Formale Semantik
02. Referentielle Semantik

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stets aktuelle Fassungen: `https://github.com/rsling/VL-Deutsche-Syntax`

Inhalt

Organization

Main textbooks

- Chierchia & McConnell-Ginet, *Meaning and Grammar*
- Partee, ter Meulen & Wall, *Mathematical Methods in Linguistics*
- Blackburn, Bos & Striegnitz, *Learn Prolog now!*
- Blackburn & Bos, *Computational Semantics for Natural Language*

Further reading

- Bucher, *Einführung in die angewandte Logik*
- Sag, Wasow & Bender, *Syntactic Theory*
- Dowty, *Tense, Time Adverbs, and Compositional Semantic Theory*
- Partee, *Noun Phrase Interpretation and Type-shifting Principles*
- Copestake, Flickinger & Sag *Minimal Recursion Semantics*

The three sessions

- Formal Semantics, 90 min. on Wednesday
- PROLOG, 30 min. on Wednesday
- Tutorial, 90 min. on Friday
- Summer course (implementation), 1 week

The first weeks: Preliminaries (subject to changes)

Session 1	Introduction to Referential Semantics (CM chap. 1 & 2)
Session 2	Set theory, ordering theory, statement logic (PMW chap. 1 - 6)
Session 3	Predicate calculi (PMW chap. 7 & 8)

The middle weeks: First steps (subject to changes)

Session 4	Quantification and model theory (CM chap. 3)
Session 5	Quantification in English (CM chap. 3)
Session 6	Intensionality (CM chap. 5)
Session 7	Tense, modals, complementizers (CM chap. 5)
Session 8	λ (CM chap. 7)

The final weeks: Advanced topics (subject to changes)

Session 9	Word meaning (CM chap. 8)
Session 10	Generalized quantifiers (CM chap. 7)
Session 11	Type shifting (Partee)
Session 12	Underspecified scope (Copestake *et al.*)
Session 13	Backup session
Session 14	Final test on 2004-07-13

What *meaning* could mean

- The meaning of an expression is the idea conveyed by it.
- ...is the mental image it creates.
- ...is what a speaker wants to achieve by uttering it.
- ...is the set of objects to which it refers (for example in the case of nouns).

What the study of meaning could be

- The study of the intellectual concepts perceivable in the world.
- ...of how the brain processes expressions, relates it to (fields of) cognitive concepts.
- ...of how a discourse of planful and intelligent agents (humans) is structured.
- ...of the correspondences between expressions and objects; and of how expressions are combined to be used productively.

What this class is about

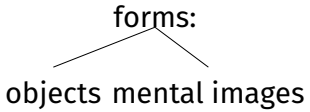
- Which objects do words refer to?
- What makes sentences true?
- How is the informational value of sentences related to their logical structure?
- How can sentences be unambiguously interpreted?

What this class is not about

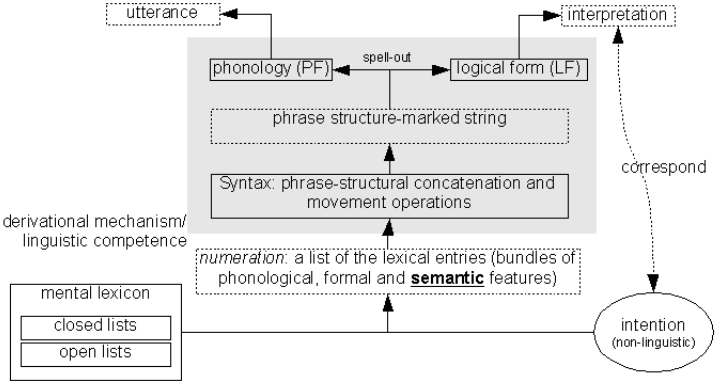
- what words mean,
- how the brain works with sentences,
- the structure of discourse (at least not much).

Linguistic theories

The theory of signs: a triangle



Semantics in the Chomskian T-model



LF is just the logical form

- No interpretation proper at LF.
- Movement transformations after the sentence has been uttered.
- At the LF level, sentences have a form compatible to their logic.
- Why? Syntax itself is often inadequate to express all alternatives of a sentence's logical representation.

A referential framework

Some properties of language

- aboutness
- referential nature
- informative
- objectiveness (of content)
- But which linguistic elements refer to what?

Names

an individual name $\longrightarrow$ one object in the world

Harald Schmidt

Common nouns

a common noun $\longrightarrow$ lots of objects

soldier

etc.

Adjectives

an adjective $\longrightarrow$ lots of different objects of different kinds

is human

Sentences

a sentence $\longrightarrow$ a situation. a fact, ...

