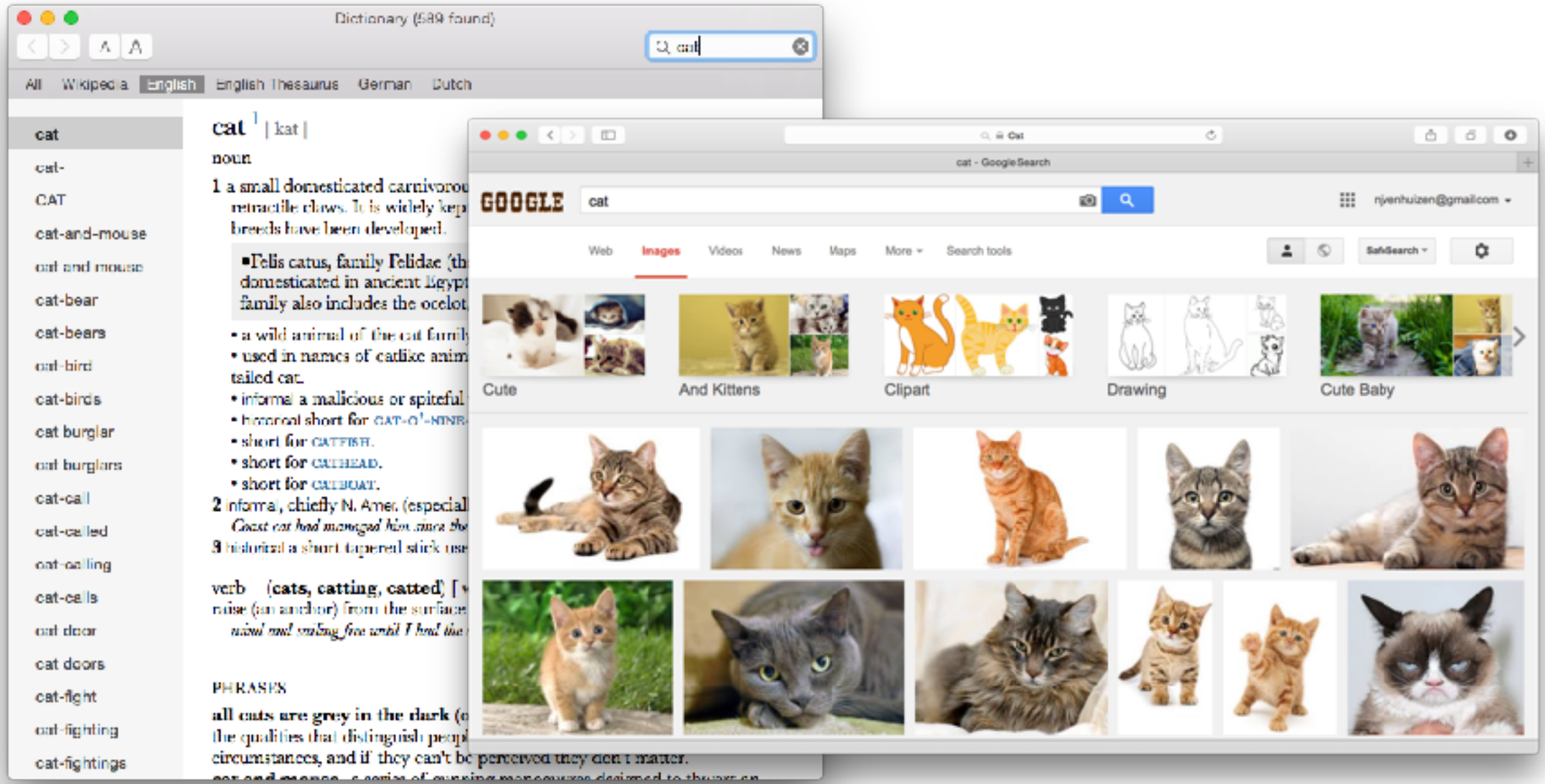
- Your grade for the exam determines your grade for the course
- You have to register before 04.07.2018
- Exam date to be confirmed

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’?

