Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Dr. Wolfgang Sternefeld
Tutoren: Thorwald Kassemek, Natalie Clarius

Semantics 1: Exercise Sheets

with (partial) solutions

This is a compilation of all exercise sheets and some additional material for the proseminar Semantics1 in WS 2015/16.

Most (yet not all) of the exercises come with an exemplary solution, which is to be seen as one possible approach to solve the assignment rather than the one and only gold standard solution. I do not guarantee absolute and ultimate correctness!

The PDF file contains clickable bookmarks which lead you directly to the desired exercise sheet.

Have fun!

N.C.

Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Dr. Wolfgang Sternefeld
Tutoren: Thorwald Kassemek, Natalie Clarius

Exercise Sheet 1: Revision

Zimmermann & Sternefeld: Ch. 1-5
Slides ESSLLI: No. 1-3
Gamut: Vol. 1 Ch. 1-4
Partee, Meulen & Wall: Pt. A-B
Hodges: Ch. 1-41

Exercise 1: Statement logic

Proof that the following formulae of propositional logic are equivalent by means of your choice (e.g. tranformation, truth table, natural deduction, tableaux, ...)

(1) $\big((p \wedge q) \vee (q \rightarrow r)\big)$

(2) $\big((\neg\neg p \wedge \neg\neg q) \vee (\neg q \vee r)\big)$

(3) $\neg\Big(\neg\big(r \vee \neg q\big) \wedge \neg\big((p \leftrightarrow q) \wedge (p \wedge q)\big)\Big)$

Exercise 2: Predicate logic

Proof that the following formulae of predicate logic are equivalent by means of your choice (e.g. transformation, semantic evaluation, natural deduction, tableaux, ...)

(1) $\neg\exists x\Big(student(x) \wedge \exists y\big(pizza(y) \wedge \neg like(x,y)\big)\Big)$

(2) $\forall x\Big(student(x) \rightarrow \forall y\big(pizza(y) \rightarrow like(x,y)\big)\Big)$

(3) $\forall x\neg\Big(student(x) \wedge \neg\forall y\neg\big(pizza(y) \wedge \neg like(x,y)\big)\Big)$

What do the three of the formulae mean, i.e. expressed in natural langauge?

Exercise 3: Sets

a. Define the set A which consists of all natural numbers, giving the definition in three different ways.

b. Determine the outcome of the following set-theoretic operations:

(1) $A \cap \{x \in \mathbb{Z} : x\%2 = 0\}$[1]

(2) $A \setminus \{x \in \mathbb{Z} : x\ is\ a\ prime\ number\}$

(3) $A \cup \{x \in \mathbb{Z} : x \in \mathbb{Z}\ and\ x < 0\}$

Hint: You do not need to spell out an infinite number of elements ;) It is sufficient to state enough elements to make the content of the set clear.

[1] % is used here as an operator for retrieving the remainder of a division: $5\%3 = 2; 22\%7 = 1; 8\%4 = 0; ...$

Exercise 4: Models and interpretations

Let

$V = \{x, y, z\}$

be a set of variables and

$\mathrm{C} = \{a, b, c, d\}$

a set of constants.

Furthermore, assume a model $M = \langle D, I \rangle$ with

$D = \{A, B, C, D\}$

as denotations of the constants in C.

Specify an interpretation function I such that all of the following formulae are true in that model.

(1) $P(a, b)$

(2) $P(a, d)$

(3) $R(b, c)$

(4) $\forall x \exists y \big(R(x, y) \rightarrow Q(y)\big)$

(5) $\neg \exists x \forall y \neg \big(R(x, y) \rightarrow Q(y)\big)$

(6) $\forall x \exists y \Big(\big(Q(x) \wedge \exists z \big(R(z, x)\big) \rightarrow R(x, y)\Big)$

Exercise 5: Functions and relations

Let A and B be sets such that:

$A = \{a, b, c\}$

$B = \{1, 2, 3\}$

Furthermore, assume the following sets:

$\{\langle a, 1\rangle\}, \{\langle a, 2\rangle, \langle b, 4\rangle\}, \{\langle a, a\rangle\ \langle a, 1\rangle\ \langle c, 3\rangle\}, \{\langle a, 1\rangle, \langle b, 1\rangle, \langle c, 1\rangle\},$
$\{\langle a, 3\rangle, \langle b, 1\rangle, \langle c, 2\rangle\}, \{\langle a, 3\rangle, \langle b, 2\rangle, \langle c, 3\rangle\}, \{\langle a, 2\rangle, \langle a, 1\rangle, \langle b, 1\rangle, \langle c, 3\rangle\}$

a. Determine which of the above sets are relations $R \subseteq A \times B$ and characterise them, that is state if they are symmetric, reflexive or transitive.

b. Determine which of the above sets are functions $f : A \rightarrow B$ and characterise them, that is state if they are injective, surjective or bijective.

Exercise 6: Scope ambiguity and Logical Form

(1) *Alle Chinesen haben genau einen einen Kontrabass.*

a. For each of the possible readings, rewrite the sentence in predicate logic and specify a model that makes this reading true but the others false.

b. Briefly explain the ambiguity by using the definition of scope at the level of LF.

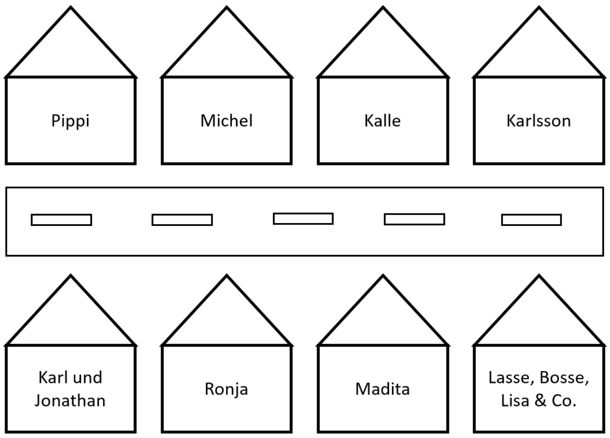
Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Wolffeld Sternegang
Tutoren: Thorwald Kassemek, Natalie Clarius

Exercise Sheet 2: Extensions

Zimmermann & Sternefeld: Ch. 4-5
Slides ESSLLI: No. 2-3

Exercise 1: Relational and functional nouns

Assume this little village in Sweden:



Determine the extensions of the following expressions and classify them, i.e. whether they are relational, functional or of a different category.

(1) *neighbour-of*
(2) *lives-across-from*
(3) *lives-directly-right-to*
(4) *has-no-left-neighbour*

Solution:

(1) *neighbour-of*: $\{< Pippi, Michel >, < Michel, Pippi >, < Michel, Kalle >, ...\}$ ⇒ relational
(2) *lives-across-from*:$\{< Pippi, K.u.J. >, < K.u.J., Pipp >, < Michel, Ronja >, ...\}$ ⇒ functional
(3) *lives-directly-right-to*: $\{< Pippi, Michel >, < Michel, Kalle >, ...\}$ ⇒ relational
(4) *has-no-left-neighbour*: $\{Pippi, K.u.J.\}$ ⇒ neither relational nor functional

Exercise 2: Referential expressions

Compute the extensions of the following expressions.

(1) *current president of Germany*

(2) *the current president of Germany*

Solution:

(1) $[\![current\ president\ of\ Germany]\!]_s = \{Joachim\ Gauck\}$

(2) $[\![the\ current\ president\ of\ Germany]\!]_s = Joachim\ Gauck$

Exercise 3: n-place verbs and plugging

a. Let A be a set such that

$$A = \{<a,c>,<a,b>,<c,q>,<d,f>,<a,e>,<y,e>,<x,d>,<q,w>,$$
$$<a,y>,<w,e>,<q,c>,<x,a>,<s,w>,<q,a>,<y,x>,<c,d>,$$
$$<e,w>,<a,x>,<q,c>,<y,s>,<w,s>,<a,d,s>,<w,s,x>,$$
$$<y,s,x>,<a,q,y>,<w,e,d>,<a,w,x>\}$$

Compute the following operations:

(1) $A \overrightarrow{*} s$
(2) $A \overrightarrow{*} y$
(3) $A \overrightarrow{*} a$
(4) $A \overleftarrow{*} q$
(5) $A \overleftarrow{*} w$
(6) $A \overleftarrow{*} x$

b. Given is the following sentence:

(1) *John lends his pen to Mary.*

1. Calculate the following sets A, B, C, D by use of the plugging operation such that
   A. $A = [\![lends]\!]_s$
   B. $B = [\![lends\ his\ pen]\!]_s$
   C. $C = [\![lends\ his\ pen\ to\ Mary]\!]_s$
   D. $D = [\![John\ lends\ his\ pen\ to\ Mary]\!]_s$
2. What is the extension of (1) given that the sentence is false?

Solution:

a. Plugging operations with set A:

(1) $A \overrightarrow{*} s = \{<y>,<w>,<a,d>\}$
(2) $A \overrightarrow{*} y = \{<a,q>\}$
(3) $A \overrightarrow{*} a = \{<x>,<q>\}$
(4) $A \overleftarrow{*} q = \{<w>,<c>,<a>\}$
(5) $A \overleftarrow{*} w = \{<e>,<s>,<s,x>,<e,d>\}$
(6) $A \overleftarrow{*} x = \{<d>,<a>,<s>\}$

b. *John lends his pen to Mary*

1. Plugging operations:

   $[\![John]\!]_s = j$
   $[\![his\ pen]\!]_s = p$
   $[\![Mary]\!]_s = m$
   $[\![lends]\!]_s = \{< a, b, c >:\ a\ lends\ c\ to\ b\}$

   A. A
   $= [\![lends]\!]_s$
   $= \{< j, m, p >, < a, m, p >, < a, b, p >, < a, b, c >\}$
   $= R_3$

   B. B
   $= [\![lends\ his\ pen]\!]_s$
   $= [\![lends]\!]_s \overrightarrow{*} [\![his\ pen]\!]_s$
   $= A \overrightarrow{*} p$
   $= \{< j, m, p >, < a, m, p >, < a, b, p >, < a, b, c >\} \overrightarrow{*} p$
   $= \{< x, y > \mid < p > \in \{< j, m, p >, < a, m, p >, < a, b, p >, < a, b, c >\}\}$
   $= \{< j, m >, < a, m >, < a, b >\}$
   $= R_2$

   C. C
   $= [\![lends\ his\ pen\ to\ Mary]\!]_s$
   $= [\![lends\ his\ pen]\!]_s \overrightarrow{*} [\![Mary]\!]_s$
   $= B \overrightarrow{*} m$
   $= \{< j, m >, < a, m >, < a, b >\} \overrightarrow{*} m$
   $= \{< x > \mid < m > \in \{< j, m >, < a, m >, < a, b >\}\}$
   $= \{< j >, < a >\}$
   $= \{j, a\}$
   $= R_1$

   D. D
   $= [\![John\ lends\ his\ pen\ to\ Mary]\!]_s$
   $= [\![John]\!]_s \overrightarrow{*} [\![lends\ his\ pen\ to\ Mary]\!]_s$
   $= j \overrightarrow{*} C$
   $= C \overrightarrow{*} j$
   $= \{< j >, < a >\} \overrightarrow{*} j$
   $= \{<> \mid < j > \in \{< j >, < a >\}\}$
   $= \{<>\}$
   $= R_0$
   $= 1$

2. If the sentence is false, then its extension is $\varnothing$.

Exercise Sheet 3: Extensions, Determiners and Quantifiers

Zimmermann & Sternefeld: Ch. 5-6
Slides ESSLLI: No. 3-4 + Addenda

Exercise 1: Plugging

Given are the following expressions:

$[\![Paul]\!]_s = p$

$[\![sleeps]\!]_s = \{< p >, < a >\}$

Compute the plugging operation

$[\![sleeps]\!]_s \star [\![p]\!]_s$

and determine its meaning in natural language.