A humming bird is hovering over a red flower.

not at all
(object type mismatch)

Frege's Principle: Meaning is compositional

- *A humming bird* $\longrightarrow$ one of many individuals
- *is hovering* $\longrightarrow$ a property of that individual
- *over* $\longrightarrow$ a relation between individuals
- *a red* $\longrightarrow$ a property of another individual
- *flower* $\longrightarrow$ the other one of many individuals
- *is hovering over a red flower* $\longrightarrow$ a complex property.

Recursion: infinite use of finite means

- Frege's principle is indispensable!
- *Harald Schmidt is human.*
- *Harald Schmidt is human and tall.*
- *Harald Schmidt is human and tall and male.*
- *Harald Schmidt is human and tall and male and not blue.*
- *Harald Schmidt is human and tall and male and not blue and grumpy in the morning...*

Some fundamental semantic notions

Basic semantics judgements

- entailment
- presupposition
- ambiguity
- synonymy

Entailment: pure logic

- A: *This is electronic.*
- B: *This is a presentation.*
- C follows logically: *This is an electronic presentation.*
- $A, B \vdash C$
- $A \nvdash C$
- $B \nvdash C$

Entailment: pure logic, formally

- D: *Harald Schmidt is human.*
- E follows logically: *Something is human.*
- $D \vdash E$
- $D \wedge D$ follows logically: *Harald Schmidt is human and Harald Schmidt is human.*
- $D \vdash D \wedge D$

Tests: X entails Y if...

- When X is true, Y is true.
- A situation described by Y is also described by X.
- The information given by Y is fully contained in the information given by X.
- One cannot say X is true and Y is false.

Entailments?

- *Harald Schmidt is a talkmaster.* $\rightarrow$ *Harald Schmidt is human.*
- *Harald Schmidt is tall.* $\rightarrow$ *Someone is tall.*
- *Some humans are tall.* $\rightarrow$ *Harald Schmidt is tall.*
- *I have listened to Paul Kalkbrenner's new 12" on bpitchcontrol.* $\rightarrow$ *Paul Kalkbrenner has released a 12" on bpitchcontrol.*
- *After I had a Beck's, I installed RedHat on my PC.* $\rightarrow$ *I had a Beck's.*
- *After the bootloader had failed to boot RedHat on my PC, I had another Beck's.* $\rightarrow$ *RedHat has never booted on my PC.*
- *My flatmate likes Beck's.* $\rightarrow$ *My flatmate hates beer.*
- *Harald Schmidt cancelled his show.* $\rightarrow$ *Harald Schmidt's show was cancelled.*

Presuppostion: the background

- A: *Willy Brandt is the current chancelor of the FRG.*
- B: *If Willy Brandt is the current chancelor of the FRG, why doesn't he do something?*
- C: *Willy Brandt is not the current chancelor of the FRG.*
- A and B presuppose D: *Willy Brandt is alive.*, C doesn't.
- A, B, and C presuppose E: *There is a chancelor of the FRG.*
- Note: $A \vdash D$, $A \vdash E$
- But: $B \nvdash D$, $B \nvdash E$, $C \nvdash E$

Presuppostion: two tests

- Presuppositions are triggered by all sorts of sentences (incl. negations, modals, conditionals, etc.).
- Presuppositions can be negated while the sentence which presupposes them remains true. Entailments cannot be negated while keeping the entailing sentence true.

Ambiguity in syntax

- *She saw the man with a telescope.*
- She [saw the man] with a telescope.
- She saw [the man with a telescope].

Ambiguity in semantics: scope

- *Everybody loves somebody.*
- Every person loves at least one other person. (Needn't be the same.)
- There is one person loved by everyone

Synonymy

- Lexical synonymy: *humming bird* $\overset{lex}{\equiv}$ *colibri*
- Compositionally (**equivalence**): *Mulder met his abducted sister after he broke into the secret army base.* $\equiv$ *Before meeting his abducted sister, Mulder broke into the secret army base.*
- $A \equiv B$ iff $A \vdash B$ and $B \vdash A$

From reference to sense

Noun-like expressions and complex NPs

- I saw a man.
- I saw the green wobbly thing crawling near.
- I saw it.