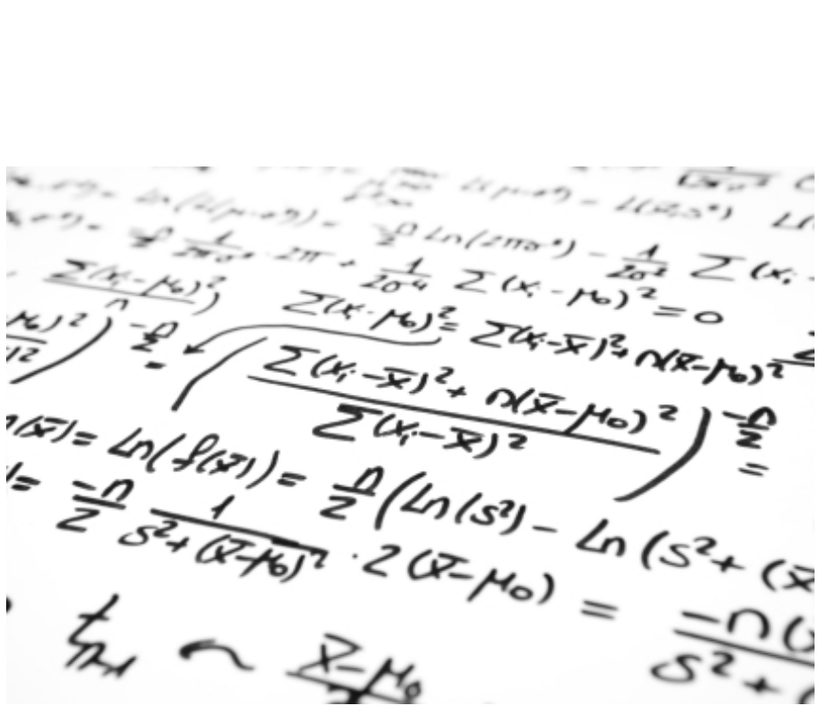
“a small domesticated carnivorous mammal with soft fur, a short snout, and retractile claws”

“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 IV: Current issues in Semantic Theory

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:
   $[\![\forall x(\text{student}'(x) \rightarrow \text{work}'(x))]\!]^{M,g} = 1$ 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, ..), logical connectives (¬, ∧, ∨, →, ↔)

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 (Love(j,m), Mortal(x), …), quantifiers (∀x ϕ, ∃x ϕ), logical connectives (∧, ∨, ¬, →, ↔)

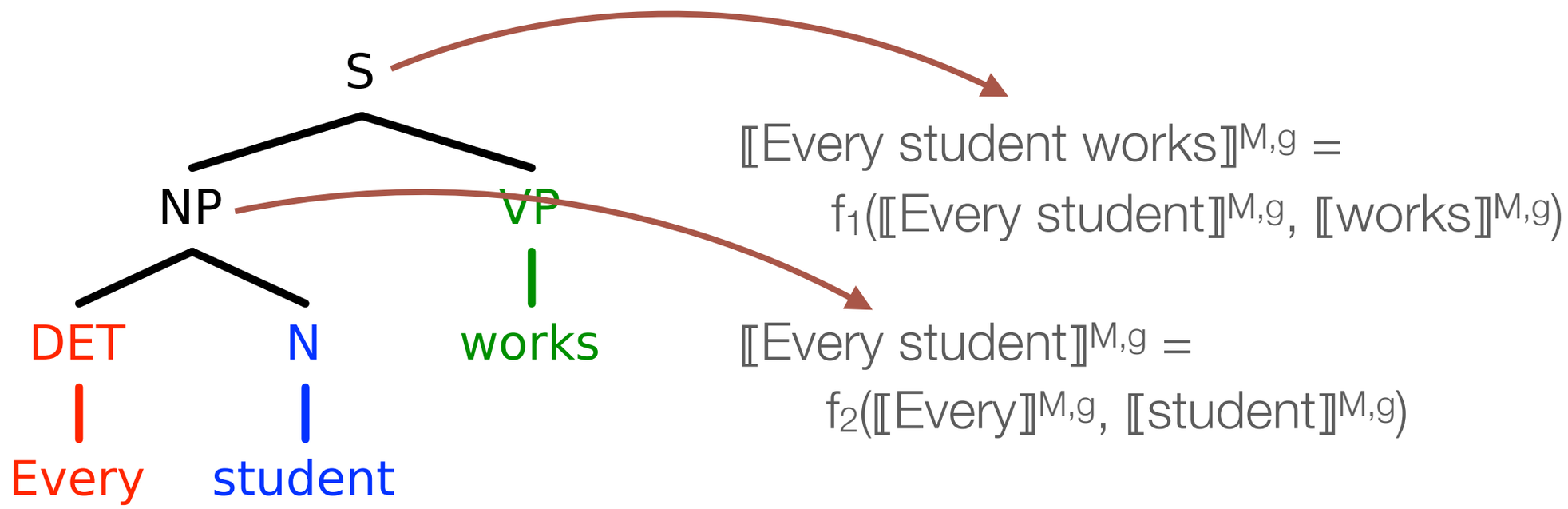
Semantics: model structures and variable assignments