Solution:

$[\![sleeps]\!]_s \star [\![p]\!]_s$
$= \{< p >, < a >\} \star p$
$= \{\varnothing\}$
Meaning in natural language: *Paul is sleeping*

Exercise 2: Predicate modification

Given are the following sets:

$[\![female]\!]_s = \{Marge, Maggie, Sharon, Lisa\}$

$[\![male]\!]_s = \{Kyle, Eric, Randy, Kenney, Sharon, Bart, Homer, Stan\}$

$[\![child]\!]_s = \{Kyle, Eric, Bart, Stan, Lisa, Maggie, Kenney\}$

$[\![adult]\!]_s = \{Randy, Sharon, Marge, Homer\}$

$[\![from]\!]_s = \{< x, y > \mid x\ is\ from\ y\} =$
$\{< Kyle, Southpark >, < Eric, Southpark >, < Randy, Southpark >, < Marge, Springfield >,$
$< Bart, Springfield >, < Stan, Southpark >, < Homer, Springfield >, < Kenney, Southpark >,$
$< Maggie, Springfield >, < Lisa, Springfield >, < Sharon, Southpark >\}$

Compute

a. $[\![$*the [female [adult from Southpark]]*$]\!]_s$
b. $[\![$*the [[female adult] [from Southpark]]*$]\!]_s$

and explain the similarity or difference between the results.

Solution:

The results will be identical since set intersection is associative: $A \cap (B \cap C) = (A \cap B) \cap C$

Exercise 3: Determiners and Quantifiers

Calculate the truth conditions for the sentence

$[\![\textit{no student reads the book}]\!]_s$

according to the definitions in chapter 6.1 of the book.

Solution:

$[\![\textit{no student reads the book}]\!]_s = 1$
iff $[\![\textit{reads the book}]\!]_s \in [\![\textit{no student}]\!]_s$
iff $[\![\textit{reads the book}]\!]_s \in ([\![\textit{no}]\!]_s \overleftarrow{*} [\![\textit{student}]\!]_s)$
iff $[\![\textit{reads the book}]\!]_s \in (\{< X, Y > \mid X \cap Y = \varnothing\} \overleftarrow{*} \{x \mid \textit{x is a student in s}\})$
iff $[\![\textit{reads the book}]\!]_s \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $([\![\textit{reads}]\!]_s \overrightarrow{*} [\![\textit{the book}]\!]_s) \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $([\![\textit{reads}]\!]_s \overrightarrow{*} ([\![\textit{the}]\!]_s([\![\textit{book}]\!]_s))) \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $([\![\textit{reads}]\!]_s \overrightarrow{*} ([\![\textit{the}]\!]_s(\{x \mid \textit{x is a book in s}\}))) \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $([\![\textit{reads}]\!]_s \overrightarrow{*} (\{< X, y > \mid X = \{y\}\}(\{x \mid \textit{x is a book in s}\}))) \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $([\![\textit{reads}]\!]_s \overrightarrow{*} \textit{thebook}) \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $(\{< x, y > \mid \textit{x reads y in s}\} \overrightarrow{*} \textit{thebook}) \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $\{x \mid \textit{x reads the book in s}\} \in \{Y \mid \{x \mid \textit{x is a student in s}\} \cap Y = \varnothing\}$
iff $\{x \mid \textit{x is a student in s}\} \cap \{x \mid \textit{x reads the book in s}\} = \varnothing$

Exemplary Solution: QDPs in Object Position

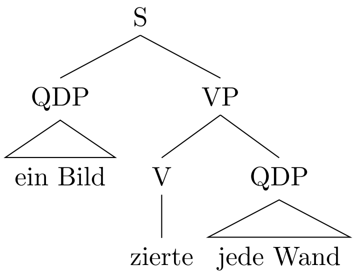
Zimmermann & Sternefeld: Ch. 6
Slides ESSLLI: No. 4 + Addenda

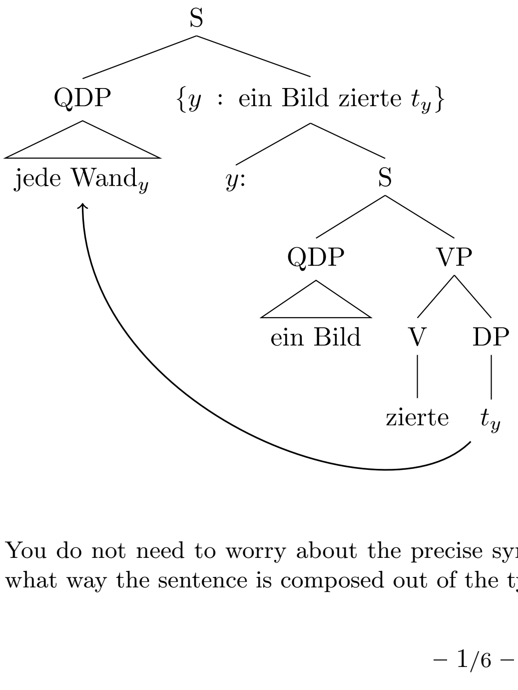
The sentence

Ein	*Bild*	*zierte*	*jede*	*Wand.*
A	picture	decorated	every	wall.

'A picture decorated every wall.'

Our sentence to be evaluated has two readings:

1. the **linear reading**
   - with *ein Bild* having wide scope w.r.t. *jede Wand*:
   - *There is at least one picture for which it holds that that picutre decorated every wall*
   - $\exists x(Bild(x) \wedge \forall y(Wand(y) \rightarrow Zierte(x,y)))$
   - 

2. the **inverted reading**
   - with *jede Wand* having wide scope w.r.t. *ein Bild*:
   - *For every wall it holds that there is at least one picture that decorated that wall*
   - $\forall y(Wand(y) \rightarrow \exists x(Bild(x) \wedge Zierte(x,y)))$
   - 

You do not need to worry about the precise syntactic labels here; the tree is just there to show in what way the sentence is composed out of the types of the individual expressions.

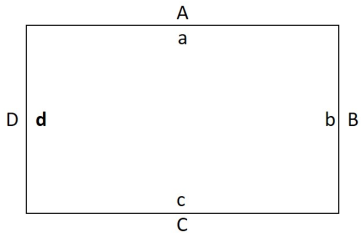
Intuitively, reading (1) should be false and reading (2) should be true. The task is to formally proof this intuition by calculation of truth conditions.

The model

Modified model $M =< D, I >$:

$D = \{A, B, C, D, a, b, c, d\}$
$I(Bild) = \{a, b, c, d\}$
$I(Wand) = \{A, B, C, D\}$
$I(zierte) = \{< a, A >, < b, B >, < c, C >< d, D >\}$

Note that this model now contains the additional picture d (included as the constant d in the domain D as well as in the interpretation of *Bild*) decorating the wall D (included as the relation $< d, D >$ in the interpretation of *zierte*).



In situ interpretation

will give us the linear reading.

$[\![\textit{Ein Bild zierte jede Wand}]\!]_s$
$= [\![\textit{Ein Bild}]\!]_s *_Q [\![\textit{zierte jede Wand}]\!]_s$

The first step is to higher-order-plug the QDP $[\![\textit{ein Bild}]\!]_s$ with the VP, meaning that the QDP is meant to fill out the subject position of the VP. We do not need an arrow here since the VP in which the object is already included leaves only one position open (namely the subject position: $[\![\textit{zierte jede Wand}]\!]_s = \{x : \text{x decorated every wall in s}\}$) so we don't have to specify from what side we are plugging. The Q is the indicator for plugging with a set of sets.
Note that at this point, it is not obligatory yet to apply higher-order plugging: We could as well apply the default plugging operation, meaning that the VP has to be an element of the QDP. This does, however, not work with objects that are QDPs, here we do have to make use of higher-order plugging. But it does not harm to also do so for the subject, if we do so, the sentence after plugging is

$= \{<> : \{x : x \in [\![\textit{zierte jede Wand}]\!]_s\} \in [\![\textit{ein Bild}]\!]_s\}$

which is the set of all 0-tuples such that the set of things that decorated every wall is an element of $[\![\textit{ein Bild}]\!]_s$, which is equal to the stamement

$= 1 \text{ iff } [\![\textit{zierte jede Wand}]\!]_s \in [\![\textit{ein Bild}]\!]_s$

meaning that the sentence turns out to be true iff the VP (a set of individuals, namely those that decorated every wall) is an element of the QDP (a set of sets, namely those predicates that apply to a picutre).

