Semantics lab class (Course 2)

Getting ready for the mid term

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Session 6

December 13, 2023

Our agenda today

- Recap: noun phrases

- Something new:

  Pronouns, assignments, and features (important!)

- Some exercise to help you with the mid-term exam

Recap: We now know the denotations of…

Syntactic Category	Denotation types	Semantic type
S (Sentence)	Truth values {0, 1}	***t***
• Proper name *John* • Referential NP *this cat, the capital of Germany*	Individual in D_e	***e***
• Common noun *cat*, • Intransitive verb *smoke*, • Predicative adjective *smart*	Functions from D_e to {0, 1} (**characteristic function**)	*<e, t>*
Transitive verb *love*	Functions from D_e to functions from D_e to {0, 1}.	*<e, <e, t>>*
Negation *not*	Function from {0, 1} to {0, 1}	*<t, t>*
or/and	Functions from {0, 1} to functions from {0, 1} to {0, 1}	*<t, <t, t>>*
Definite article *the*	Functions from characteristic function to D_e	*<<e,t>,e>*

Recap: Sentence denote truth-values

Recall: One can only decide the truth or falsity of the sentence in a given situation.

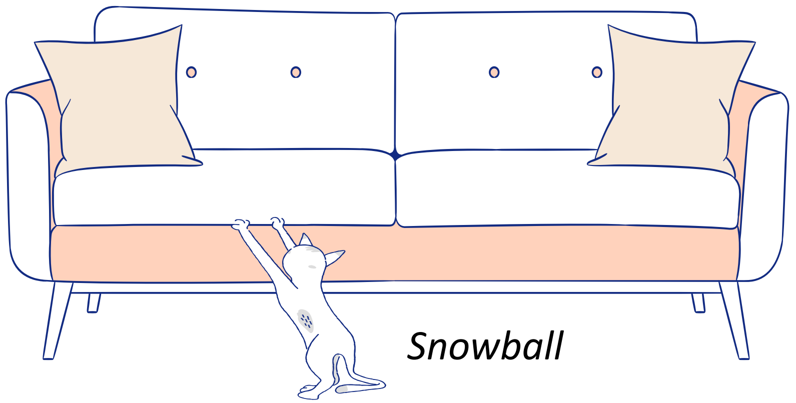
(1) Snowball is on the sofa.

To determine whether (1) is true or false, you have to inspect the situation and know

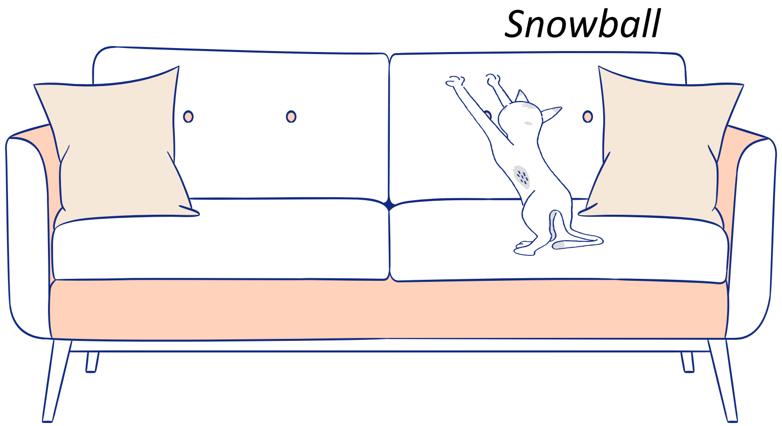
a) who Snowball is

b) whether Snowball is on the sofa.

In Situation S_1, (1) is false.



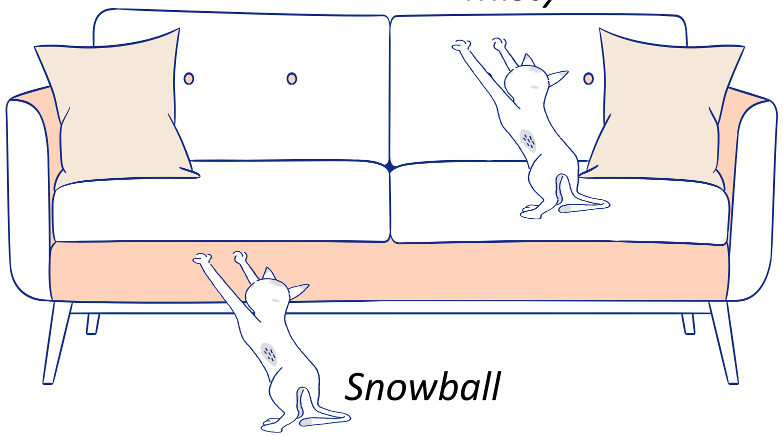
In Situation S_2, (1) is true.



What about pronouns?

What's the truth-conditions of (2)?

(2) He is on the sofa.