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)

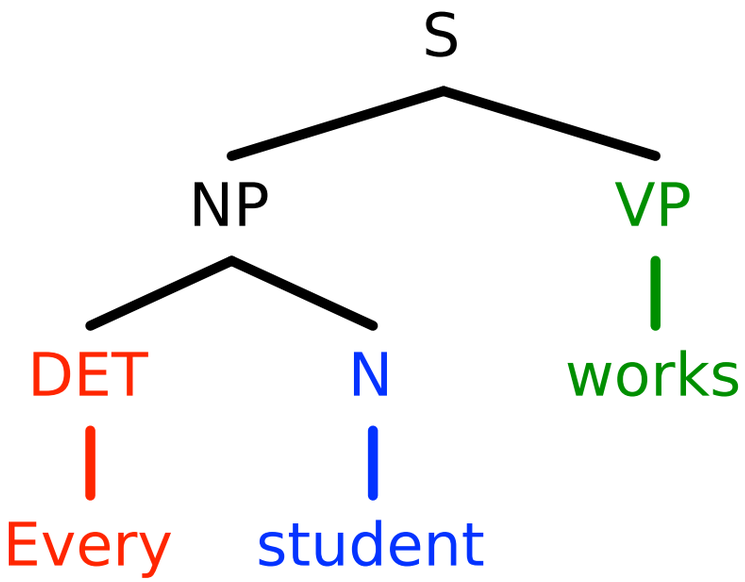
- *Every student works*



Compositional Semantics Construction

Semantic lexicon:

- every ↦ λPλQ∀x(P(x) → Q(x))
- student ↦ student'
- works ↦ work'



Semantics construction:

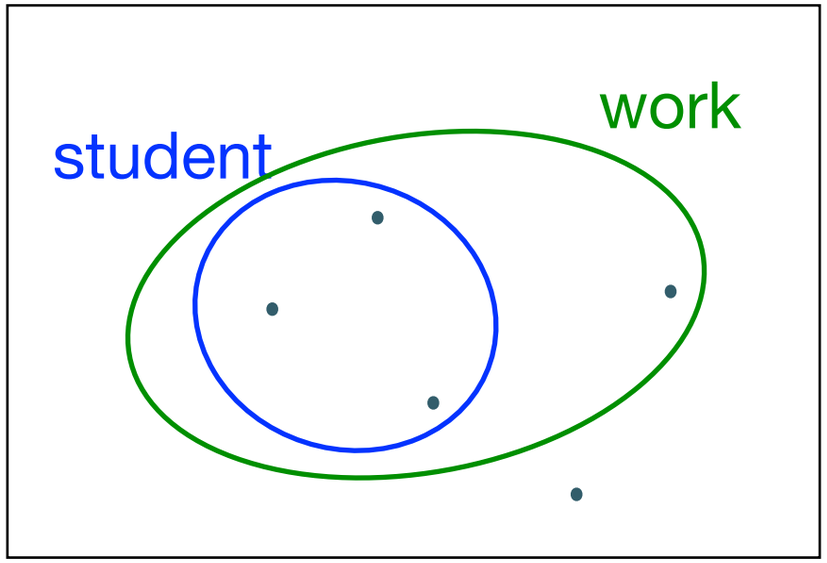
- λPλQ∀x(P(x) → Q(x))(student') ⇒β λQ∀x(student'(x) → Q(x))
- λQ∀x(student'(x) → Q(x))(work') ⇒β ∀x(student'(x) → work'(x))

