Semantics

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Bureaucracy

Course Details

- This course will be *interactive*
  - regular class participation
  - questions/comments desired
- Course webpage: `https://home.uni-leipzig.de/~gkobele/courses/2018/Semantik`

How to contact me

- I am available for short questions immediately after class
  - (please) try to ask questions about the lecture *during the lecture*
- email me (gkobele@uni-leipzig.de) to schedule a meeting
- my office:

H1 5.11
Beethovenstr 15

Tutorial

- *Max Polter* teaches the tutorial for this course
- The tutorial is especially important:
  Mathematics is like dancing, you cannot learn to do it by watching

Grading

- The final grade is based on an exam at the end of the semester

Readings

- It is your responsibility to learn the material in this course
- There are a number of excellent texts out there
  - von Stechow's lecture notes (I, II)
  - Winter's textbook
  - Heim & Kratzer's textbook (at the publisher)
  - Portner's textbook (at the publisher)

Topics

Linguistic

- What meaning is
- Meaning of complex objects
- Quantification
- Pronouns?
- Tense?
- Propositional Attitudes?

Topics

Formal

- Sets and functions
- Types
- Lambda calculus
- Boolean algebra?

Introduction

An empirical science

Goal:
to understand *linguistic competence*

Linguistic Competence
The regularities underlying our ability to *use* language

Phonology

- What are the basic sounds in a language?
- What are the restrictions on sound combinations in a language?
- How does the pronunciation of morphemes change?

Phonological Competence

Morphology

- What are the different forms of words

Morphological Competence

Syntax

- Which sequences of words are grammatical?

Syntactic Competence

What can we do?

- this sentence is true/false in this situation
- these sentences are contradictory
- these sentences entail this one

Meaning

We could say:
Semantics is the study of meaning

Meaning

We could say:
Semantics is the study of meaning

What is meaning?

Entailment

Entailment

$S_1 \Rightarrow S_2$

1. in any situation where S_1 is true, S_2 is also true
2. committing to S_1 commits you to S_2
    - you can't (coherently) assert both S_1 and $\neg S_2$

sometimes I'll say 'implication'/'implies'
instead of 'entailment'/'entails'

An example

1. John walked
2. John moved

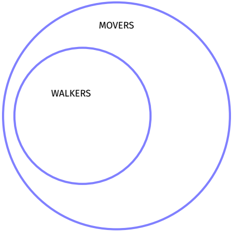
An example

1. John walked
2. John moved

$$1 \Rightarrow 2$$

A useful intuition

- imagine the people who walk (WALKERS)
- and the people who move (MOVERS)



Another example

1. A dog barked
2. An animal barked
3. A dog made a sound

Another example

1. A dog barked
2. An animal barked
3. A dog made a sound

$1 \Rightarrow 2$ and $1 \Rightarrow 3$

Restrictor	Scope
up	up

Yet another example

1. No dog barked
2. No animal barked
3. No dog made a sound

Yet another example

1. No dog barked
2. No animal barked
3. No dog made a sound

$1 \Leftarrow 2$ and $1 \Leftarrow 3$

Restrictor	Scope
down	down

One more time

1. Every dog barked
2. Every animal barked
3. Every dog made a sound

One more time

1. Every dog barked
2. Every animal barked
3. Every dog made a sound

$1 \Leftarrow 2$ and $1 \Rightarrow 3$

Restrictor	Scope
down	up

Summary

Det	Restrictor	Scope
a	up	up
no	down	down
every	down	up
exactly two	xxx	xxx

We want to

- catalogue *entailment* relations between sentences
- identify *regularities* therein
- explain them

Semantics

A Semantic Theory

How to explain:

1. this sentence is true/false in this situation
2. these sentences are contradictory
3. these sentences entail this one

One approach

- if we knew under what conditions a sentence were true
- we could model these abilities

How truth conditions explain

Assume we know:
for each sentence, what the world has to be like for it to be true

this sentence is true/false in this situation
check whether this situation is one which makes the sentence true

these sentences are contradictory
check whether their truth conditions are incompatible

these sentences entail this one
check whether the conditions the world has to satisfy to make all of these sentences true also makes this one true

Truth conditional semantics

The goal
associate to each sentence its *truth-conditions*

Sentence	Truth conditions
Greg is awake	there is a person named greg and he is awake at the time of speech
John loves pizza	there is a person named john and he really likes stuff called pizza
⋮	⋮

Another Semantic Theory

How to explain:

1. this sentence is true/false in this situation
2. these sentences are contradictory
3. these sentences entail this one

Another approach

- If we could translate a sentence into a logical formula
- we could model these abilities

How logic explains

Assume we know:
for each sentence, what its logical formula is

this sentence is true/false in this situation
describe the situation in logical formulae, and see if they prove the formula for our sentence

these sentences are contradictory
check whether their formulae prove a condtradiction

these sentences entail this one
check whether their formulae allow this one's formula to be proven

The goal
associate to each sentence a logical formula

Sentence	Formula
Greg is awake	$\exists x.\text{name}(x) = \text{Greg} \wedge \text{awake}(x)$
John loves pizza	$\exists x.\text{name}(x) = \text{John} \wedge \forall y.\text{pizza}(y) \rightarrow \text{loves}(x, y)$
⋮	⋮

How to do this?