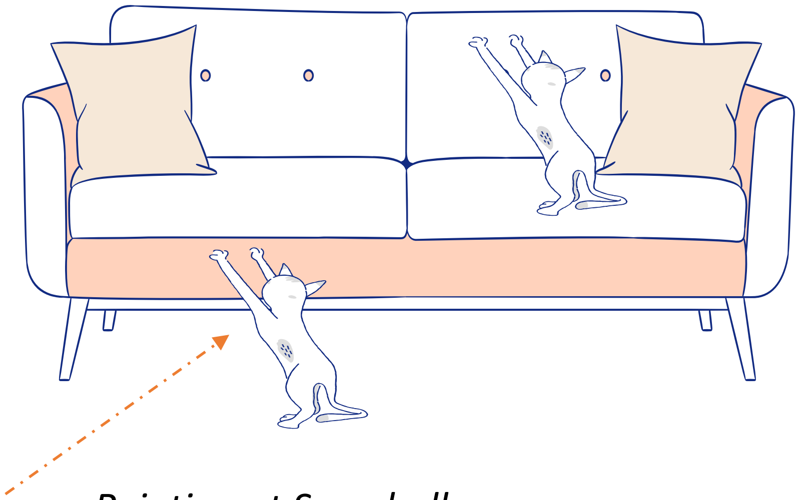


Assume a situation with two tom cats named Snowball and Misty.

We cannot decide the truth/ falsity of (2) even when a situation is given.

What about pronouns?

(2) He is on the sofa.

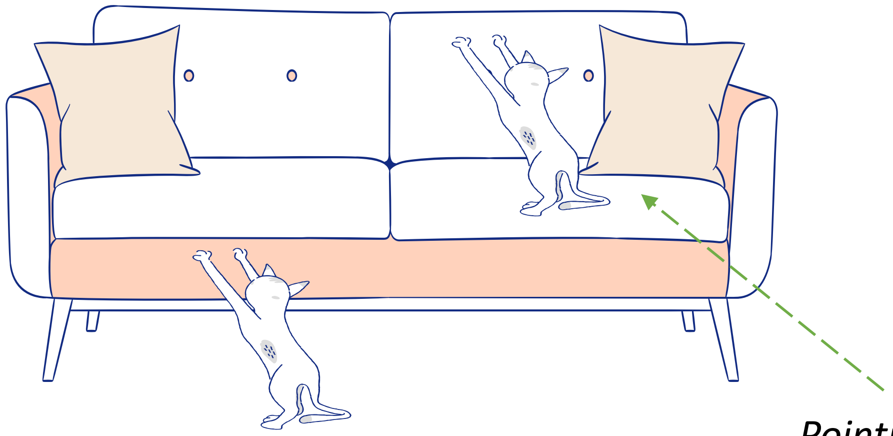


Pointing at Snowball

In a context where I am pointing at Snowball, (2) is false.

What about pronouns?

(2) He is on the sofa.



Pointing at Misty

In a context where I am pointing at Misty, (2) is true.

It seems the interpretation of the pronoun *he* **varies** relative to the **context**.

Context dependence of pronouns

Unlike proper names, pronouns are variables. They receive their denotation **via an assignment** from the context. Deictic pointing can be an example of assignment.

(2) He is on the sofa.

Under assignment Snowball, [[he]]= Snowball.

Under assignment Misty, [[he]]= Misty.

Pronoun rule (to be revised)

We use special superscripts on “[[.]]” to represent contextual information.

If α is a pronoun, then for any assignment a,

$[[\alpha]]^{a} = a$ for “*α* under assignment *a* denotes *a*”.

$[[he]]^{Snowball}$ = Snowball $[[he]]^{Misty}$ = Misty

For the moment, we see an assignment as an individual.

Now we add assignment to our interpretation rules:

α is in the domain of [[ ]]^a:

α receives its denotation via assignment.

FA If $\boldsymbol{\alpha}$ is a branching node, $\{\boldsymbol{\beta}, \boldsymbol{\gamma}\}$ is the set of $\boldsymbol{\alpha}$'s daughters, then for any assignment a $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]^a$ if $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are in the domain of $[\![\ ]\!]^a$ and $[\![\boldsymbol{\gamma}]\!]^a$ is in the domain of $[\![\boldsymbol{\beta}]\!]^a$. Then $[\![\boldsymbol{\alpha}]\!]^a = [\![\boldsymbol{\beta}]\!]^a([\![\boldsymbol{\gamma}]\!]^a)$.

NN If $\boldsymbol{\alpha}$ is a non-branching node, and $\boldsymbol{\beta}$ is $\boldsymbol{\alpha}$'s daughter, then for any assignment a, $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]^a$ if $\boldsymbol{\beta}$ is in the domain of $[\![\ ]\!]^a$. Then $[\![\boldsymbol{\alpha}]\!]^a = [\![\boldsymbol{\beta}]\!]^a$.

PM If $\boldsymbol{\alpha}$ is a branching node, $\{\boldsymbol{\beta}, \boldsymbol{\gamma}\}$ is the set of $\boldsymbol{\alpha}$'s daughters, then for any assignment a, $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]^a$ if $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are in the domain of $[\![\ ]\!]^a$ and $[\![\boldsymbol{\beta}]\!]^a$ and $[\![\boldsymbol{\gamma}]\!]^a$ are both in $D_{\langle e,t\rangle}$. Then $[\![\boldsymbol{\alpha}]\!]^a = \lambda x \in D_e\ .\ [\![\boldsymbol{\beta}]\!]^a(x) = [\![\boldsymbol{\gamma}]\!]^a(x) = 1$.

