ACTL
INTRO TO FORMAL SEMANTICS

Lecture 1

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Course info

- Instructors
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- All lecture material (including slides & homework) will be available on [Moodle]

Course info (cont.)

- This course is an introduction to **formal semantics**
  - Formal semantics uses formal/mathematical/logical concepts and techniques to study natural language semantics
  - Topics of this course: **quantification**

- Tentative plan
  - Lecture 1: Truth-conditions, compositionality
  - Lecture 2: Quantification in Predicate Logic vs. English
  - Lecture 3: Generalized Quantifiers
  - Lecture 4: Quantifier Scope
  - Lecture 5: Cross-linguistic variation, generics

What formal semanticists do

Syntax vs. Semantics

- **Syntax** = scientific study of **sentence structure**
  - Main data: grammaticality judgments
    (= native speakers' intuitions about well-formedness)
  - Research questions include:
    - What are the principles behind the observed patterns of grammaticality judgments?
    - How do languages differ?
    - How do we acquire such knowledge?

- **Semantics** = scientific study of **meaning**
  - Main data: native speaker's intuitions about meaning

- **But what is meaning???**

Truth-conditional intuitions

- One important aspect of our semantic intuitions concerns the **truth** of declarative sentences
- A native speaker can tell when a given (grammatical) declarative sentence is **true** and when it is **false**

1) A yellow squirrel danced with a blue fox

- Truth-conditional intuitions underlie intuitions about **entailment**:
  - S_1 *entails* S_2 iff whenever S_1 is true, S_2 is also true
  - e.g. 1) entails 2)

2) A squirrel danced with a fox

Truth-conditions

- To know the meaning of a sentence, you need to know its truth-conditions
  - "**A yellow squirrel danced with a blue fox**"
    is true if there is a yellow squirrel and a blue fox and the former danced with the latter;
    is false otherwise
  - Abbr.:
    "**A yellow squirrel danced with a blue fox**" is true **iff** (=if and only if) there is a yellow squirrel and a blue fox and the former danced with the latter

Truth-conditions

- Generally,

  "**S**" is true iff S is the case

- This looks trivial because so far the **object language** and **meta-language** are the same, i.e. English

- Consider a different object language. What are the truth-conditions of "**Aslan Tursundin igiz**" in Uyghur?
- In order to know the meaning of this sentence, you at least need to know its truth-conditions

Non-truth-conditional meanings

- NB: Truth-conditions are not everything there is to meaning!
  - Pragmatic inferences (incl. conversational implicatures)
    1) "Do you want to go to movies with us?"
       "Well, I need to work" ⇝ I cannot!
  - Conventional implicatures
    2) "Yasu is Japanese **but** rude"
       ⇝ Japanese people are usually polite
  - Proverbs/idioms, irony, etc. etc.

Syntax-semantics interface

- Q: What forms express what truth-conditional meanings?
  (the form/syntax-meaning/semantics mapping)

- A native speaker knows the truth-conditions of sentences that they have not encountered before

  1) A pink squirrel kissed a transparent fox
  2) A transparent squirrel kissed a pink fox

- Since there are infinitely many such sentences, there must be some general mechanism that computes the truth-conditions of sentences based on their parts

Compositionality

- One way to make sense of this is the assumption that natural languages are **compositional**

- **The Principle of Compositionality**:
  The meaning of a complex phrase (TP, VP, DP, etc.) is determined by
  - the meanings of its parts; and
  - how they are combined

- E.g. if you know the meanings of "**pink**", "**squirrel**" and how to put together, you know the meaning of "**pink squirrel**"

Compositional semantics

- We know the truth-conditions of sentences
- Assuming the principle of compositionality,
  - what kind of meanings do we need to assign to subsentential constituents? (e.g. "**pink squirrel**")
  - what are the ways to combine such meanings?

