

Formale Semantik

02. Referentielle Semantik

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

- 1 Organization
 - Syllabus
 - Course Structure
 - Our subject
- 2 Linguistic theories
 - Semiotics
 - Generative Grammar
 - Levels of representation
- 3 A referential framework
 - The simple case
 - Complex cases
- 4 Some fundamental semantic notions
 - Entailment
 - Presupposition
 - Ambiguity, Synonymy, Vagueness, ...
- 5 From reference to sense
 - Referential and non-referential NPs
 - A 'reference' for complex terms?
 - Sentences refer to 0 and 1
 - Sense and reference
- 6 We're talking in fragments: F1
 - A syntax
 - The semantics: individuals, sets, functions, T-sentences
 - Bottom-up evaluation

Organization

- Chierchia & McConnell-Ginet, *Meaning and Grammar*

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- Partee, ter Meulen & Wall, *Mathematical Methods in Linguistics*

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- Blackburn, Bos & Striegnitz, *Learn Prolog now!*
- Blackburn & Bos, *Computational Semantics for Natural Language*

- Bucher, *Einführung in die angewandte Logik*

Further reading

- Bucher, *Einführung in die angewandte Logik*
- Sag, Wasow & Bender, *Syntactic Theory*

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- Dowty, *Tense, Time Adverbs, and Compositional Semantic Theory*

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- 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

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- PROLOG, 30 min. on Wednesday

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- 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 <i>et al.</i>)
Session 13	Backup session
Session 14	Final test on 2004-07-13

What *meaning* could mean

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- 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

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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?

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- What makes sentences true?

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- 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,

What this class is **not** about

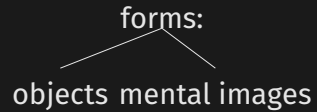
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What this class is **not** about

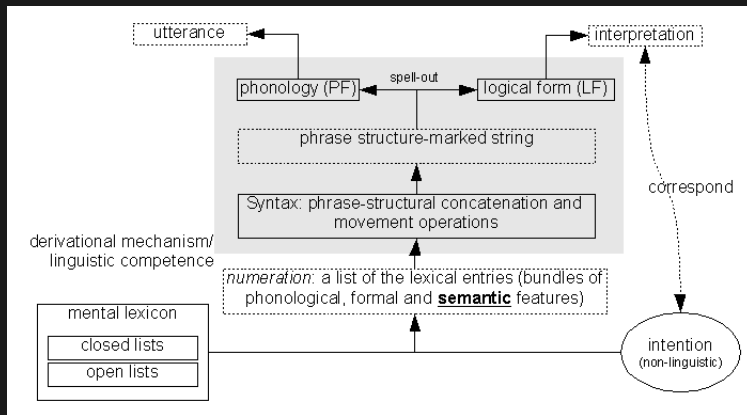
- what words mean,
- how the brain works with sentences,
- the structure of discourse (at least not much).

Linguistic theories

The theory of signs: a triangle



Semantics in the Chomskian T-model



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- 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

Some properties of language

- aboutness
- referential nature

Some properties of language

- aboutness
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- informative

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- objectiveness (of content)

Some properties of language

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

an individual name \longrightarrow one object in the world

Harald Schmidt



Common nouns

a common noun → lots of objects

soldier



etc.

Adjectives

an adjective → lots of different objects of different kinds

is human



a sentence



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* \rightarrow one of many individuals

Frege's Principle: Meaning is compositional

- *A humming bird* \longrightarrow one of many individuals
- *is hovering* \longrightarrow a property of that individual

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- *A humming bird* \longrightarrow one of many individuals
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- *over* \longrightarrow a relation between individuals

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- *A humming bird* \longrightarrow one of many individuals
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- *a red* \longrightarrow a property of another individual

Frege's Principle: Meaning is compositional

- *A humming bird* → one of many individuals
- *is hovering* → a property of that individual
- *over* → a relation between individuals
- *a red* → a property of another individual
- *flower* → the other one of many individuals

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.

- Frege's principle is indispensable!

Recursion: infinite use of finite means

- Frege's principle is indispensable!
- *Harald Schmidt is human.*

Recursion: infinite use of finite means

- Frege's principle is indispensable!
- *Harald Schmidt is human.*
- *Harald Schmidt is human and tall.*

Recursion: infinite use of finite means

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- *Harald Schmidt is human and tall.*
- *Harald Schmidt is human and tall and male.*

Recursion: infinite use of finite means

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- *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.*

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

- entailment

Basic semantics judgements

- entailment
- presupposition

Basic semantics judgements

- entailment
- presupposition
- ambiguity

Basic semantics judgements

- entailment
- presupposition
- ambiguity
- synonymy

- A: *This is electronic.*

Entailment: pure logic

- A: *This is electronic.*
- B: *This is a presentation.*

Entailment: pure logic

- A: *This is electronic.*
- B: *This is a presentation.*
- C follows logically: *This is an electronic presentation.*

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- $A, B \vdash C$

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- $A \not\vdash C$

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- B: *This is a presentation.*
- C follows logically: *This is an electronic presentation.*
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- $A \not\vdash C$
- $B \not\vdash C$

Entailment: pure logic, formally

- D: *Harald Schmidt is human.*

Entailment: pure logic, formally

- D: *Harald Schmidt is human.*
- E follows logically: *Something is human.*

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- $D \vdash E$

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.*

Entailment: pure logic, formally

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

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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?