No matter what we choose to do
we must assign something (truth-conditions, a formula) to *infinitely many* sentences

- we can generically call this a meaning

This is the core problem of semantics

Composition

Lists

We cannot make a list of sentences and their meanings
because infinite

but what about just those sentences that people use?

Familiar objection

Language is creative
We can understand sentences we've never heard before

$\rightsquigarrow$ language is infinite

Let's look at all possible short *sentences (20 words or fewer)*

Just short sentences please

There's still a lot to write down!

- let n be the number of English words
- n^k is the number of sequences of words of length k

You know around 20,000 words

Possible seqences of 20 words

$$20000^{20} > 10^{80}$$

Even short lists are too long

Possible seqences of 20 words

$$20000^{20} > 10^{80}$$

The Universe
there are $\approx 10^{80}$ atoms in the known universe

The moral
there are too many sentences to brute force

The way to describe an infinite set
is to find some way to make it finite

Numbers
The set of all (non-negative) integers is gotten by the following two operations:

1. 0
2. add 1 to something

Linguistic regularities

To describe the meaning associated with a sentence need to

1. identify parts of sentences, and
2. how they are put together

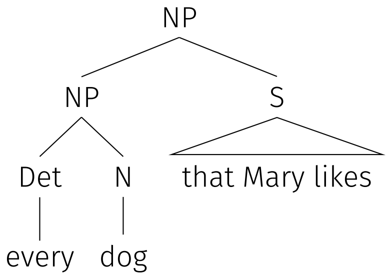
Compositionality

The meaning of a sentence is determined by

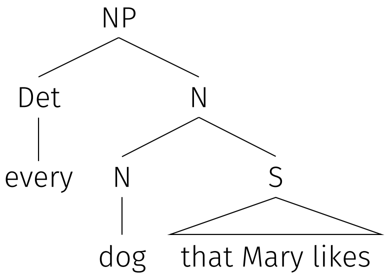
1. *the meanings of its parts, and*
2. *the way they are put together*

Relative clause structure

NP-adjunction



N'-adjunction



that Mary likes is part of the restrictor

- every dog barked ⇒ every dog that Mary likes barked
- the meanings of N and S should be combined *before* they are combined with the determiner

Compositionality

The meaning of a sentence is determined by

1. *the meanings of its parts, and*
2. *the way they are put together*

if structure = syntactic structure

- syntactic theory influences semantic theory

  syntax *this* is the right structure

- and semantic theory influences syntactic theory

  semantics the structure must look like *this*

Meanings

What are the meanings of parts?

Sentence meanings

truth conditions descriptions of how the world must be like for the sentence to be true

logical formulae structured objects that support inference

Parts

truth conditions ???

logical formulae parts of formulae

Parts of logical formulae

Every boy will laugh

$\forall x.\textsc{boy}(x) \rightarrow \textsc{laugh}(x)$

need some way to break this up into pieces:

word	meaning
boy	BOY
laugh	LAUGH
every	$\forall x.\Box_1(x) \rightarrow \Box_2(x)$

$\forall x.\Box_1(x) \rightarrow \Box_2(x)$
a formula that is missing parts

- two 'holes'

The λ-calculus
a language for talking about decomposing structured objects

- holes have names $\lambda P, Q.\forall x.P(x) \rightarrow Q(x)$
- here, P is the name for the first hole
- and Q the name for the second

Parts of truth conditions

Every boy will laugh
true iff the set of all boys is a subset of the set of all laughers

need some way to break this up into pieces:

word	meaning
boy	BOYS
laugh	LAUGHERS
every	???

EVERY should be a *function*
takes two arguments

- restrictor set
- scope set
- output: a truth value
  true iff $RESTRICTOR \subseteq SCOPE$

Truth in a Model

We want truth *conditions*
under what circumstances a sentence is true

We *explicitly represent* ways the world could be
A model is a way the world might be

- there is some set of things
- there are relations that hold between these things

An interpretation of a sentence
we say what each word means

- *boy* denotes a set of things (these are the boys)
- *laugh* denotes a set of things (these are the laughers)
- *Greg* denotes a thing (this is Greg)

in general we write
$[\![\textit{word}]\!]$ for the denotation of a word

Parts of truth conditions again

Every boy will laugh
true iff the set of all boys is a subset of the set of all laughers

$[\![\textit{every}]\!]$
the function which takes two sets and returns true if the one is a subset of the other

$$[\![\textit{every boy will laugh}]\!] = [\![\textit{every}]\!] \left([\![\textit{boy}]\!], [\![\textit{laugh}]\!] \right)$$

Parts revisited

Sentence meanings

truth conditions descriptions of how the world must be like for the sentence to be true

logical formulae structured objects that support inference

Parts

truth conditions sets, functions, relations

logical formulae formulae with holes