Problems with referential NPs

- *The dark subatomic particles in the universe have a total mass much larger than the visible subatomic particles.*
- *Problems with referential semantic theories don't concern Rumpletweezer.*
- and of course, vagueness (e.g., Sorites Paradox)

Problems with non-referential NPs

- *some guy*
- *not the faintest trace of blood*
- *any axiom of Zermelo-Fraenkel set theory*

Beyond pointin-at-and-naming

We need a logic to explain for effects like:

	my humming bird's favorite flower	is red
$\vdash$	some flower	is red

Some content-synonymous simple expressions

- a: *colibri*
- b: *humming bird*
- c: *a brunette lady*
- d: *a brown-haired dame*
- e: *the primates*
- f: *the apes and humans*
- $\mathsf{a} \overset{lex}{\equiv} \mathsf{b}$, $\mathsf{c} \overset{lex}{\equiv} \mathsf{d}$, $\mathsf{e} \overset{lex}{\equiv} \mathsf{f}$

Some content-synonymous complex expressions

- A: *A colibri is hovering over a red flower.*
- B: *A humming bird is hovering over a red flower.*
- C: *Lauren Bacall was a brunette lady*
- D: *Lauren Bacall was a brown-haired dame*
- E: *Primates are intelligent.*
- F: *The apes and humans are inteligent.*
- A $\equiv$ B, C $\equiv$ D, E $\equiv$ F

Two axioms

- Ax1 Two expressions (e.g., NPs, sentences) that are synonymous have the same reference.
- Formally: $A \equiv B$ then $[\![A]\!] = [\![B]\!]$
- Note: $[\![A]\!]$ is applicable to simplex and complex expressions A; it just produces the reference of A.
- Ax2 If we replace expression B within expression A with the synonymous expression C, then A does not change its reference.
- Formally: If $[\![B]\!] = [\![C]\!]$ then $[\![[_A\ B]]\!] = [\![[_A\ C]]\!]$

One common property of sentences: the truth value

- A: *Lauren Bacall was a brunette lady.* (assumed to be true in the actual world)
- B: *My cat sleeps quietly.* (assumed to be true in the actual world)

First conclusion

- $[_{\mathsf{T}}A]$ = *The truth value of 'Lauren Bacall was a brunette lady' is 1.*
- $[_{\mathsf{T}}B]$ = *The truth value of 'My cat sleeps quietly' is 1.*
- Such that $\mathsf{A} \equiv [_{\mathsf{T}}A]$ and $\mathsf{B} \equiv [_{\mathsf{T}}B]$.
  (Check: Whenever A is true, $[_{\mathsf{T}}A]$ is true and v.v.)
- So, by Ax1 $[\![\mathsf{A}]\!] = [\![[_{\mathsf{T}}A]]\!]$
  and $[\![\mathsf{B}]\!] = [\![[_{\mathsf{T}}B]]\!]$

Second conclusion

- Check the denotations of the contained NPs:
  $[\![\textit{the truth value of A}]\!] = [\![\textit{the truth value of B}]\!] = 1$
- Such that by Ax2:
  $[\![[_{\mathrm{T}} A]]\!] = [\![[_{\mathrm{T}} B]]\!]$
- Why? Exchanging the referentially identical NPs ‘the truth value of A’ and ‘the truth value of B’ in the otherwise identical sentences ‘_ is 1’ forces us to conclude by Ax2 that also the whole sentences must have the same reference. Our book (CM) is a bit vague on that point.

Final conclusion

$$[\![A]\!] = [\![[_T A]]\!] = [\![[_T B]]\!] = [\![B]\!] = 1$$

Sentences denote truth values.

Advantages of truth values

- indirect encoding of ‘richer’ semantics (One must know the truth conditions of a sentence and the state of affairs to decide about the truth of a sentence.)
- a minimal common semantic property of sentences
- easily computable in a formal system (binary)
- their logic provides a basis for ‘richer’ semantics (cf. second half of class)

Frege also thought, reference couldn't be all

Type	**Reference**	**Sense**
NP	individuals *Venus*	individual concepts
VP	sets *humming birds*	property concepts
S	1 or 0 *I like cats.*	thoughts

Some terminology

- *reference* = *extension* = what we're dealing with first
- *sense* = *intension* = what we will be dealing with later
- *proposition* = the intensions of sentences as informational content: The 'thought that S'.

We’re talking in fragments: F1

Decomposing compositionality and composing truth

- How are sentences compositionally built up?
- What do their parts denote?
- How does the denotation of the parts contribute to the whole.
- T-sentences: S of L is true in v iff p.
- *S* a sentence, *L* a language, *v* a state of affairs, *p* a statement of the truth conditions.