Entailments?

- *Harald Schmidt is a talkmaster.* \rightarrow *Harald Schmidt is human.*

Entailments?

- *Harald Schmidt is a talkmaster.* → *Harald Schmidt is human.*
- *Harald Schmidt is tall.* → *Someone is tall.*

Entailments?

- *Harald Schmidt is a talkmaster. → Harald Schmidt is human.*
- *Harald Schmidt is tall. → Someone is tall.*
- *Some humans are tall. → Harald Schmidt is tall.*

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- *I have listened to Paul Kalkbrenner's new 12" on bpitchcontrol.* → *Paul Kalkbrenner has released a 12" on bpitchcontrol.*

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- *After I had a Beck's, I installed RedHat on my PC. → I had a Beck's.*

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- *Harald Schmidt cancelled his show. → Harald Schmidt's show was cancelled.*

Presupposition: the background

- A: *Willy Brandt is the current chancellor of the FRG.*

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- C: *Willy Brandt is not the current chancelor of the FRG.*

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- A and B presuppose D: *Willy Brandt is alive.*, C doesn't.
- A, B, and C presuppose E: *There is a chancellor of the FRG.*

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- Note: $A \vdash D$, $A \vdash E$

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- A, B, and C presuppose E: *There is a chancellor of the FRG.*
- Note: $A \vdash D$, $A \vdash E$
- But: $B \not\vdash D$, $B \not\vdash E$, $C \not\vdash E$

Presupposition: two tests

- Presuppositions are triggered by all sorts of sentences (incl. negations, modals, conditionals, etc.).

Presupposition: 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.

- *She saw the man with a telescope.*

Ambiguity in syntax

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

Ambiguity in syntax

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

- *Everybody loves somebody.*

Ambiguity in semantics: scope

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

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

- Lexical synonymy: *humming bird* $\overset{lex}{\equiv}$ *colibri*

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- 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.*

- 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.

Noun-like expressions and complex NPs

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

Noun-like expressions and complex NPs

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

- *The dark subatomic particles in the universe have a total mass much larger than the visible subatomic particles.*

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- *Problems with referential semantic theories* don't concern *Rumpletweezer*.

- *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 *Rumplesteeze*.
- and of course, vagueness (e.g., Sorites Paradox)

- *some guy*

Problems with non-referential NPs

- *some guy*
- *not the faintest trace of blood*

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
⊢	some flower	is red

Some content-synonymous simple expressions

- a: *colibri*

Some content-synonymous simple expressions

- a: *colibri*
- b: *humming bird*

Some content-synonymous simple expressions

- a: *colibri*
- b: *humming bird*
- c: *a brunette lady*

Some content-synonymous simple expressions

- a: *colibri*
- b: *humming bird*
- c: *a brunette lady*
- d: *a brown-haired dame*

Some content-synonymous simple expressions

- a: *colibri*
- b: *humming bird*
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- d: *a brown-haired dame*
- e: *the primates*

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- a: *colibri*
- b: *humming bird*
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- d: *a brown-haired dame*
- e: *the primates*
- f: *the apes and humans*

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*
- $a \stackrel{\text{lex}}{=} b, c \stackrel{\text{lex}}{=} d, e \stackrel{\text{lex}}{=} f$

Some content-synonymous complex expressions

- A: *A colibri is hovering over a red flower.*

Some content-synonymous complex expressions

- A: *A colibri* is hovering over a red flower.
- B: *A humming bird* is hovering over a red flower.

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*

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- 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.

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*
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- F: *The apes and humans* are intelligent.

Some content-synonymous complex expressions

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- 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 intelligent.
- $A \equiv B, C \equiv D, E \equiv F$

Two axioms

- **Ax1** Two expressions (e.g., NPs, sentences) that are synonymous have the same reference.

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- **Ax2** If we replace expression B within expression A with the synonymous expression C, then A does not change its reference.