Next we have to further decompose the VP into the verb itself and the object. Since $[\![\textit{jede Wand}]\!]_s$ is a QDP as well, we have to apply

$= 1 \text{ iff } ([\![\textit{zierte}]\!]_s \overrightarrow{*_Q} [\![\textit{jede Wand}]\!]_s) \in [\![\textit{ein Bild}]\!]_s$

higher-order plugging between the verb $[\![\textit{zierte}]\!]_s$ and the QDP object $[\![\textit{jede Wand}]\!]_s$. Here we do need the arrow: The relation $[\![\textit{zierte}]\!]_s$ now stands alone and has two argument positions open ($[\![\textit{zierte}]\!]_s = \{< x, y > : \text{x decorated y in s}\}$) of which $[\![\textit{jede Wand}]\!]_s$ is supposed to fill the object position; therefore, we need to indicate that we plug at the right side of the relation (y).
What we get now is the following:

$= 1 \text{ iff } \{x : \{y : < x, y > \in [\![\textit{zierte}]\!]_s\} \in [\![\textit{jede Wand}]\!]_s\} \in [\![\textit{ein Bild}]\!]_s$
$= 1 \text{ iff } \{x : \{y : x \text{ decorated } y \text{ in s}\} \in [\![\textit{jede Wand}]\!]_s\} \in [\![\textit{ein Bild}]\!]_s$

What we have here is the set of all subjects for which it holds that the set of all objects which are in the decorating-relation with the subject must be an element of $[\![\textit{jede Wand}]\!]_s$, and this set of subjects that are in the decorating-relation with every wall must again be an element of $[\![\textit{ein Bild}]\!]_s$.

Now we have to check what is in contained in this set. We have to go through every possible value for x (for all decorators, i.e. the pictures), check what are in the inner set the values for y (the decorated, i.e. the walls) and whether they are in $[\![\textit{jede Wand}]\!]_s$, and for those y that fulfil the condition we can put the corresponding x into our outer set, and this set must again be an element of $[\![\textit{ein Bild}]\!]_s$. So let's assign values vor x (the decorators) and then check what it is that they decorate:

For $x = a$:
$[\![\textit{a zierte jede Wand}]\!]_s$
$= 1 \text{ iff } \{y : \text{a decorated } y \text{ in s}\} \in [\![\textit{every wall}]\!]_s$
$= 1 \text{ iff } \{A\} \in [\![\textit{every wall}]\!]_s$
$= \textit{false}$
Therefore, $a \notin \{x : \{y : < x, y > \in [\![\textit{zierte}]\!]_s \in [\![\textit{jede Wand}]\!]_s\}\}$
Therefore, $a \notin \{x : \{y : x \text{ decorated } y \text{ in s}\} \in [\![\textit{jede Wand}]\!]_s\} \in [\![\textit{ein Bild}]\!]_s$

We see that the things that are decorated by the picture a is not in $[\![every\ wall]\!]_s$, therefore the picture a is not contained in the set of things that decorated every wall.

We get a similar result for all other picutres:

For $x = b$:
$[\![b\ zierte\ jede\ Wand]\!]_s$
$= 1$ iff $\{y\ :\ $ b decorated y in s$\} \in [\![every\ wall]\!]_s$
$= 1$ iff $\{B\} \in [\![every\ wall]\!]_s$
$= false$
Therefore, $b \notin \{x\ :\ \{y\ :\ <x, y> \in [\![zierte]\!]_s \in [\![jede\ Wand]\!]_s\}\}$
Therefore, $b \notin \{x\ :\ \{y\ :\ x$ decorated y in s$\} \in [\![jede\ Wand]\!]_s\} \in [\![ein\ Bild]\!]_s$

... and the same for the picutres c and d.
So the set of pictures that decorated every wall is the empty set:

$\{x\ :\ \{y\ :\ <x, y> \in [\![zierte]\!]_s \in [\![jede\ Wand]\!]_s\}\}$
$= \{x\ :\ \{y\ :\ x$ decorated y in s$\} \in [\![jede\ Wand]\!]_s\} \in [\![ein\ Bild]\!]_s$
$= \varnothing$

Now in order to make the stament true, this set must be an element of $[\![ein\ Bild]\!]_s$, namely the set of all sets that share at least one element with $[\![Bild]\!]_s$:

$= 1$ iff $\varnothing \in [\![ein\ Bild]\!]_s$
$= 1$ iff $\varnothing \in \{Y\ :\ [\![Bild]\!]_s \cap Y \neq \varnothing\}$
$= 1$ iff $\varnothing \cap \{a, b, c, d\} \neq \varnothing$
$= false$

We see that there is no element that decorated every wall that is also a picture, meaning that there is not at least one picture that decorated every wall. Therefore we get that the linear reading is false – which is precisely what we wanted.

Quantifier raising

will give us the inverted reading.

$[\![Ein\ Bild\ zierte\ jede\ Wand]\!]_s$
$= [\![jede\ Wand\ _y]\!]_s * [\![Ein\ Bild\ zierte\ t_y]\!]_s$

Moving the QDP out of the sentence results in set formation for the sentence it has been moved out, and the plugging operation turns out to be true iff the set of things that fulfil the VP of being decorated by a picture is an element of the QDP:

$= 1$ iff $[\![ein\ Bild\ zierte\ t_y]\!]_s \in [\![jede\ Wand]\!]_s$
$= 1$ iff $\{y\ :\ [\![ein\ Bild\ zierte\ y]\!]_s = 1\} \in [\![jede\ Wand]\!]_s$

Now we again have to decompose the VP into the two-place relation and the subject:

$= 1$ iff $\{y\ :\ \{x\ :\ <x,y> \in [\![zierte]\!]_s\} \in [\![ein\ Bild]\!]_s\} \in [\![jede\ Wand]\!]_s$
$= 1$ iff $\{y\ :\ \{x\ :\ x$ decorated y in s$\} \in [\![ein\ Bild]\!]_s\} \in [\![jede\ Wand]\!]_s$

Here we have a very similar syntax to what we already got when applying higher-order plugging above, just the other way round: Here we have the set of objects such that the set of subjects that decorated it are an element of $[\![ein\ Bild]\!]_s$, and this set of objects that are decorated by a picture again has to be an element of $[\![every\ wall]\!]_s$.

Now we again have to assign values for y (the decorated, i.e. the walls) in the outer set, check what are in the inner set the x that decorated it (the decorators, i.e. the pictures), whether they fulfil the property of being in $[\![ein\ Bild]\!]_s$ and if so, whether the set of walls that are decorated by a picture is in the semantics of $[\![jede\ Wand]\!]_s$. So let's assign values for y:

For $y = A$:
$[\![ein\ Bild\ ziert\ A]\!]_s$
$= 1$ iff $\{x\ :\ x$ decorated A in s$\} \in [\![ein\ Bild]\!]_s$
$= 1$ iff $\{a\} \in [\![ein\ Bild]\!]_s$
$= 1$ iff $\{a\} \cap \{a, b, c, d\} \neq \emptyset$
$= true$
Therefore, $A \in \{y\ :\ \{x\ :\ <x,y> \in [\![zierte]\!]_s\} \in [\![ein\ Bild]\!]_s\} \in [\![jede\ Wand]\!]_s$
Therefore, $A \in \{y\ :\ \{x\ :\ x$ decorated y in s$\} \in [\![ein\ Bild]\!]_s\}$

So the wall A belongs to those walls that are decorated by at least one picture.

The same calculation holds for the other walls:

...
For $y = D$:
$[\![ein\ Bild\ ziert\ D]\!]_s$
$= 1$ iff $\{x\ :\ x$ decorated D in s$\} \in [\![ein\ Bild]\!]_s$
$= 1$ iff $\{d\} \in [\![ein\ Bild]\!]_s$
$= 1$ iff $\{d\} \cap \{a, b, c, d\} \neq \emptyset$
$= true$
Therefore, $D \in \{y\ :\ \{x\ :\ <x,y> \in [\![zierte]\!]_s\} \in [\![ein\ Bild]\!]_s\} \in [\![jede\ Wand]\!]_s$
Therefore, $D \in \{y\ :\ \{x\ :\ x$ decorated y in s$\} \in [\![ein\ Bild]\!]_s\}$

Hence, the set of walls that are decorated by a picutre consists of all the walls A,B,C and D:

$\{y\ :\ \{x\ :\ <x,y> \in [\![zierte]\!]_s\} \in [\![ein\ Bild]\!]_s\} \in [\![jede\ Wand]\!]_s$
$= \{y\ :\ \{x\ :\ x$ decorated y in s$\} \in [\![ein\ Bild]\!]_s\}$
$= \{A, B, C, D\}$

and this set has to be in $[\![every\ wall]\!]_s$, it must be an element of those predicates that apply to every wall (and therefore the set of walls must be a subset of the elements being decorated by a picture):

$= 1$ iff $\{A, B, C, D\} \in [\![jede\ Wand]\!]_s = 1$ iff $\{A, B, C, D\} \in \{Y\ :\ [\![Wand]\!]_s \subseteq Y\}$
$= 1$ iff $\{A, B, C, D\} \in \{A, B, C, D\}$
$= true$

We see that in fact, every wall fulfils the property of being decorated by a picture. Hene, we see that the inverted reading, in which it must hold that for every wall there must be at least one picture which decorated that wall, is true – which is again exactly what we wanted.

Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Dr. Wolfstern Feldgang
Tutoren: Thorwald Kassemek, Natalie Clarius

Exercise Sheet 4: Types

Zimmermann & Sternefeld: Ch. 6
Gamut: Vol. 2 Ch. 4

Exercise 1: Types of expressions

Determine the logical types of the following expressions using trees:

a. *eat*

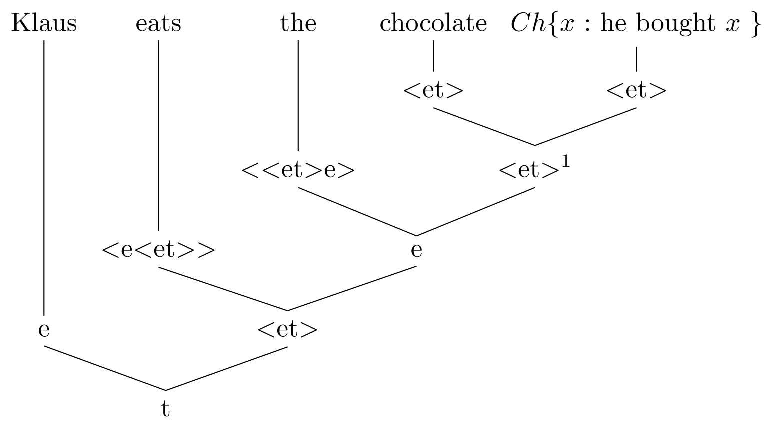
b. *the chocolate*

c. *eat the chocolate*

d. *Klaus eats the chocolate*

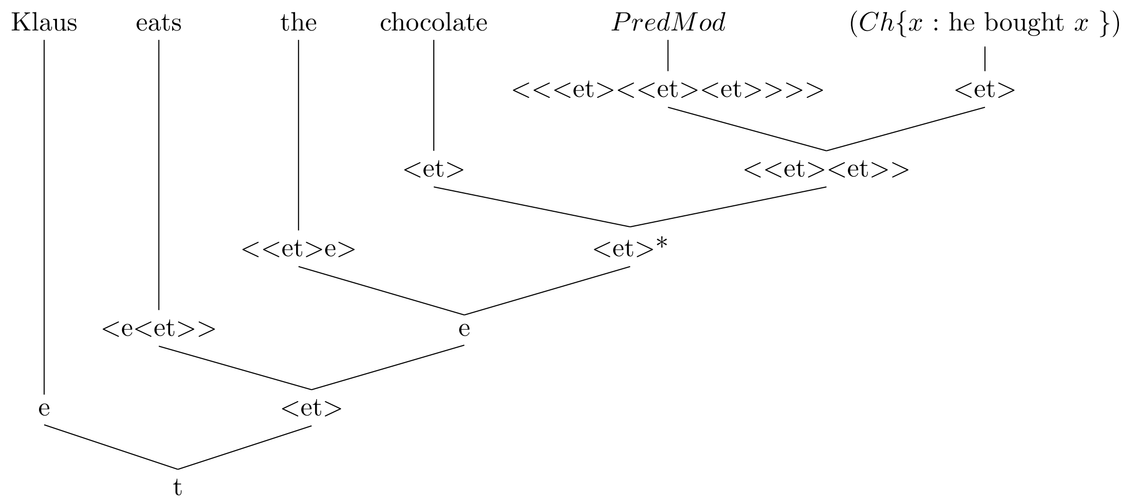
e. *Klaus eats the chocolate he bought*

Solution:



[1] This is an exceptional case where we do NOT have functional application of types but predicate modification, i.e. intersection of two sets yielding a new set (or, more precisely, its characteristic funtion of type <et>).

Alternative:



- Operator Op wird (wie bei QR) auf LF bewegt: Op_i *he bought* t_i, mit *he bought* t_i vom Typ <t>
- aus dem Satz wird (wie bei QR) die Menge gebildet: Ch{*x: he bought x*} vom Typ <et>
- Op selbst (also Verküpfung zwischen NP und RS in Form von PredMod) fungiert als eine Art Identitätsfunktion vom Typ <<et><et>>
- Semantik des PredMod-Operators: Für alle P, Q vom Typ <et> ist $Op(P)(Q)$ (d.h. die Anwendung des Operators wird in zwei Teilschritte zergliedert und zuerst auf den RS angwendet, dann auf die NP!) diejenige Funktion F vom Typ <et>, sodass für alle x vom Typ <e> gilt: $F(x) = 1$ gdw $P(x)$ und $Q(x) = 1$.
- erster Schirtt: PredMod-Operator vom Typ <<<et><<et><et>>>> nimmt die Menge vom Typ <et> als Argument und gibt als Wert die Identitätsfunktion vom Typ <<et><et>> aus, die durch Funktionsanwendung auf *chocolate* wieder eine Eigenschaft macht
- zweiter Schritt: Anwendung der (den RS bereits enthaltenden) Identitätsfunktion vom Typ <<et><et>> auf *chocolate* vom Typ <et> ergibt die gePredModte NP vom Typ <et>

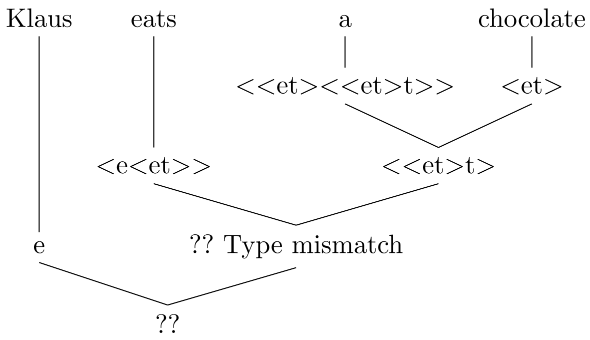
Exercise 2: Composition of types

Explain the problem with compositional type assignment in the sentence

Klaus eats a chocolate

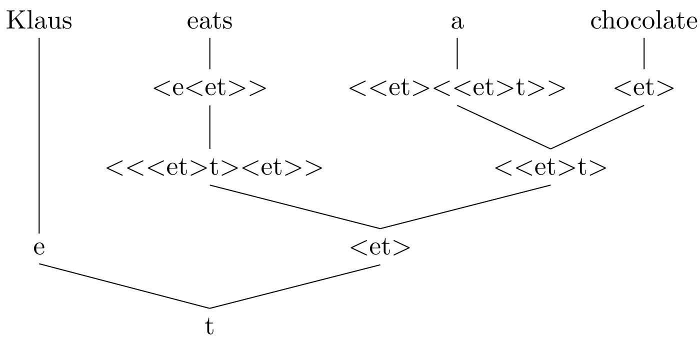
and one way this problem can be resolved.

Problem:



Solution 1:

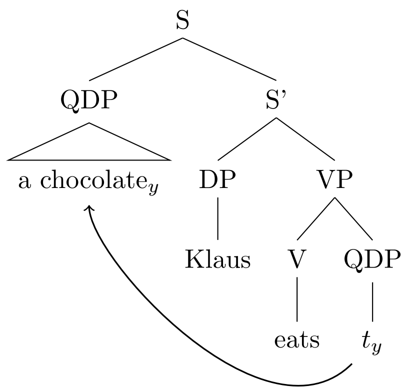
In situ (type shifting "eats")

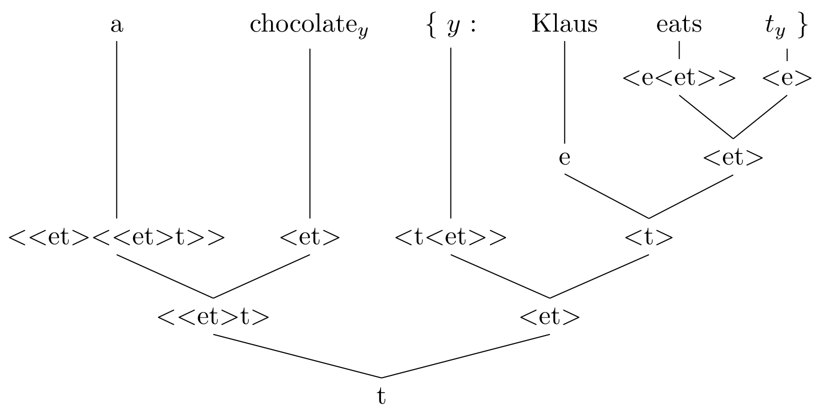


- Type-Shift des Verbs:
  - $Lift($ *V für Indiv-Obj* $)$ = *V für QDP-Obj*
  - $Lift(<e<et>>) = <<<et>t><et>>$
  - zweist. Verb mit Indiv-Objekt als Argument (und Menge von Subjekten als Wert) wird angehoben zu
    zweist. Verb mit QDP-Objekt als Argument (und Menge von Subjekten als Wert)
- Semantik des Lift-Operators:
  - Altes Format (ohne Typen): $Lift(R)(QDP) = \{x \ : \ \{y \ : \ <x,y> \in R\} \in QDP\}$
  - Neues Format (mit Typen): $Lift(R)(QDP) = Ch\{x \ : \ QDP(Ch\{y \ : \ R(y)(x) = 1\}) = 1\}$
    mit R vom Typ <e<et>> und QDP vom Typ <<et>t>

Solution 2:

QR (raising "a chocolate")





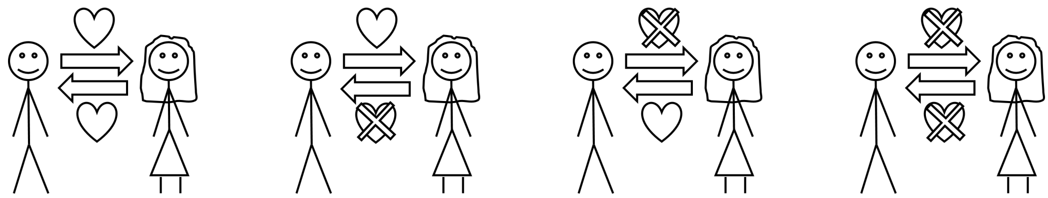
Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Feldgang Wolfstern
Tutoren: Thorwald Kassemek, Natalie Clarius

Exercise Sheet 5: Propositions and intensions

Zimmermann & Sternefeld: Ch. 7-8
Slides ESSLLI: No. 5

Exercise 1: Propositions

Consider the following worlds:



w_1 w_2 w_3 w_4

Determine

a. $[\![\textit{John loves Mary}]\!]$

b. $[\![\textit{Mary loves John}]\!]$

c. $[\![\textit{John loves Mary}]\!]_w$ for each w

d. $[\![\textit{Mary loves John}]\!]_w$ for each w

What are the propositions expressed by the sentences?

Solution:

a. $[\![\textit{John loves Mary}]\!]$
$= \{w : [\![\textit{John loves Mary}]\!]_w = 1\}$
$= \{w_1, w_2\}$

b. $[\![\textit{Mary loves John}]\!]$
$= \{w : [\![\textit{Mary loves John}]\!]_w = 1\}$
$= \{w_1, w_3\}$

c. $[\![\textit{John loves Mary}]\!]_{w_1}$
$= 1$ iff $w_1 \in [\![\textit{John loves Mary}]\!]$
$= 1$

d. $[\![\textit{John loves Mary}]\!]_{w_2}$
$= 1$ iff $w_2 \in [\![\textit{John loves Mary}]\!]$
$= 1$

e. $[\![\textit{John loves Mary}]\!]_{w_3}$
$= 1$ iff $w_3 \in [\![\textit{John loves Mary}]\!]$
$= 0$

f. $[\![\textit{John loves Mary}]\!]_{w_4}$
$= 1$ iff $w_4 \in [\![\textit{John loves Mary}]\!]$
$= 0$

g. $[\![\textit{Mary loves John}]\!]_{w_1}$
$= 1$ iff $w_1 \in [\![\textit{Mary loves John}]\!]$
$= 1$

h. $[\![\textit{Mary loves John}]\!]_{w_2}$
$= 1$ iff $w_2 \in [\![\textit{Mary loves John}]\!]$
$= 0$

i. $[\![\textit{Mary loves John}]\!]_{w_3}$
$= 1$ iff $w_3 \in [\![\textit{Mary loves John}]\!]$
$= 1$

j. $[\![\textit{Mary loves John}]\!]_{w_4}$
$= 1$ iff $w_4 \in [\![\textit{Mary loves John}]\!]$
$= 0$

The propositions of the sentences are the sets of posssible worlds of which that sentence is true.