Assignment independent denotations (AID)

Unlike pronouns, the denotations of certain lexical elements are **not affected by contexts.**

(3) (John is a teacher.) Mary kissed Bill.

Under assignment John:

$[[\text{Mary}]]^{\text{John}}$ = [[Mary]] = Mary

$[[\text{Bill}]]^{\text{John}}$ = [[Bill]] = Bill

$[[\text{kissed}]]^{\text{John}}$ = [[kissed] = $\lambda x \in D_e$. [$\lambda y \in D_e$. y kissed x]

We say they have **assignment independent denotations (AID)**.

They are not in the domain of $[[\ ]]^a$, but in the domain of [[ ]], i.e. they don't receive their denotations via assignments.

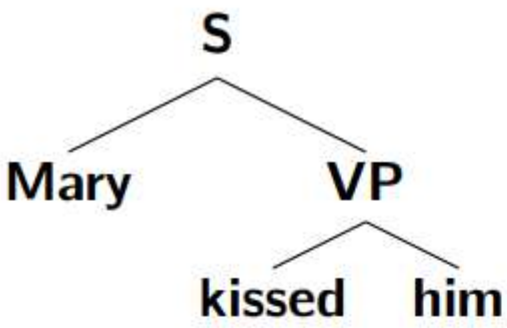
New rule: AID

For every $\boldsymbol{\alpha}$, $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]$ iff for all assignments a and b, $[\![\boldsymbol{\alpha}]\!]^a = [\![\boldsymbol{\alpha}]\!]^b$.

If $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]$, then for every assignment a, $[\![\boldsymbol{\alpha}]\!] = [\![\boldsymbol{\alpha}]\!]^a$.

For every assignment a: $[\![\textbf{kiss}]\!] = [\![\textbf{kiss}]\!]^a$

Truth-conditions with assignments



$$[\![S]\!]^{John} = [\![VP]\!]^{John}([\![Mary]\!]^{John}) \qquad \text{(FA)}$$

$$= [\![VP]\!]^{John}([\![Mary]\!]) \qquad \text{(AID)}$$

$$= [\![kissed]\!]^{John}([\![him]\!]^{John})([\![Mary]\!]) \qquad \text{(FA)}$$

$$= [\![kissed]\!]([\![him]\!]^{John})([\![Mary]\!]) \qquad \text{(AID)}$$

Note that now we have two different kinds of terminal nodes.

Two different kinds of terminal nodes

- For **assignment independent items**, their denotations are specified in the **lexicon:**

[[Mary]]= Mary

[[kissed]] = $\lambda x \in D_e$. [$\lambda y \in D_e$. y kissed x]

- For **pronouns**, they receive their denotations via **assignment**.

[[him]]^{John} = John

Old rule TN

Recall our rule TN:

TN If $\boldsymbol{\alpha}$ is a terminal node, then $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]$ if $[\![\alpha]\!]$ is specified in the lexicon.

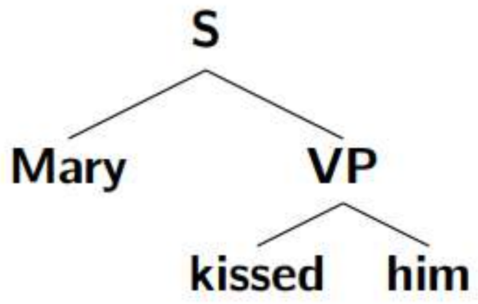
It only applies to **assignment independent items, not pronouns.**

Two rules for Terminal Nodes:

1. If $\boldsymbol{\alpha}$ is a terminal node, then $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]$ if $[\![\boldsymbol{\alpha}]\!]$ is specified in the lexicon.

2. If $\boldsymbol{\alpha}$ is a pronoun, then for any assignment a, $[\![\boldsymbol{\alpha}]\!]^a = \mathrm{a}$.

With TN1 and TN2, we can now handle two kinds of terminal nodes



$$
\begin{aligned}
\llbracket \text{S} \rrbracket^{John} &= \llbracket \text{VP} \rrbracket^{John}(\llbracket \text{Mary} \rrbracket^{John}) && \text{(FA)} \\
&= \llbracket \text{VP} \rrbracket^{John}(\llbracket \text{Mary} \rrbracket) && \text{(AID)} \\
&= \llbracket \text{kissed} \rrbracket^{John}(\llbracket \text{him} \rrbracket^{John})(\llbracket \text{Mary} \rrbracket) && \text{(FA)} \\
&= \llbracket \text{kissed} \rrbracket(\llbracket \text{him} \rrbracket^{John})(\llbracket \text{Mary} \rrbracket) && \text{(AID)}
\end{aligned}
$$

Truth-conditions with assignments

$$= [\![\textbf{kissed}]\!]([\![\textbf{him}]\!]^{John})([\![\textbf{Mary}]\!]) \qquad \text{(AID)}$$

$$= [\lambda x \in D_e\ .\ [\lambda y \in D_e\ .\ y \text{ kissed } x]]([\![\textbf{him}]\!]^{John})(\text{Mary}) \qquad (2\times\text{TN1})$$

$$= [\lambda x \in D_e\ .\ [\lambda y \in D_e\ .\ y \text{ kissed } x]](\text{John})(\text{Mary}) \qquad \text{(TN2)}$$

$$= 1 \text{ iff Mary kissed John}$$

Gender features and (un)definedness

Pronouns bear features for grammatical gender.