Step 2: from formula to model

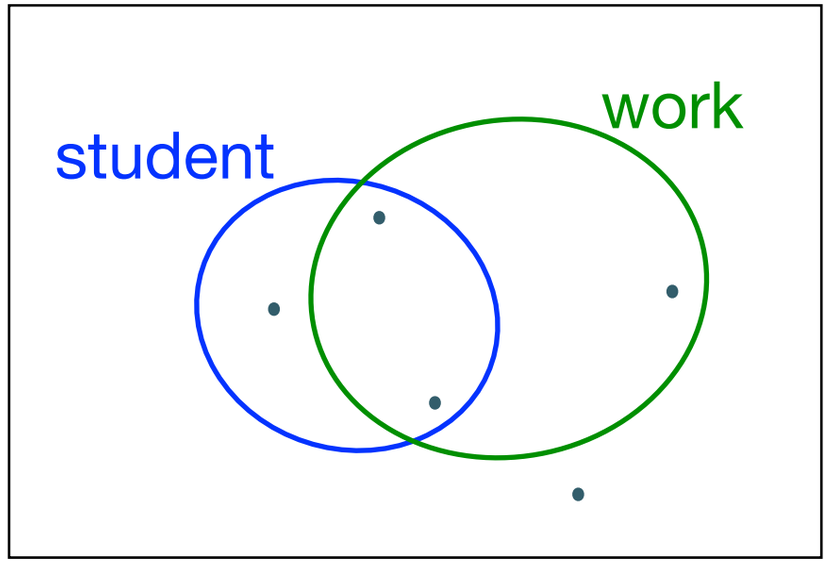
Every student works

$[\![\forall x(\text{student'}(x) \rightarrow \text{work'}(x))]\!]^{M,g} = 1$ 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 ↦ Jumbo is grey

   b. Jumbo is a small elephant ↛ 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 ↦ All children came home

6. No children came home late ↛ No children came home

Part II:
Lexical semantics

Zooming in: the meaning of words

Lexical semantics revisited:

- student ↦ 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 ⊭ 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.

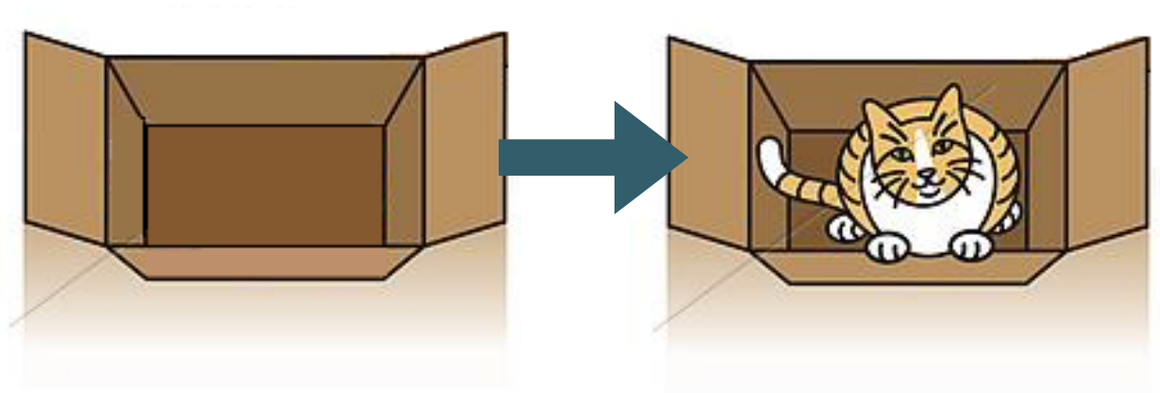
       b. Bill doesn’t regret that his cat has died