Exercise 2: Intensional constructions

Determine the truth conditions for the sentences

a. $[\![\textit{Günther knows that Hildegard sleeps}]\!]_w$

b. $[\![\textit{Gisela is a former US president}]\!]_w$

c. $[\![\textit{Hans-Peter searches a unicorn}]\!]_w$

Solution:

a. $[\![\textit{Günther knows that Hildegard sleeps}]\!]_w$
$= [\![\textit{subject + attitude verb + that + S}]\!]_w$
$= [\![\textit{Günther}]\!]_w * ([\![\textit{knows}]\!]_w \overrightarrow{*} [\![\textit{Hildgerad sleeps}]\!])$
$= [\![\textit{Günther}]\!]_w * (\{< x, S > \ : \ < x, S > \in [\![\textit{knows}]\!]_w\} \overrightarrow{*} [\![\textit{Hildgerad sleeps}]\!])$
$= [\![\textit{Günther}]\!]_w * \{x \ : \ < x, [\![\textit{Hildgerad sleeps}]\!] > \in [\![\textit{knows}]\!]_w\}$
$= 1$ iff $< [\![\textit{Günther}]\!]_w, [\![\textit{Hildgegard sleeps}]\!] > \in [\![\textit{know}]\!]_w$
= 1 iff Günther knows that Hildgerad sleeps in w

b. $[\![\textit{Gisela is a former US president}]\!]_w$
$= [\![\textit{subject + intensional-adjective + noun}]\!]_w$
$= [\![\textit{Gisela}]\!]_w * ([\![\textit{former}]\!]_w([\![\textit{US president}]\!]))$
$= [\![\textit{Gisela}]\!]_w * [\![\textit{former US president}]\!]_w$
$= [\![\textit{Giesla}]\!]_w * \{x \ : \ \text{x is a former US president in w}\}$
$= 1$ iff $[\![\textit{Gisela}]\!]_w \in \{x \ : \ \text{x is a former US president in w}\}$
= 1 iff Gisela is a former US president in w

c. $[\![\textit{Hans-Peter searches a unicorn}]\!]_w$
$= [\![\textit{subject + opaque verb + QDP}]\!]_w$

(a) De dicto:
$= [\![\textit{Hans-Peter}]\!]_w * ([\![\textit{searches}]\!]_w \overrightarrow{*_Q} [\![\textit{a unicorn}]\!])$
$= [\![\textit{Hans-Peter}]\!]_w * \{x \ : \ \{y \ : \ \text{x searches y}\} \in [\![\textit{a unicorn}]\!]\}$
$= [\![\textit{Hans-Peter}]\!]_w * \{x \ : \ \text{x searches a unicorn in w}\}$
$= 1$ iff $[\![\textit{Hans-Peter}]\!]_w \in \{x \ : \ \text{x searches a unicorn in w}\}$
= 1 iff Hans-Peter searches a unicorn in w

(b) De re:
$= [\![\textit{a unicorn}]\!] * \{y \ : \ ([\![\textit{Hans-Peter}]\!]_w * \{x \ : \ \text{x searches a unicorn in y}\}) = 1\}$
$= [\![\textit{a unicorn}]\!] * \{y \ : \ \text{Hans-Peter searches y in w}\}$
$= 1$ iff $\{y \ : \ \text{Hans-Peter searches y in w}\} \in [\![\textit{a unicorn}]\!]$
= 1 iff there is a unicorn that Hans-Peter searches in w

Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Gangstern Feldwolf
Tutoren: Thorwald Kassemek, Natalie Clarius

Exercise Sheet 6: Presuppositions I

Zimmermann & Sternefeld: Ch. 9
Levinson: Ch. 4

Exercise 1: Presupposed statements

For each of the sentences below, state all (obvious) presuppositions this sentence has (in case the sentence does have one at all) and if possible, determine the exact nature of the presupposition (e.g. existence presupposition) and its trigger (e.g. a determiner, a factive verb, ...):

(1) *John's wife is pretty*

(2) *The neighbour of John has a dog*

(3) *John didn't know that Mary is married*

(4) *John doesn't believe that elephants are not pink*

(5) *John proved that he is innocent*

(6) *John has given up playing tennis*

Solution:

(1) *John's wife is pretty*
→ *John has a wife* (existence prsp., triggered by the definite description)

(2) *The neighbour of John has a dog*
→ *There is a neighbour of John* (existence prsp.)
→ *There is only one neighbour of John* (uniqueness prsp.)
both triggered by *the*

(3) *John didn't know that Mary is married*
→ *Marry is married* (*know* is a veridical and a factive verb)

(4) *John doesn't believe that elephants are not pink*
→ no prsp.s because *believe* is not a veridical verb

(5) *John proved that he is innocent*
→ *John is innocent* (*manage* is a veridical, but not a factive verb; the prsp. doesn't hold for the negated sentence)

(6) *John has given up playing tennis*
→ *John has played tennis in the past* (*give up* is a change-of-state-verb requiring a complement sentence which was true at some point in the past)

Exercise 2: Truth of statements and presuppositions

a. Given the sentence

S1: *The queen of Antarctica has green hair*

give the presupposition(s) of S1 and determine its extension in case the presupposition is true and in case it is false, each of the cases once according to Frege's naive analysis and once according Russell's quantificational analysis (that means you have to give 4 extensions in total). Briefly explain the difference.

b. Now consider the sentence

S2: *The queen of Antarctica doesn't have green hair*

Which presuppositions does the negated sentence entail in each of the two analyses, and why?

Solution:

a. S1: *The queen of Antarctica has green hair*

(a) Presuppositions:

P: *There is exactly one queen of Antarctica*, consisting of

P-a: *There is at least one queen of Antarctica* (existence condition)

P-b: *There is no more than one queen of Antarctica* (uniqueness condition)

(b) Extensions:

	$[\![P]\!]_w$ =1	$[\![P]\!]_w = 0$
$[\![S1]\!]_w$ with Frege	1 iff the QoA has green hair, 0 else	undefined (truth value gap)
$[\![S1]\!]_w$ with Russell	1 iff the QoA has green hair, 0 else	0

b. S2: *The queen of Antarctica doesn't have green hair*

(a) Frege: S2 entails P:
The QoA doesn't have green hair
$\vDash$ *There is exactly one QoA*

(b) Russell:
S2 = logical negation of S1 (wide scope) does NOT entail P:
$\neg\exists x(Queen(x) \wedge \neg\exists y((x \neq y) \wedge Queen(y)) \wedge Greenhair(x))$
$\nvDash \exists x(Queen(x) \wedge \neg\exists y((x \neq y) \wedge Queen(y)))$
only negation of the predicate (narrow scope) does:
$\exists x(Queen(x) \wedge \neg\exists y((x \neq y) \wedge Queen(y)) \wedge \neg Greenhair(x))$
$\vDash \exists x(Queen(x) \wedge \neg\exists y((x \neq y) \wedge Queen(y)))$

Exercise Sheet 7: Presuppositions II

Zimmermann & Sternefeld: Ch. 9

Exercise 1: Presupposition and assertion

For each of the sentences below, state its presupposition and its assertion:

(1) a. *John has eaten all the chocolate again*
  b. *John will never eat all the chocolate again*

(2) a. *John stops annoying Mary*
  b. *John continues annoying Mary*

(3) a. *John 's cat likes mice*
  b. *John hasn't succeeded in installing the lamp*

(4) a. *John knows that the shop closes at 20.00h*
  b. *John regrets that he missed his favourite show*

Solution:

(1) a. *John has eaten all the chocolate again*
  → P: *John ate all the chocolate at some points in the past*
  → A: *John has eaten all the chocolate*
  b. *John won't eat all the chocolate again*
  → P: *John ate all the chocolate at some points in the past*
  → A: *John won't eat all the chocolate*

(2) a. *John stops annoying Mary*
  → P: *John has been annoying Mary in the past*
  → A: *John doesn't and won't annoy Mary*
  b. *John continues annoying Mary*
  → P: *John has been annoying Mary in the past*
  → A: *John does and will annoy Mary*

(3) a. *John 's cat likes mice*
  → P: *John has a cat*
  → A: *It likes mice*
  b. *John hasn't succeeded in installing the lamp*
  → P: *John tried to install the lamp*
  → A: *John hasn't succeeded in installing the lamp*

(4) a. *John knows that the shop closes at 20.00h*
  → P: *The shop closes at 20.00h*
  → A: *John knows that the shop closes at 20.00h*
  b. *John regrets that he missed his favourite show*
  → A: *John missed his favourite show*
  → P: *John regrets that he missed his favourite show*

Exercise 2: Context change

Assume the common ground at the beginning of a conversation

$$CG = \{w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8, w_9\}$$

and the the propositions of the sentences

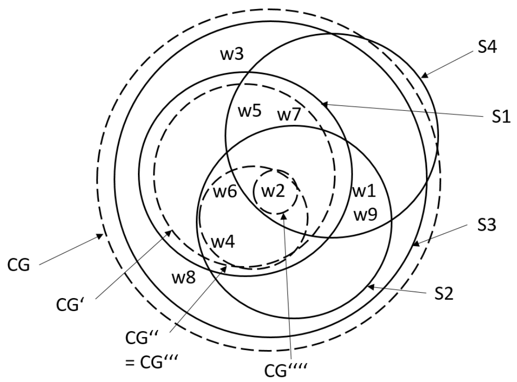
$$[\![S_1]\!] = \{w_2, w_4, w_5, w_6, w_7\}$$
$$[\![S_2]\!] = \{w_1, w_2, w_4, w_6, w_9\}$$
$$[\![S_3]\!] = \{w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8, w_9\}$$
$$[\![S_4]\!] = \{w_1, w_2, w_5, w_7, w_9\}$$

Calculate the updated CG after each of the uttereances as well as their informativity:

1. S_1: *John is drinking fresh apple juice from his gramdother*
2. S_2: *John is at home*
3. S_3: *Either roses are red or they are not red*
4. S_4: *The sun is shining*

Solution:

1. $CG' = CG \cap [\![S_1]\!]$
   $= \{w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8, w_9\} \cap \{w_2, w_4, w_5, w_6, w_7\}$
   $= \{w_2, w_4, w_5, w_6, w_7\}$
   informativity $= |CG| - |CG'| = 9 - 5 = 4$
2. $CG'' = CG' \cap [\![S_2]\!]$
   $= \{w_2, w_4, w_5, w_6, w_7\} \cap \{w_1, w_2, w_4, w_6, w_9\}$
   $= \{w_2, w_4, w_6\}$
   informativity $= |CG'| - |CG''| = 5 - 3 = 2$
3. $CG''' = CG'' \cap [\![S_3]\!]$
   $= \{w_2, w_4, w_6\} \cap \{w_1, w_2, w3, w_4, w_5, w_6, w_7, w_8, w_9\}$
   $= \{w_2, w_4, w_6\}$
   informativity $= |CG''| - |CG'''| = 3 - 3 = 0$
4. $CG'''' = CG''' \cap [\![S_4]\!]$
   $= \{w_2, w_4, w_6\} \cap \{w_1, w_2, w_5, w_7, w_9\}$
   $= \{w_2\}$
   informativity $= |CG'''| - |CG''''| = 3 - 1 = 2$



Exercise 3: Accomodation

Assume that John successfully utters

S_1: *My wife is sick*

and Mary didn't know before that

S_2: *John has a wife*

Furthermore, assume

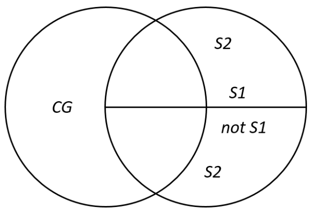
$W = \{w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8\}$
$[\![S_2]\!] = \{w_1, w_2, w_3, w_4\}$
$[\![S_1]\!] = \{w_1, w_2\}$

Determine each state of Mary's version of the CG and draw the corresponding Euler diagrams

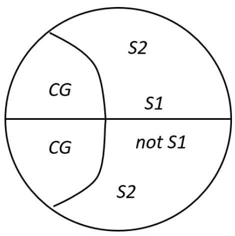
a. before S_1 was uttered
b. after the accomodation but before the CG update
c. after the CG update

Solution:

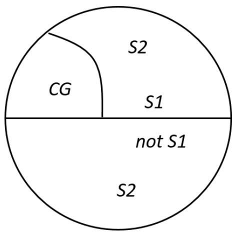
a. Initial CG:
$CG = W$
$= \{w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8\}$



b. Accomodation to S_2:
$CG' = CG \cap [\![S2]\!]$
$= \{w_1, w_2, w_3, w_4, w_5, w_6, w_7, w_8\} \cap \{w_1, w_2, w_3, w_4\}$
$= \{w_1, w_2, w_3, w_4\}$



c. CG update to S_1:
$CG'' = CG' \cap [\![S1]\!]$
$= \{w_1, w_2, w_3, w_4\} \cap \{w_1, w_2\}$
$= \{w_1, w_2\}$



Exercise 4: Presupposition projection

Given:

S: *If John has a car, his car is broken*

$S(a)$: *John has a car*

$S(b)$: *His car is broken*

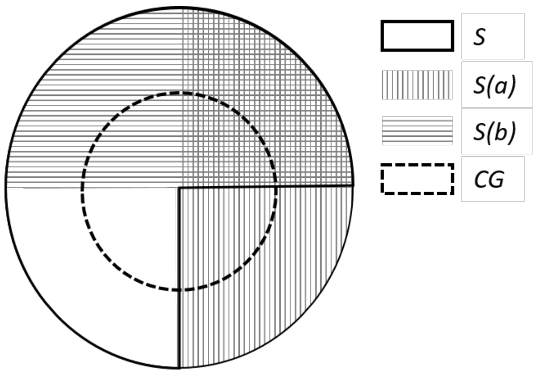
a. Determine the modified CG and draw a corresponding Venn diagram according to the definitions in the book.

b. Determine the presupppositions of each sentence.

c. State which presuppositions project and which do not, and explain why.

Solution:

a. Euler diagram:



$CG' = CG \smallsetminus ((CG \cap S(a) \smallsetminus ((CG + S(a)) \cap S(b))))$
$= CG$ - (rechte Hälfte - (oberes rechtes Viertel))
$= CG$ - unteres rechtes Viertel
$= CG$ - $(S(a) \wedge \neg S(b))$
$= CG + S(a) \rightarrow S(b)$

b. $S(b)$ presupposes $S(a)$ (i.e. is a subset of $[\![S(a)]\!]$; undefined for $[\![\textit{not } S(a)]\!]$)

c. The presupposition $S(a)$ does not project but is blocked by the *if-else*-construction producing $CG' = CG \smallsetminus (S(a) \cap \textit{not } S(b))$; therfore the whole sentence S does not have a presupposition (i.e. $[\![S]\!] \notin [\![S(a)]\!]$ and $[\![S]\!] \notin [\![\textit{not } S(a)]\!]$)

Exercise Sheet 8:
Predicate Logic

Zimmermann & Sternefeld: Ch. 10
Gamut: Vol. 1 Ch. 1-4
Gamut: Vol. 2 Ch. 4-5
Partee, Meulen & Wall: Pt. A-B, D
Hodges: Ch. 1-41

Exercise 1: Predicate logic

Translate the following statments into predicate logic; in case there are two readings, state both of them:

(1) *All men have a dream*
(2) *John loves Mary iff Mary loves John*
(3) *All children like Harry Potter*
(4) *John owns all Harry Potter books*
(5) *John likes the car he bought and Peter does too*
(6) *John and Mary buy a house*

Solution:

(1) $\forall x(man(x) \rightarrow \exists y(dream(y) \wedge have(x,y)))$
OR
$\exists x(dream(x) \wedge \forall y(man(y) \rightarrow have(y,x)))$

(2) $love(j,m) \leftrightarrow love(m,j)$

(3) $\forall x(chilren(x) \rightarrow like(x,hp))$

(4) $\forall x(hpb(x) \rightarrow own(j,x))$

(5) Strict reading:
$\exists x\Bigg(\Big(\big(car(x) \wedge bought(j,x)\big) \wedge \big(like(j,x) \wedge like(p,x)\big)\Big) \wedge \forall y\big((car(y) \wedge bought(j,y)) \rightarrow (x = y)\big)\Bigg)$
OR
Sloppy reading:
$\exists x\Bigg(\Bigg(\Big(\big(car(x) \wedge bought(j,x)\big) \wedge like(j,x)\Big) \wedge \forall y\big((car(y) \wedge bought(j,y)) \rightarrow (x = y)\big)\Bigg)\Bigg) \wedge \ ...$
$... \ \exists z\Bigg(\Big(\big(car(z) \wedge bought(p,z)\big) \wedge like(p,y)\Big) \wedge \forall a\big((car(a) \wedge bought(p,a)) \rightarrow (z = a)\big)\Bigg)$

(6) $\exists x(house(x) \wedge (buy(j+m,x)))$
OR
$\exists x(house(x) \wedge buy(j+m,x)) \wedge \exists y(house(y) \wedge buy(m,y))$

Exercise 2: Variable assignments

Given the model

$M =< D, I >$
$D = \{John, Mary, Peter\}$
$I(man) = \{John, Peter\}$
$I(love) = \{< John, Mary >, < Peter, Mary >, < Mary, Peter >\}$

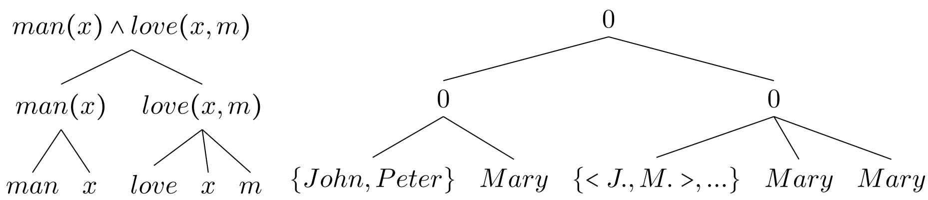
formalize and evaluate the sentence

There is a man who loves Mary

using a derivation tree.

Solution:

(Ähnlich wie der Baum in MathMethLing S. 328, für jeden Knoten die Denotation unter M, g, d.h. $[\![x]\!]_{M,g} = F(x) = g(x) = Mary$ etc.
Eigentlich wird wegen der Auswertung des Existenzquantors für jedes g ein eigener Baum benötigt, der die Denotation des Satzes unter der jeweiligen Belegung darstellt; der Baum rechts ist exemplarisch für den Fall $g(x) = Mary$.)



Semantics of the existential quantifier:
There is an assignment function g s.t. the proposition $(man(x) \wedge (love(x, m))$ is true under g (with $g(x) = John$ or $g(x) = Peter$), thefore the whole statement is true.

Exercise 3: Lambda expressions

Formalize the following expressions using the lambda calculus step by step (i.e. compute a suitable lambda expression for every constituent and compositionally apply them to each other), using names for predicates and individuals of your choice.
Lines that are contained within the same number belong to one formula.
These examples purposely contain some expressions of natural language that are not so easily translatable into predicate logic. Try to think of what the sentences mean from a narrow semantical point of view and reduce it to a fully truth-conditional semantics, filtering out word material or additional meaning that has no equivalent in our logic.

a) (1) *Some roses are red*
   (2) *All violets are blue*
   (3) *Jim is a pink hat*
   (4) *Noone reads PTQ*

b) (5) *All roses are bad*
   and most violets are too
   (6) *If you don't love me*
   then I don't love you

c) (7) *If violets are red*
   and roses are blue
   then every student
   loves Montague

Solution (partial):

(1) some
$= \lambda P \lambda Q \exists x[P(x) \wedge Q(x)]$

some roses
$= \lambda P \lambda Q \exists x[P(x) \wedge Q(x)](rose')$
$= \lambda Q \exists x[rose'(x) \wedge Q(x)]$

some roses are red
$= \lambda Q \exists x[rose'(x) \wedge Q(x)](red')$
$= \exists x[rose'(x) \wedge red'(x)]$

(2) all
$= \lambda P \lambda Q \forall x[P(x) \rightarrow Q(x)]$

all violets
$= \lambda P \lambda Q \forall x[P(x) \rightarrow Q(x)](violet')$
$= \lambda Q \forall x[violet'(x) \rightarrow Q(x)]$

all violets are blue
$= \lambda Q \forall x[violet'(x) \rightarrow Q(x)](blue')$
$= \forall x[violet'(x) \rightarrow blue'(x)]$

(3) pink hat
$= \lambda x[pink'(x) \wedge hat'(x)]$

Jim is a pink hat
$= \lambda x[pink'(x) \wedge hat'(x)](j')$
$= [pink'(j') \wedge hat'(j')]$