[±feminine] *[± masculine]*

(4) #Sue is a friend of Mary. Mary likes him.

him should not be able to refer to a female individual *Sue*. $[[\text{him}]]^{Sue}$ is undefined.

This (un)definedness conditions is not yet encoded in the system we've constructed so far.

Encoding (un)definedness

In our semantic system:

Definedness conditions are contributed by functions.

Recall *win* triggers presuppositions**.** John won the game presupposes John took part in the game.

win is only in the domain of **[[ ]]** if for some individual to win a game, this individual has to first take part in this game.

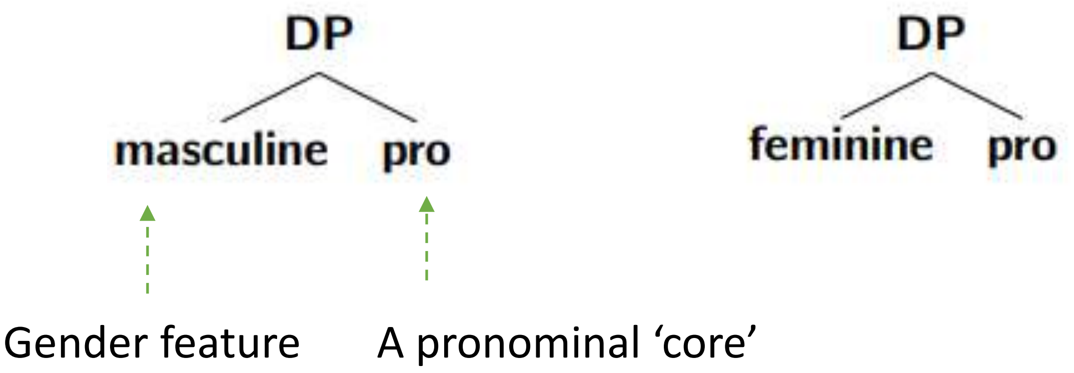
[[won]] = $\lambda x \in D_e$. [$\lambda y \in D_e$ and y took part in x. y came first in x]

This means, we also want **gender features to denote functions.**

Encoding (un)definedness

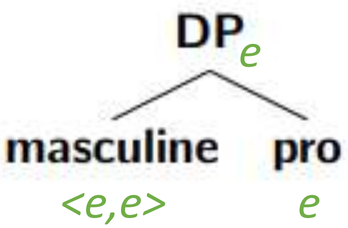
- Step 1: The Syntactic Representation of gender

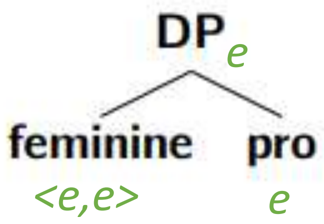
We assume pronouns are complex expressions, although we pronounce it as a single word at PF.



Encoding (un)definedness:

- Step 2: The Semantic Contribution of gender





Gender features denote restricted identity functions.

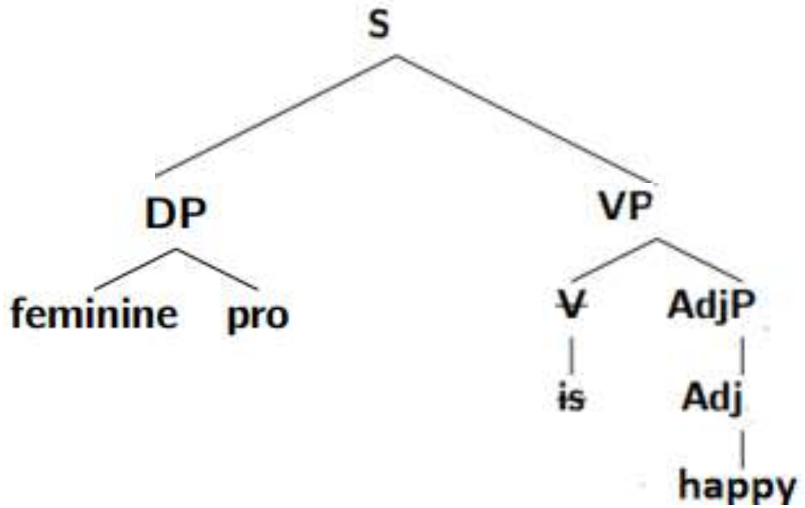
$[\![\textbf{masculine}]\!] = \lambda x : x \in D_e \text{ and } \boxed{x \text{ is male}}\, .\ x$