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

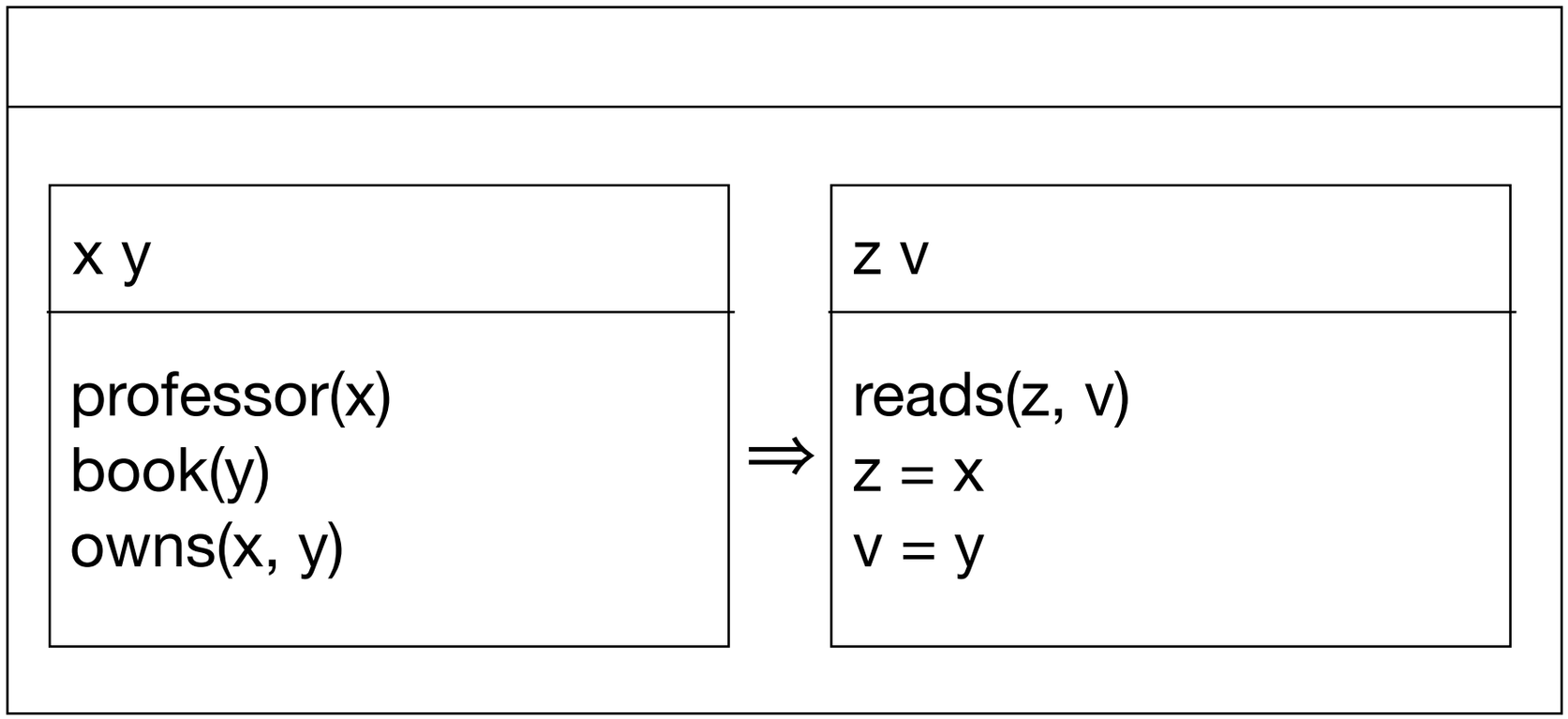
Solution: Meaning = context-change potential