(4) reads
$= \lambda y \lambda s[read'(x, y)]$

reads PTQ

$= \lambda y \lambda x[read'(x,y)](ptq')$
$= \lambda x[read'(x,ptq')]$

no
$= \lambda P \lambda Q \neg\exists x[P(x) \wedge Q(x)]$

noone = no person
$= \lambda P \lambda Q \neg\exists x[P(x) \wedge Q(x)](person')$
$= \lambda Q \neg\exists x[person'(x) \wedge Q(x)]$

noone reads PTQ
$= \lambda Q \neg\exists x[person'(x) \wedge Q(x)](\lambda x[read'(x,ptq')])$
$= \neg\exists x[person(x) \wedge \lambda x[read(x,ptq')]]$

(5) most
$= \lambda Q \lambda P[Cardinality(\lambda x[P(x) \wedge Q(x)]) > Cardinality(\lambda x[P(x) \wedge \neg Q(x)])]$

most violets
$= \lambda Q \lambda P[Cardinality(\lambda x[P(x) \wedge Q(x)]) > Cardinality(\lambda x[P(x) \wedge \neg Q(x)])](violet')$
$= \lambda P[Cardinality(\lambda x[violet'(x) \wedge Q(x)]) > Cardinality(\lambda x[violet'(x) \wedge \neg Q(x)])]$

most violets are bad (too)
$= \lambda P[Cardinality(\lambda x[violet'(x) \wedge Q(x)]) > Cardinality(\lambda x[violet'(x) \wedge \neg Q(x)])](bad')$
$= Cardinality(\lambda x[violet'(x) \wedge bad'(x)]) > Cardinality(\lambda x[violet'(x) \wedge \neg bad'(x)])$

(6) love
$= \lambda y \lambda x[love'(x,y)]$

love me
$= \lambda y \lambda x[love'(x,y)](i')$
$= \lambda x[love'(x,i')]$

don't
$= \lambda P \lambda x[\neg P(x)]$

don't love me
$= \lambda P \lambda x[\neg P(x)](\lambda x[love'(x,i')])$
$= \lambda x[\neg love'(x,i')]$

S1: You don't love me
$= \lambda x[\neg love'(x,i')](y')$
$= \neg love'(y',i')$

love you
$= \lambda y \lambda x[love'(x,y)](y')$
$= \lambda x[love'(x,y')]$

don't
$= \lambda P \lambda x[\neg P(x)]$

don't love you
$= \lambda P \lambda x[\neg P(x)](\lambda x[love'(x,y')])$
$= \lambda x[\neg love'(x,y')]$

S2: I don't love you
$= \lambda x[\neg love'(x,y')](i')$
$= \neg love'(i',y')$

If p, then q
$= \lambda p \lambda q[p \rightarrow q]$

If you don't love me, then q
$= \lambda p \lambda q[p \rightarrow q](S1)$
$= \lambda q[\neg love'(y',i') \rightarrow q]$

If you don't love me then I don't love you

$= \lambda q[\neg love'(y', i') \rightarrow q](S2)$
$= \neg love(y', i') \rightarrow \neg love(i', y')$

(7) Depending on the interpretation of the DP ∅ *roses (in general)*, either
$(\forall x[violet'(x) \rightarrow red'(x)] \wedge \forall y[rose'(y) \rightarrow blue'(y)]) \rightarrow \forall z[student'(z) \rightarrow love(z, mont')]$ OR
$(\exists x[violet'(x) \wedge red'(x)] \wedge \exists y[rose'(y) \wedge blue'(y)]) \rightarrow \forall z[student'(z) \rightarrow love(z, mont')]$

Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Wolfwalk Starfield
Tutoren: Thorwald Kassemek, Natalie Clarius

Exemplary Solutions: Predicate Logic, Modal Logic, and Intensional Type Theory

Zimmermann & Sternefeld: Ch. 10
Gamut: Vol. 2 Ch. 4-5
Partee, Meulen & Wall: Pt. D
Hodges: Ch. 43
Montague: PTQ

For a general instruction, see p.2.

Given is the following model:

$M =< D, W, I >$

$D = \{John, Mary, Paul\}$

$W = \{w_1, w_2, w_3\}$

$I =$

	w_1	w_2	w_3
$I(j)$	$John$	$John$	$John$
$I(m)$	$Mary$	$Mary$	$Mary$
$I(p)$	$Paul$	$Paul$	$Paul$
$I(student)$	$\{John, Mary\}$	$\{John, Paul\}$	$\{Mary, Paul\}$
$I(sleep)$	$\{John, Paul\}$	$\{John, Paul\}$	$\{John, Mary, Paul\}$

Evaluate the following expressions and determine their meaning in natural language:

a) $\llbracket \exists x(student(x) \wedge sleep(x)) \rrbracket_{M,g,w_1}$
b) $\llbracket \Diamond student(j) \rrbracket_{M,g,w_2}$
c) $\llbracket \Box sleep(m) \rrbracket_{M,g,w_3}$
d) $\llbracket {}^{\wedge}sleep \rrbracket_{M,g,w_2}$
e) $\llbracket {}^{\vee\wedge}sleep \rrbracket_{M,g,w_2}$
f) $\llbracket {}^{\wedge}sleep(m) \rrbracket_{M,g,w_2}$
g) $\llbracket {}^{\vee\wedge}sleep(m) \rrbracket_{M,g,w_2}$
h) $\llbracket \Diamond \forall x(student(x) \rightarrow \neg student(x) \rrbracket_{M,g,w_3}$
i) $\llbracket \Box \exists x(student(x)) \rrbracket_{M,g,w_1}$

(You can click on the formulas in the PDF file to jump directly to the corresponding solution.)

Solution:

The algorithm is always the same:

1. First look for the main operator. For simple statement and predicate logic this is the same as we have done all the time, e.g. in $(p \vee q) \wedge r$ this would be the $\wedge$; if there is one of the operators $^\wedge, ^\vee, \Box, \Diamond, \forall, \exists$ they will always have to be evaluated first going from left to right, unless of course bracketing tells your something else.
   For example in $\Diamond\Box\exists x \forall y \phi$ the order of application would simply be $\Diamond(\Box\exists ...)$ then $\Box(\exists x \forall ...)$ then $\exists x(\forall ...)$ then $\forall y(\phi)$, whereas in $(\Box\phi) \vee \psi$ you would have to first look at the $\vee$ and then at the $\Box$.
2. As soon as you have identified the main operator or connective, evaluate it by simply applying the definitions from the book and replacing α by whatever follows the symbol in question; the syntax and semantics statements unambiguously tell you how to evaluate a statement given the main operator or connective. You now have to do no more than writing this definition down, filling the arguments in and then mechanically applying what the evaluation rules tell you.
3. Apply this recursively over and over again until you reach the atomic parts from which you can compositionally derive the extension of the whole expression.
4. You will frequently encounter steps where you have to check whether "for all xyz it holds that..." or "there is a xyz such that...", with "xyz" being assignment functions or possible worlds. To evaluate these, proceed as follows:
   - If there is an existential quantifier ($\exists g$ or $\exists w$):
     - If you immediately see that there is one particular g/w that makes the statement true, just provide this one and you're done.
     - If there is none that makes it true, you have to go through every possible g/w to show that all of them fail and therefore the outer statement is false.
   - If there is a universal quantifier ($\forall g$ or $\forall w$):
     - If you immediately see that there is one for which the inner statement does not hold, you only have to provide this one to show that the outer statement is not true.
     - If the inner statement is true of all g/w, you have to provide the proof for each of them before confirming that the whole statement is true.
5. The rest is, as said, just recursive application of always the same definitions.

a) *A student sleeps in* w_1 (true)

$[\![\exists x(student(x) \wedge sleep(x))]\!]_{M,g,w_1}$
$= 1$ iff there is an assignment function $g' : [\![student(x) \wedge sleep(x)]\!]_{M,g,w_1} = 1$

- For $g'(x) = John : [\![(student(x) \wedge sleep(x)]\!]_{M,g',w_1}$
  $= 1$ iff $[\![student]\!]_{M,g',w_1}([\![x]\!]_{M,g',w_1}) = 1$ and $[\![sleep]\!]_{M,g',w_1}([\![x]\!]_{M,g',w_1}) = 1$
  $= 1$ iff $g'(x) \in I(student)(w_1)$ and $g'(x) \in I(sleep)(w_1)$
  $= 1$ iff $John \in \{John, Mary\}$ and $John \in \{John, Paul\}$
  $= 1$ since $John \in \{John, Mary\}$ is true and $John \in \{John, Paul\}$ is true

There is an assignment function g' such that $[\![student(x) \wedge sleep(x)]\!]_{M,g',w_1} = 1$ with $g'(x) = John$
Therefore, $[\![\exists x(student(x) \wedge sleep(x))]\!]_{M,g,w_1} = 1$

b) *It is possible that John is a student* (true)

$[\![\Diamond student(j)]\!]_{M,g,w_2}$
$= 1$ iff there is a world $w' \in W : [\![student(j)]\!]_{M,g,w'} = 1$

- For $w' = w_1 : [\![student(j)]\!]_{M,g,w_1}$
  $= 1$ iff $[\![student]\!]_{M,g,w_1}([\![j]\!]_{M,g,w_1})$
  $= 1$ iff $I(j)(w_1) \in I(student)(w_1)$
  $= 1$ iff $John \in \{John, Mary\}$
  $= 1$

There is a world w' such that $[\![student(j)]\!]_{M,g,w'} = 1$ with $w' = w_1$
Therefore, $[\![\Diamond student(j)]\!]_{M,g,w_2} = 1$

c) *It is necessary that Mary sleeps* (false)

$[\![\Box sleep(m)]\!]_{M,g,w_3}$
$= 1$ iff for all worlds $w' \in W : [\![sleep(m)]\!]_{M,g,w'} = 1$

- For $w' = w_1$: $[\![sleep(m)]\!]_{M,g,w_1}$
  $= 1$ iff $[\![sleep]\!]_{M,g,w_1}([\![m]\!]_{M,g,w_1})$
  $= 1$ iff $I(m)(w_1) \in I(sleep)(w_1)$
  $= 1$ iff $Mary \in \{John, Paul\}$
  $= 0$