$[\![\textbf{feminine}]\!] = \lambda x : x \in D_e \text{ and } \boxed{x \text{ is female}}\, .\ x$

Interpretation of pronouns

(5) (Mary is a teacher.) She is happy.

$$
\begin{aligned}
[\![\mathbf{DP}]\!]^{Mary} &= [\![\mathbf{feminine}]\!]^{Mary}([\![\mathbf{pro}]\!]^{Mary}) && \text{(FA)}\\
&= [\![\mathbf{feminine}]\!]([\![\mathbf{pro}]\!]^{Mary}) && \text{(AID)}\\
&= [\![\mathbf{feminine}]\!](\text{Mary}) && \text{(TN2)}\\
&= [\lambda x : x \in D_e \text{ and } x \text{ is female} .\ x](\text{Mary}) && \text{(TN1)}\\
&= \text{Mary}\\
&\ \text{defined only if Mary is female}
\end{aligned}
$$



[[S]]^{Mary} = 1 iff Mary is happy

defined only if Mary is female.

More than one pronouns

(5) (Mary is a teacher.) She is happy.

Sentence (5) is under assignment *Mary*.

(6) (John and Bill are best friends.) He loves him.

What's the interpretation of *he* and *him*?

Our intuitions tell us, different pronouns need different assignments.

$[[\text{he}]]^{\text{John}}$ = John $[[\text{him}]]^{\text{Bill}}$ = Bill

Assignment is not a single individual

So far, **we treat an assignment as an *single* individual**.

If this is the case, then all pronouns in a sentence will have to be interpreted as referring to that same single individual.

[[He loves him]] ^{John} = 1 iff John loves John

[[He loves him]] ^{Bill} = 1 iff Bill loves Bill

But the truth conditions we want:

[[He loves him]]^{a} = 1 iff John loves Bill

Indices

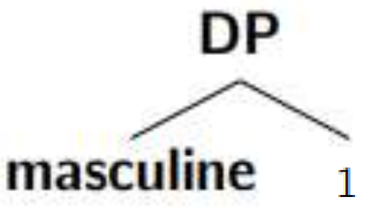
Every instance of a pronoun in a sentence is assigned an index.

We write indices as **numeric subscripts**.

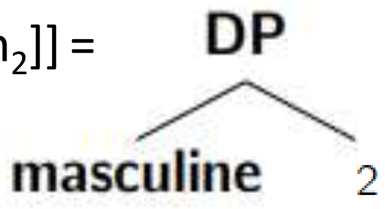
(6) (John likes Bill.) He_1 loves him_2.

The *pro*-core corresponds to the index:

$[[he_1]]$ =



$[[him_2]]$ =



Assignment function

An assignment *a* can no longer be a single individual.

It is a function mapping **natural numbers (indices)** to **the set of individuals**.

(6) (John likes Bill.) He_1 loves him_2.

$$\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix}$$

Side note: how to think about indices

Note: We are not saying we actually add numbers(indices) to each whenever we use a pronoun in the conversation.

Assignments are mental representations of how speakers **keep track of what they are talking about**.

(6) (John likes Bill.) He_1 loves him_2.

Indices are '**memory slots**' that assigned to individuals in the course of the conversation.

Terminal nodes (TN) with indices:
A new TN2

1. If $\boldsymbol{\alpha}$ is a terminal node, then $\boldsymbol{\alpha}$ is in the domain of $[\![\ ]\!]$ if $[\![\boldsymbol{\alpha}]\!]$ is specified in the lexicon.

2. If $\boldsymbol{\alpha}$ is an index $\mathbf{i}$ then for any assignment a such that $\mathbf{i}$ is in the domain of a, $[\![\mathbf{i}]\!]^a = a(\mathbf{i})$.

A new TN2

If $\boldsymbol{\alpha}$ is an index $\mathbf{i}$ then for any assignment a such that $\mathbf{i}$ is in the domain of a, $[\![\mathbf{i}]\!]^a = a(\mathbf{i})$.

The interpretation of an index under assignment = **applying assignment function to the index**

$[[1]]^{\begin{bmatrix} 1 & \to & \text{John} \\ 2 & \to & \text{Bill} \end{bmatrix}} = \begin{bmatrix} 1 & \to & \text{John} \\ 2 & \to & \text{Bill} \end{bmatrix}(1) = \text{John}$

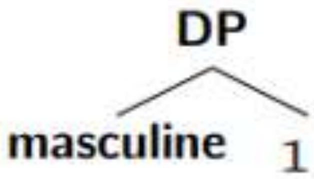
$[[2]^{\begin{bmatrix} 1 & \to & \text{John} \\ 2 & \to & \text{Bill} \end{bmatrix}} = \begin{bmatrix} 1 & \to & \text{John} \\ 2 & \to & \text{Bill} \end{bmatrix}(2) = \text{Bill}$

$[[3]]^{\begin{bmatrix} 1 & \to & \text{John} \\ 2 & \to & \text{Bill} \end{bmatrix}} = \text{undefined}$

because 3 is not in the domain of $\begin{bmatrix} 1 & \to & \text{John} \\ 2 & \to & \text{Bill} \end{bmatrix}$