- Formal semantics offers interesting answers to these questions
- It makes use of techniques developed by logicians to study artificial languages like Predicate Logic

Model-theoretic semantics

- The standard approach in formal semantics is called **model-theoretic**
- (alternatives include proof-theoretic semantics)

- In model-theoretic semantics, each phrase is given a meaning (called **denotation**) relative to a **model**
- A model is a set-theoretic structure of a certain kind, and is meant to represent a particular (possible) state of affairs

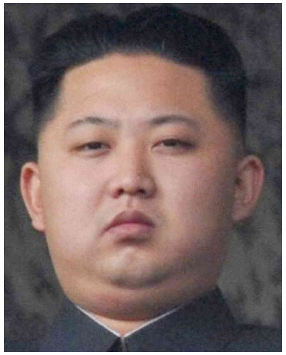
- The denotation of a phrase α relative to a model M is often written as $[\![\alpha]\!]^M$

Referring expressions

- For example, 'referring expressions' like proper names and definite descriptions are assigned **entities/ individuals** as their denotations
  - $[\![\text{David}]\!]^{M1}$ =  $[\![\text{David}]\!]^{M2}$ = 
- And sentences are assigned **truth-values** (0/falsity or 1/truth)
  - $[\![\text{David is a football player}]\!]^{M1} = 0$
  - $[\![\text{David is a football player}]\!]^{M2} = 1$

Non-actual models

- A model represents a possible state of affairs and does not necessarily have to look like the actual state of affairs

  - $[\![\text{David}]\!]^{M5} =$ 

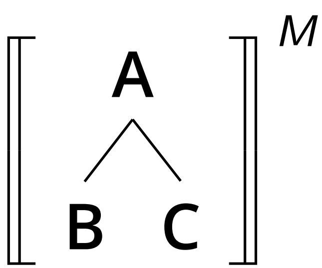
  - $[\![\text{David lives in Tuscany}]\!]^{M5} = 1$

Functional meanings

- The denotations of other kinds of phrases are generally taken to be **functions** of some kind, e.g.
  - $[\![[_{VP} \text{ speaks Hawaiian}]]\!]^M$ = the function that maps any entity x to 1 if x speaks Hawaiian in M, and to 0 if x does not speak Hawaiian in M
  - $[\![[_{VP} \text{ is British}]]\!]^M$ = the function that maps any entity x to 1 if x is British in M, and to 0 if x is not British in M

- (other non-functional semantic objects include degrees, time intervals, possible worlds, situations, etc. We won't discuss these in this course)

Frege's Conjecture

- Following Gottlob Frege's conjecture, it is assumed that meanings combine via **function application**
  - When two meanings combine, one of them is a function and the other one is its argument, and the result is the former applied to the latter
  - I.e. 

$= [\![\mathbf{B}]\!]^{M}([\![\mathbf{C}]\!]^{M})$ or $[\![\mathbf{C}]\!]^{M}([\![\mathbf{B}]\!]^{M})$
  - E.g. $[\![[_{TP}$ David $[_{VP}$ is British$]]]\!]^{M1}$
    $= [\![[_{VP}$ is British$]]\!]^{M1}([\![$David$]\!]^{M1})$
    $=$ 1 if David Bowie is British in M1, and 0 otherwise