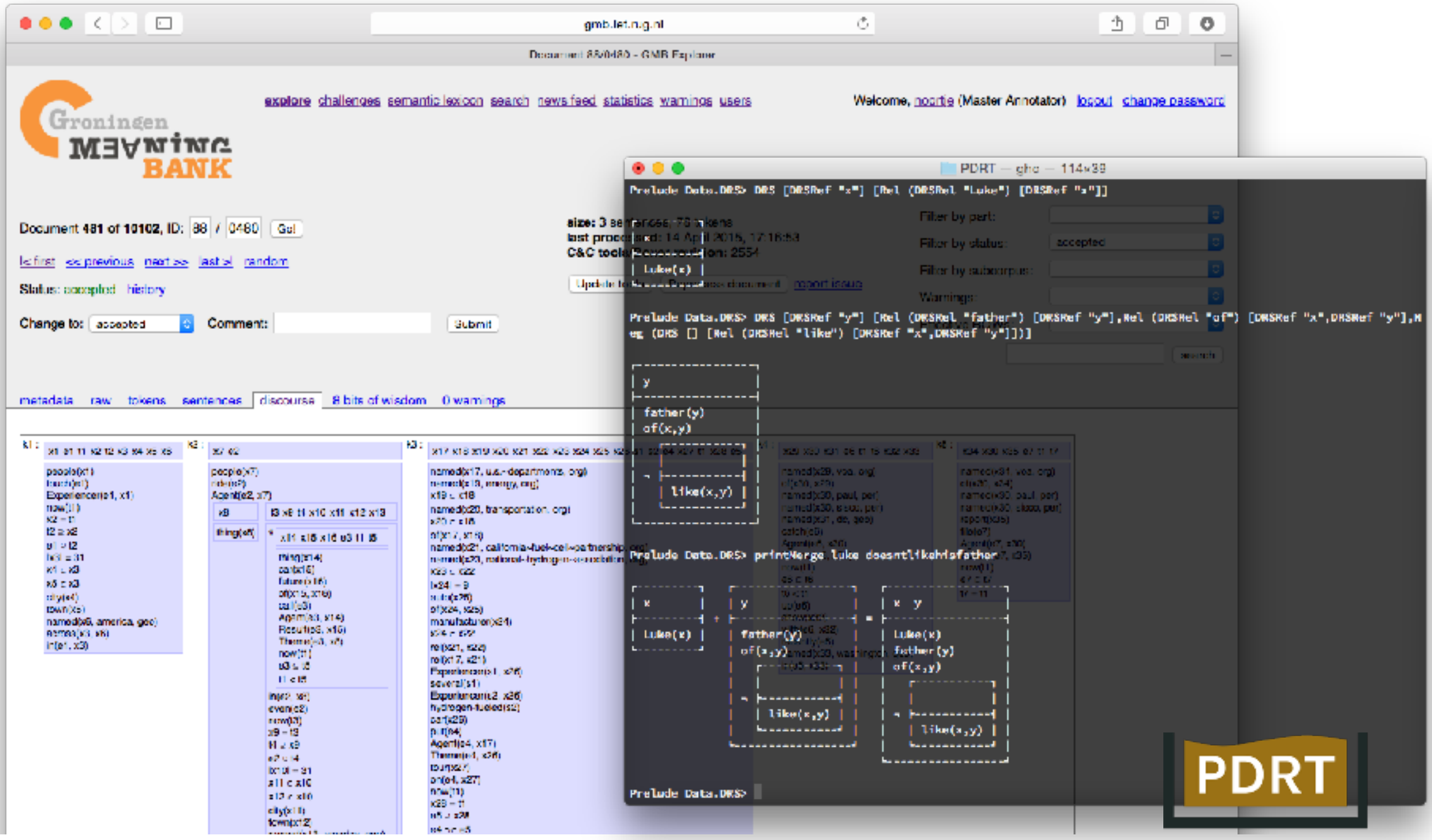
Discourse Representation Theory

If a professor owns a book, he reads it.

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



Applications of DRT



Part IV:
Current Issues in Semantic Theory

The Next Big Thing in Semantic Theory…

"*You shall know a word by the company it keeps*" (J. R. Firth, 1957)

Distributional Semantics

- word meaning as high dimensional vectors derived from corpora (*big data!*)
- semantic similarity ~ vector similarity
- … but what about formal semantic principles such as compositionality?

Distributed Situation State-space

- Meaning vectors defined over propositions in a world
- Expressive, compositional, probabilistic, inferential and neurally plausible
- … but how does it relate to formal semantic models?

Open questions

- 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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