Interpretation of pronouns with assignment functions

(6) (John likes Bill.) He_1 introduced his teacher to him_2.



$$[[\text{DP}]]^{\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix}} = [[\text{masculine}]]^{\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix}} ([[1]]^{\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix}}) \quad \text{(FA)}$$

$$= [[\text{masculine}]] ([[1]]^{\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix}}) \quad \text{(AID)}$$

$$= [[\text{masculine}]] \begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix} (1) \quad \text{(TN2)}$$

$$= [[\text{masculine}]] (\text{John})$$

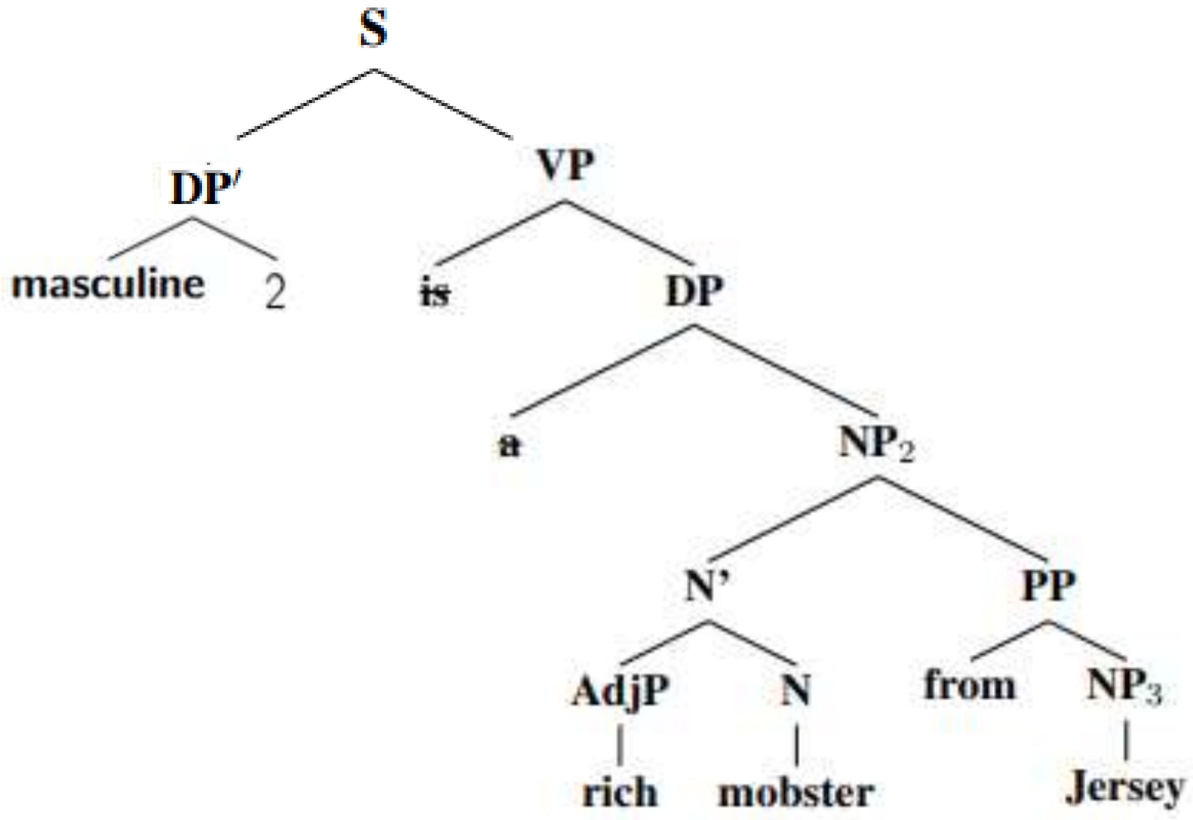
$$= [x : x \in D_e \text{ and } x \text{ is male. } x](\text{John}) \quad \text{(TN1)}$$

$$= \text{John}$$

defined only if John is male

Exercise 1: Assume an appropriate assignment function

(7) He is a poor mobster from Jersey.