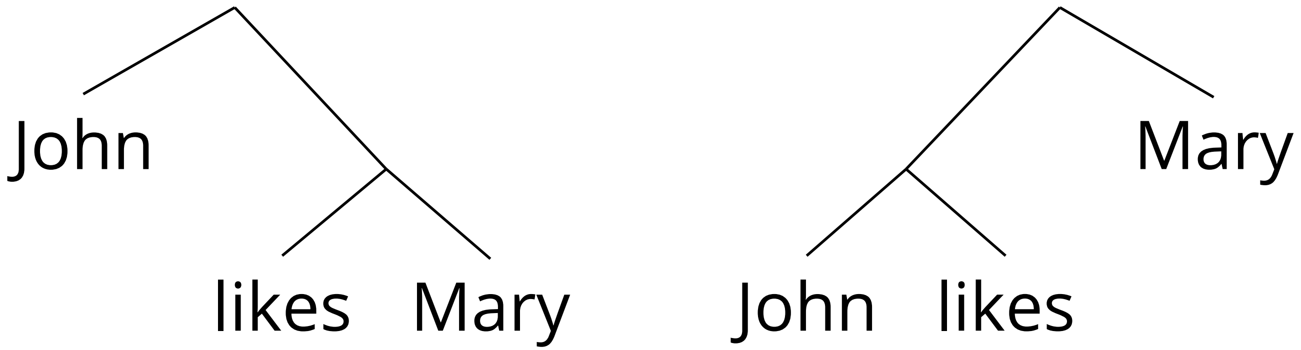
Expressions with constant denotations

- The denotations of expressions like “David” and “is British” vary across models
  - Who David is depends on the situation
  - Who is British depends on the situation

- But meanings of items like “and” and “every” should stay constant across models
- Formal semantics has lots of interesting things to say about such expressions
- In this course, we will analyze **quantificational expressions** like “every” and “no”

Role of syntax

- Semantics is inherently contingent on syntax
- If the structure were different, we would need to give different meanings
  - E.g., depending on which structure is right, we need a different semantics for "likes"



- We assume the kind of structure that syntacticians assume to be correct

Summary

- <u>**Compositionality Principle**</u>

  The meaning of a complex phrase is determined by the meanings of its parts and how they are combined
- **Model-theoretic semantics** assigns each phrase a **denotation** relative to a **model**
- Meanings combine via **function application** (Frege's conjecture):

$$\left[\!\!\left[\begin{array}{c} \mathbf{A} \\ \wedge \\ \mathbf{B} \quad \mathbf{C} \end{array} \right]\!\!\right]^{M} = [\![\mathbf{B}]\!]^{M}([\![\mathbf{C}]\!]^{M}) \text{ or } [\![\mathbf{C}]\!]^{M}([\![\mathbf{B}]\!]^{M})$$

- The resulting theory accounts for truth-conditions of arbitrary sentences (and their entailment patterns)

Quantification

Quantification

- Every natural language has **quantificational expressions** that are about 'quantities'

1) **One** syntactician bought **three** laptops
2) **Every** semanticist speaks German
3) **Few** phonologists are idiots
4) **More** linguists **than** psychologists like teaching
5) **20%** of the water is contaminated
6) **Whenever** I come to UCL, I get depressed
7) Honestly, I **often** go to Starbucks
8) I am **required** to teach semantics

Quantification (cont.)

- If English didn't have quantificational expressions, how would you express the following?
  1) According to **one survey** of faculty salaries in **28 countries**, in **no country** are **academics** paid **as much as** their peers with **non-academic jobs**

- Quantification is essential to natural language and human cognition in general
  - How do natural languages express quantification?
  - How are the meanings of quantificational expressions acquired?

Syntax-semantics mapping

- Q: How do natural languages express quantification?
- English vs. Predicate Logic (see Lecture 2)

1) a. No boy has a cat
   b. $\neg \exists x[boy(x) \wedge \exists y[cat(y) \wedge have(x,y)]]$
2) a. Every boy has a cat
   b. $\forall x[boy(x) \Rightarrow \exists y[cat(y) \wedge have(x,y)]]$

- English vs. Japanese (see Lecture 5)

3) **every** paper that **anybody** wrote
4) **dare**-ga kaita **dono** ronbun-**mo**
   who-nom wrote **which** article-??

Summary and look ahead

- **Key concepts**
  - Truth-conditions
  - Compositionality
  - Quantification
- **Plan**
  - Lecture 2: Quantification in Predicate Logic and how it differs from English
  - Lecture 3: Generalized Quantifier Theory
  - Lecture 4: Quantifier Scope
  - Lecture 5: More on quantification in natural language