A phrase-structure grammar

- $S \rightarrow N\ VP$
- $S \rightarrow S\ conj\ S$
- $S \rightarrow neg\ S$
- $VP \rightarrow V_i$
- $VP \rightarrow V_t\ N$

A lexicon

- N $\rightarrow$ *Herr Webelhuth, Frau Eckardt, the Turm-Mensa*
- V_i $\rightarrow$ *is relaxed, is creative, is stupid*
- V_t $\rightarrow$ *prefers*
- conj $\rightarrow$ *and, or*
- neg $\rightarrow$ *it is not the case that*

Simple denotiations

- ⟦Herr Webelhuth⟧ = Herr Webelhuth
- ⟦Frau Eckardt⟧ = Frau Eckardt
- ⟦the Turm-Mensa⟧ = the Turm-Mensa
- ⟦is relaxed⟧ = {x:x is relaxed}
- ⟦is creative⟧ = {x:x is creative}
- ⟦is stupid⟧ = {x:x is stupid}
- ⟦prefers⟧ = {⟨x,y⟩: x prefers y}

Some words don't really 'denote', they act like functions

- $[\![\textit{neg}]\!] = \begin{bmatrix} 1 \rightarrow 0 \\ 0 \rightarrow 1 \end{bmatrix}$
- $[\![\textit{and}]\!] = \begin{bmatrix} \langle 1,1 \rangle \rightarrow 1 \\ \langle 1,0 \rangle \rightarrow 0 \\ \langle 0,1 \rangle \rightarrow 0 \\ \langle 0,0 \rangle \rightarrow 0 \end{bmatrix}$
- $[\![\textit{or}]\!] = \begin{bmatrix} \langle 1,1 \rangle \rightarrow 1 \\ \langle 1,0 \rangle \rightarrow 1 \\ \langle 0,1 \rangle \rightarrow 1 \\ \langle 0,0 \rangle \rightarrow 0 \end{bmatrix}$

T-sentences: rule-to-rule

- $[\![[_S \text{ N VP}]]\!] = 1$ iff $[\![\text{N}]\!] \in [\![\text{VP}]\!]$, else 0
- $[\![[_S \text{ S1 conj S2}]]\!] = [\![\text{conj}]\!] (\langle [\![\text{S1}]\!], [\![\text{S2}]\!] \rangle)$
- $[\![[_S \text{ neg S}]]\!] = [\![\text{neg}]\!] ([\![\text{S}]\!])$
- $[\![[_{VP} \text{ V}_t \text{ N}]]\!] = \{x: \langle x, [\![\text{N}]\!] \rangle \in [\![\text{V}_t]\!]\}$
- semantics for non-branching nodes: pass-up

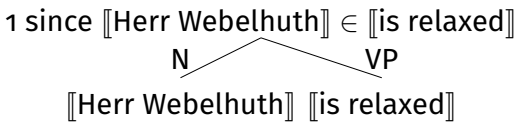
A starting point for our computation

Herr Webelhuth is relaxed.

- Circumstances (Model): Herr Webelhuth is an element of the set of relaxed individuals.
- (1) The syntax is well-formed by $S \rightarrow N\ VP$
- (2) for N: $[\![\text{Herr Webelhuth}]\!]$ = Herr Webelhuth
- (3) for VP: $[\![\text{is relaxed}]\!]$ = {x: x is relaxed}
- (4) for S: $[\![[_S\ N\ VP]]\!] = 1$ iff $[\![N]\!] \in [\![VP]\!]$, else 0

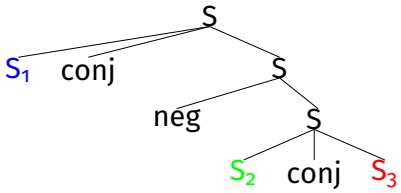
A starting point for our computation

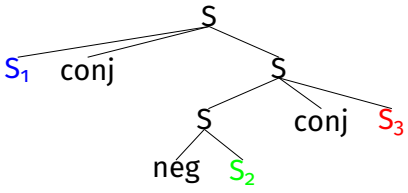
The tree:



We compute syntactic representations, not flat sentences

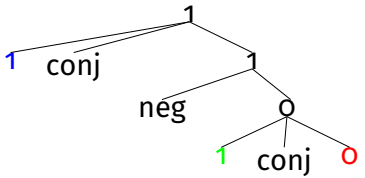
(S_1 Frau Eckardt is creative) and it is not the case that (S_2 Herr Webehlhuth is relaxed) and (S_3 Frau Eckardt prefers the Turm-Mensa).

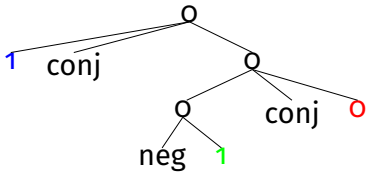




A starting point for our computation

Circumstances: Herr Webelhuth is relaxed, Frau Eckardt is creative, and Frau Eckardt does not prefer the Turm-Mensa:





Literatur I

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Lizenz