Two axioms

- **Ax1** Two expressions (e.g., NPs, sentences) that are synonymous have the same reference.
- Formally: $A \equiv B$ then $\llbracket A \rrbracket = \llbracket B \rrbracket$
- Note: $\llbracket A \rrbracket$ 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 $\llbracket B \rrbracket = \llbracket C \rrbracket$ then $\llbracket [A \ B] \rrbracket = \llbracket [A \ C] \rrbracket$

One common property of sentences: the truth value

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

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

- $[\text{t}A]$ = *The truth value of 'Lauren Bacall was a brunette lady' is 1.*

First conclusion

- $[_TA]$ = *The truth value of 'Lauren Bacall was a brunette lady' is 1.*
- $[_TB]$ = *The truth value of 'My cat sleeps quietly' is 1.*

First conclusion

- $[\top A]$ = *The truth value of 'Lauren Bacall was a brunette lady' is 1.*
- $[\top B]$ = *The truth value of 'My cat sleeps quietly' is 1.*
- Such that $A \equiv [\top A]$ and $B \equiv [\top B]$.
(Check: Whenever A is true, $[\top A]$ is true and v.v.)

First conclusion

- $[\top A] = \text{The truth value of 'Lauren Bacall was a brunette lady' is 1.}$
- $[\top B] = \text{The truth value of 'My cat sleeps quietly' is 1.}$
- Such that $A \equiv [\top A]$ and $B \equiv [\top B]$.
(Check: Whenever A is true, $[\top A]$ is true and v.v.)
- So, by Ax1 $\llbracket A \rrbracket = \llbracket [\top A] \rrbracket$
and $\llbracket B \rrbracket = \llbracket [\top B] \rrbracket$

Second conclusion

- Check the denotations of the contained NPs:
 $\llbracket \textit{the truth value of A} \rrbracket = \llbracket \textit{the truth value of B} \rrbracket = 1$

Second conclusion

- Check the denotations of the contained NPs:
 $\llbracket \textit{the truth value of A} \rrbracket = \llbracket \textit{the truth value of B} \rrbracket = 1$
- Such that by Ax2:
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Second conclusion

- Check the denotations of the contained NPs:
 $\llbracket \text{the truth value of } A \rrbracket = \llbracket \text{the truth value of } B \rrbracket = 1$
- Such that by Ax2:
 $\llbracket [\tau A] \rrbracket = \llbracket [\tau B] \rrbracket$
- 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.

$$\llbracket A \rrbracket = \llbracket [\neg A] \rrbracket = \llbracket [\neg B] \rrbracket = \llbracket B \rrbracket = 1$$

Sentences denote truth values.

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- 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 <i>Venus</i>	individual concepts
VP	sets <i>humming birds</i>	property concepts
S	1 or 0 <i>I like cats.</i>	thoughts

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- *proposition* = the intensions of sentences as informational content: The 'thought that S'.

We're talking in fragments: F1

- How are sentences compositionally built up?

Decomposing compositionality and composing truth

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Decomposing compositionality and composing truth

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- S a sentence, L a language, v a state of affairs, p a statement of the truth conditions.

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- $VP \rightarrow V_t N$

- $N \rightarrow$ *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*

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- $\llbracket \text{prefers} \rrbracket = \{\langle x, y \rangle: x \text{ prefers } y\}$

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- semantics for non-branching nodes: **pass-up**

A starting point for our computation

Herr Webelhuth is relaxed.

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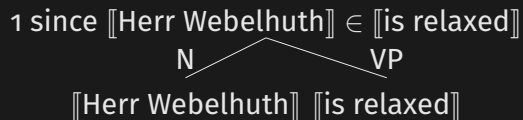
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- (4) for S: $\llbracket [{}_S N VP] \rrbracket = 1$ iff $\llbracket N \rrbracket \in \llbracket VP \rrbracket$, else 0

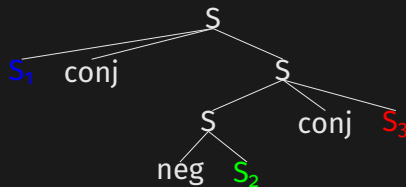
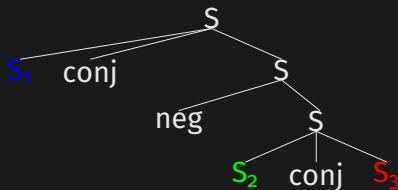
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The tree:



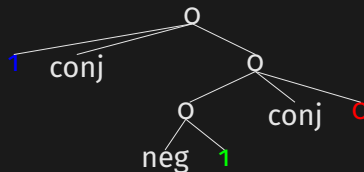
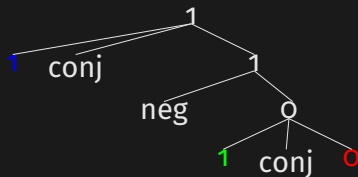
We compute syntactic representations, not flat sentences

(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:



Kontakt

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