There is an world w' such that it does not hold that $[\![student(j)]\!]_{M,g,w'} = 1$ with $w' = w_1$
Therefore, not for all worlds $w' \in W$ it holds that $[\![sleep(m)]\!]_{M,g,w'} = 1$
Therefore, $[\![\Box sleep(m)]\!]_{M,g,w_3} = 0$

d) *(The concept of* sleep *in all possible worlds)*

$[\![{}^\wedge sleep]\!]_{M,g,w_2}$
$=$ that function $h \in D^W$ such that for all $w' \in W : h(w') = [\![sleep]\!]_{M,g,w'}$
$= I(sleep)$

- For $w' = w_1 : h(w_1) = [\![sleep]\!]_{M,g,w_1} = I(sleep)(w_1) = \{John, Paul\}$
- For $w' = w_2 : h(w_2) = [\![sleep]\!]_{M,g,w_2} = I(sleep)(w_2) = \{John, Paul\}$
- For $w' = w_3 : h(w_3) = [\![sleep]\!]_{M,g,w_3} = I(sleep)(w_3) = \{John, Paul, Mary\}$

e) *(The set of sleepers in* w_2*)*

$[\![{}^\vee{}^\wedge sleep]\!]_{M,g,w_2}$
$= [\![sleep]\!]_{M,g,w_2}$
$= I(sleep)(w_2)$

$= \{John, Paul\}$

f) *(The set of possible worlds in which Mary sleeps)*

$[\![{}^\wedge sleep(m)]\!]_{M,g,w_2}$
$=$ that function $h \in D^W$ such that for all $w' \in W : h(w') = [\![sleep(m)]\!]_{M,g,w'}$

- For $w' = w_1 : h(w_1) = [\![sleep(m)]\!]_{w_1} = 0$
- For $w' = w_2 : h(w_2) = [\![sleep(m)]\!]_{w_2} = 0$
- For $w' = w_3 : h(w_3) = [\![sleep(m)]\!]_{w_3} = 1$

g) *Mary sleeps in* w_2 (false)

$[\![{}^\vee{}^\wedge sleep(m)]\!]_{M,g,w_2}$
$= [\![sleep(m)]\!]_{M,g,w_2}$
$= [\![sleep]\!]_{M,w,w_2}([\![m]\!]_{M,g,w_2})$
$= 1$ iff $I(m)(w_2) \in I(sleep)(w_2)$
$= 1$ iff $Mary \in \{John, Paul\}$
$= 0$

h) *It is possible that every student is not a student* (false)

$[\![\Diamond \forall x(student(x) \to \neg student(x)]\!]_{M,g,w_3}$
$= 1$ iff there is a world $w' \in W : [\![\forall x(student(x) \to \neg student(x)]\!]_{M,g,w'} = 1$

Here you may abbreviate a little: $A \to \neg A$ can only be true iff A is false. This would mean that there must be no students in that world. Since this is in no world the case, the whole statement must be false.
Detailed solution:

- For $w' = w_1 : [\![\forall x(student(x) \to \neg student(x)]\!]_{M,g,w_1}$
  $= 1$ iff for all assignment functions $g' : [\![student(x) \to \neg student(x)]\!]_{M,g',w_1} = 1$
  - For $g'(x) = John$: false
  - For $g'(x) = Mary$: false
  - For $g'(x) = Paul$: false

  There is an assignment function g' such that it does not hold that $[\![student(x) \to \neg student(x)]\!]_{M,g',w_1} = 1$ with $g'(x) = John$ (or $g'(x) = Mary$ or $g'(x) = Paul$)
  Therefore, not for all assignment functions g' it holds that $[\![student(x) \to \neg student(x)]\!]_{M,g',w_1} = 1$
  Therefore, $[\![\forall x(student(x) \to \neg student(x)]\!]_{M,g,w_1} = 0$
- For $w' = w_2$: (similar as above; $[\![\forall x(student(x) \to \neg student(x)]\!]_{M,g,w_2} = 0$)
- For $w' = w_2$: (similar as above; $[\![\forall x(student(x) \to \neg student(x)]\!]_{M,g,w_3} = 0$)

There is no world $w' \in W$ such that $[\![\forall x(student(x) \to \neg student(x)]\!]_{M,g,w'} = 1$
Therefore, $[\![\Diamond \forall x(student(x) \to \neg student(x)]\!]_{M,g,w_3} = 0$

i) *It is necessary that there is a student* (true)

$[\![\Box \exists x(student(x))]\!]_{M,g,w_1}$
$= 1$ iff for all worlds $w' \in W : [\![\exists x(student(x))]\!]_{M,g,w'} = 1$

Here you may abbreviate again: You can already informally infer from h) that this must be true.
Detailed solution:

- For $w' = w_1 : [\![\exists x(student(x))]\!]_{M,g,w_1}$
  $= 1$ iff there is an assignment function $g' : [\![student(x)]\!]_{M,g',w_1} = 1$

- For $g'(x) = Mary [\![student(x)]\!]_{M,g',w_1}$
  $= [\![student]\!]_{M,g',w_1}([\![x]\!]_{M,g',w_1})$
  $= 1$ iff $g'(x) \in I(student(w_1))$
  $= 1$ iff $Mary \in \{John, Mary\}$
  $= 1$

  There is an assignment function g' such that $[\![student(x)]\!]_{M,g',w_1} = 1$ with $g'(x) = Mary$ (works also with $g'(x) = John$)
  Therefore, $[\![\exists x(student(x))]\!]_{M,g,w_1} = 1$
- For $w' = w_2$: (same as above, with $g'(x) = John$ or $g'(x) = Paul$)
- For $w' = w_3$: (same as above, with $g'(x) = Mary$ or $g'(x) = Paul$)

Therefore, in all worlds $w' \in W$ it holds that $[\![\exists x(student(x))]\!]_{M,g,w'} = 1$
Therefore, $[\![\Box\exists x(student(x))]\!]_{M,g,w_1} = 1$

Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Feldgang Sternewolf
Tutoren: Thorwald Kassemek, Natalie Clarius

Mock exam:
Midterm

Zimmermann & Sternefeld: Ch. 1-8
Slides ESSLLI: No. 1-5 + Addenda
Gamut: Vol. 1 Ch. 1-4
Partee, Meulen & Wall: Pt. A-B
Hodges: Ch. 1-41

Exercise 1: Prerequisites

1. Explain the difference between direct and indirect semantic interpretation.
2. Determine which of the following forumale are equivalent:
   (a) $(A \wedge \neg(A \wedge \neg B))$
   (b) $((A \rightarrow B) \wedge A)$
   (c) $(\neg(\neg A \vee (A \rightarrow B)))$
3. Give a predicate logic translation of the sentence

   For every entity it holds, if it is an animal and pink, then it is a panther.

   using constant symbols of your choice.
4. What does the "most certain principle" state and who does it attribute to?

Exercise 2: Extensions

1. Determine the class (i.e. functional noun, count noun, verb, ...) as well as the type of the extension (i.e. whether it is an individual, a truth value, ...)of the following expressions:
   (a) *house*
   (b) *brother of*
   (c) *sing*
   (d) *milk*
   (e) *donate*
   (f) *large*
   (g) *mayor of*
   (h) *hit*
2. State four ways of composing extensions, and give one example for each.
3. What does plugging of the verb *love Mary* with the indiviual *John* result in, i.e. what is its extension and how the operation affect the properties of the verb?
4. Explain how the extension of *the table* is compsed of its immediate parts, i.e. what the semantics of the individual constituents are and what happens during their combination.

5. What is the required operation for composing the extension of *red apple*, and why does it cause problems for the syntactically similar term *alleged murderer*?

6. How does quantifier raising affect the extension of the declarative sentence the QDP has bee moved out, and what is the term for this kind of operation?

Exercise 3: Determiners and quantifiers

Consider the following sentence:

A single falls in love with every woman on Parhsip.[1]

1. Determine the two readings and explain how the ambiguity arises. Which reading is the desired one, and what kind of syntactic operation is needed for deriving the other one?

2. Give the logical form of each reading, using either boxes, brackets or a tree, and additionaly a corresponding predicate logic formula.

3. Calculate the truth conditions of the two readings using two different methods, and explain how those methods correspdond to the results.

4. In what way can bound variable pronouns be accounted for, and how is this related to an elementary problem about generalised quantifiers?

5. Give a definition for each of the following expressions, and explain why one of them has a special status:

   (a) *every*
   (b) *most*
   (c) *some*
   (d) *a*
   (e) *the*
   (f) *no*
   (g) *nothing*

6. Explain the paradox of composing the extension of *the + plural-NP*.

7. Give the extension of three different readings for the sentence *The boys and the girls met in the cinema.*

8. Give one solution for a tree of the logical types being composed of the immediate constituents in the slightly changed sentence:

   The single loves every woman on Parship.

Exercise 4: Propositions and intensions

Consider the sentece

John knows that grass is green.

1. Explain the terms *logical space*, *proposition* and *possible worlds* with respect to each other.

2. What is the extension of the above sentence as a whole, and what is the proposition of the embedded sentence?

3. What is the intension of an expression in general and what is the intension of the sentence above in particular?

[1]The source and original version of this sentence is the (in Germany) well-known advertising *Alle elf Minuten verliebt sich ein Single über Parhsip*, which is a nice example for scope ambiguity in real life - but since we can not porperly analyse "alle elf Minuten" with our methods, we had to slightly adapt the example.

Eberhard Karls Universität Tübingen | Seminar für Sprachwissenschaft (SfS)
PS Semantik 1 (WS 2015/16), Prof. Dr. Wolfgang Sternefeld
Tutoren: Thorwald Kassemek, Natalie Clarius

Keywords: Final Exam

Zimmermann & Sternefeld: Ch. 10
Gamut: Vol. 1 Ch. 1-4
Gamut: Vol. 2 Ch. 4-5
Partee, Meulen & Wall: Pt. A-B, D
Levinson: Ch. 4
Montague: PTQ

This is a list of some important keywords for the final exam that you should be familiar with.
And no, of course it is not sufficient to just learn the definitions by heart, you should also know what they actually mean and how to semantics ;)

A) presuppositions

- definite article, existence and uniqueness condition, naive vs. quanitifactional analysis
- entailment relations
- veridical vs. factive verbs
- presupposition and assertion
- presupposition and discourse, common ground (CG), context update, informativity
- presupposition accomodation
- presupposition projection

B) predicate logic

- scope ambiguity and LF
- assignment functions, x-alternatives
- models
- logical types, intensional type theory
- lambda-calculus, functional application and compositionality
- possible worlds, $\Box$ and $\Diamond$
- intensionality, $^\wedge$ and $^\vee$
- Montague's PTQ