Solutions: Exercise 1

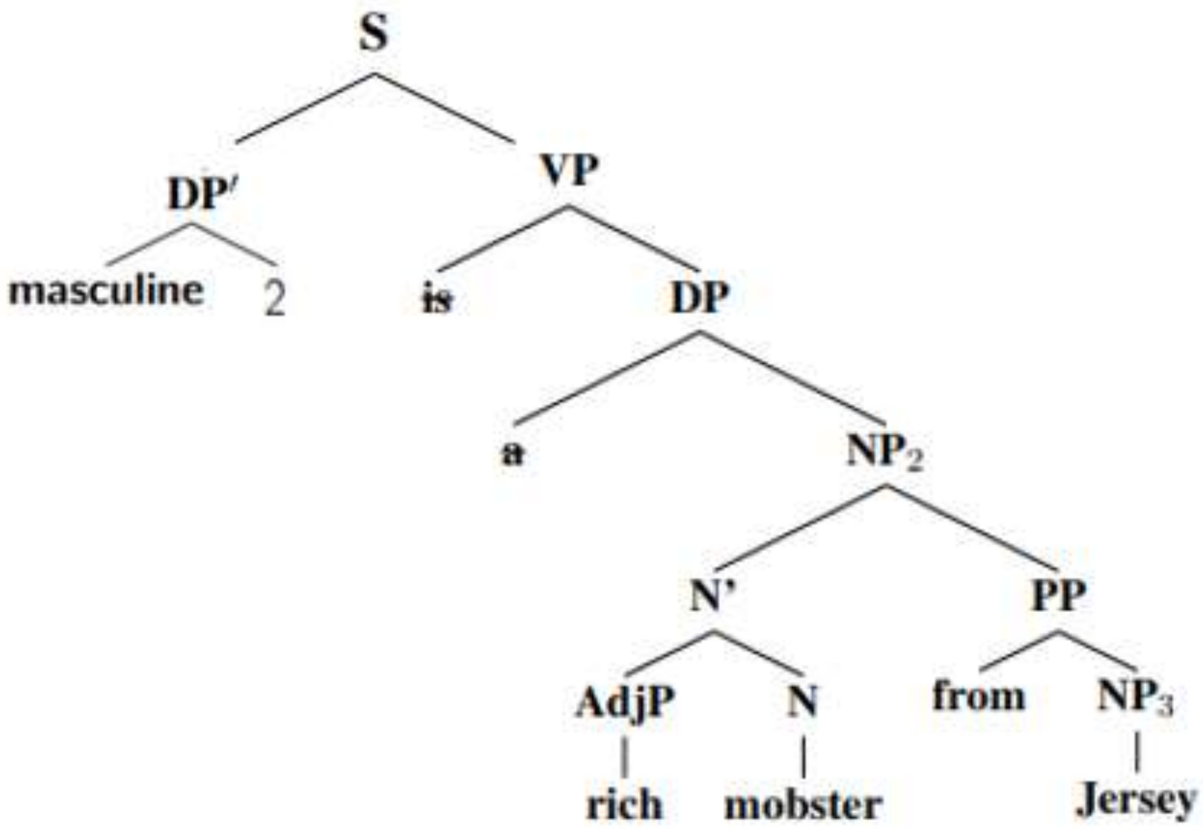
Appropriate assignment function: **As long as we can map 2 to a male individual.**

$$\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix} \text{ or } \begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{John} \end{bmatrix} \text{ or } \begin{bmatrix} 2 & \rightarrow & \text{John} \\ 5 & \rightarrow & \text{Mary} \end{bmatrix}$$

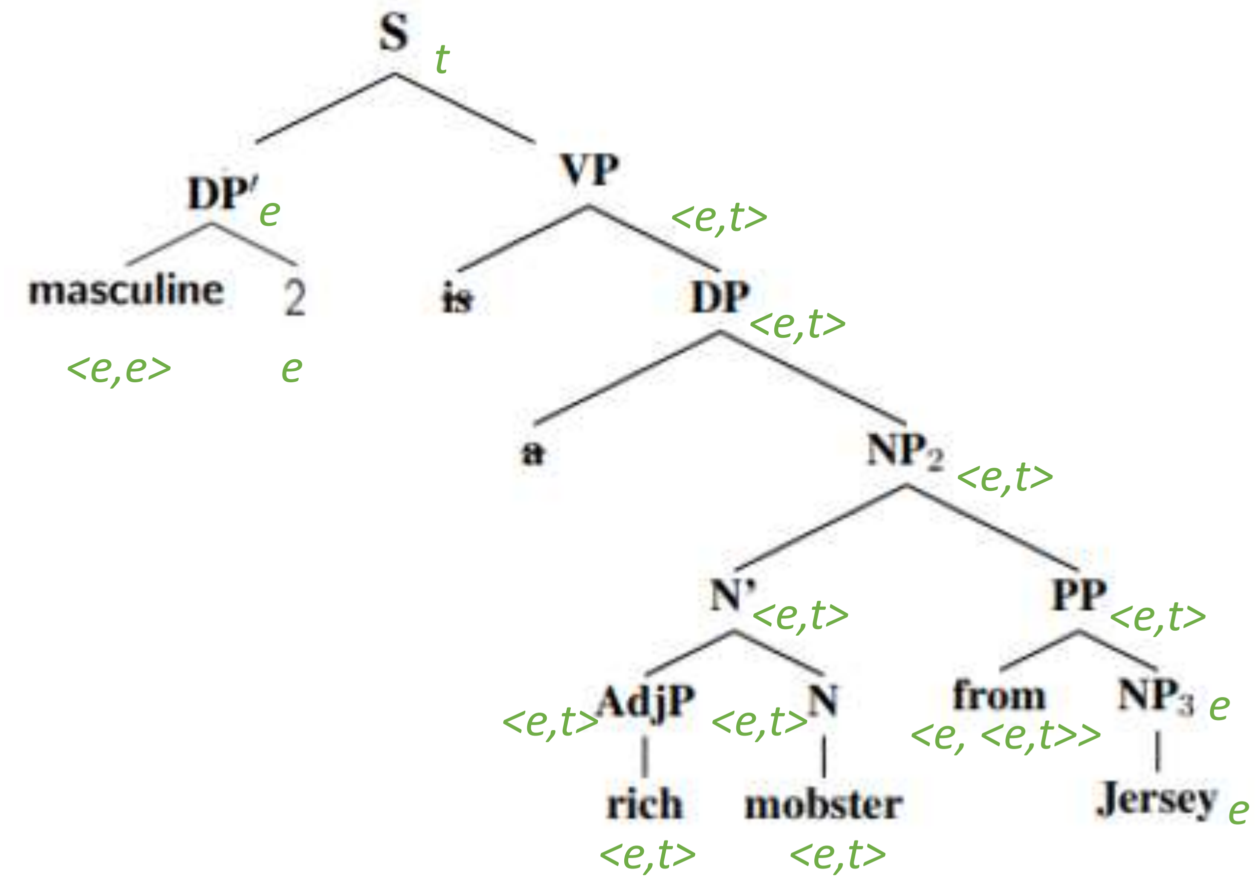
Undefined:

$$\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 5 & \rightarrow & \text{Mary} \\ 9 & \rightarrow & \text{Ann} \end{bmatrix} \qquad \begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Mary} \\ 3 & \rightarrow & \text{John} \end{bmatrix}$$

Exercise 2a: annotate the tree with semantic types

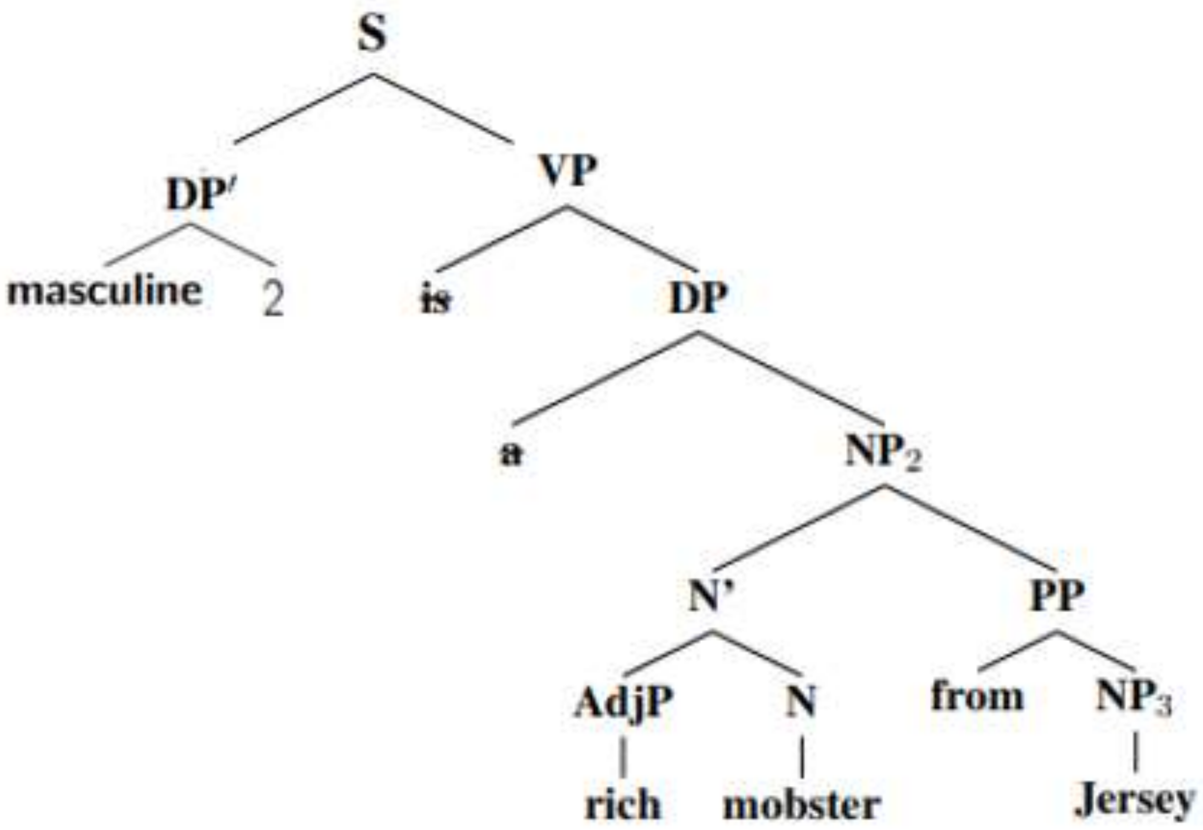


Exercise 2a: solutions



Exercise 2b: Compute the truth-conditions and definedness

$$\begin{bmatrix} 1 & \rightarrow & \text{John} \\ 2 & \rightarrow & \text{Bill} \end{bmatrix}$$



Solutions: Exercise 2b

I won't repeat the computation of VP here. See assignment 5 for details.

$$[[S]]^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} = [[VP]]^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} ([[DP']])^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} \quad \text{(FA)}$$

$$[[VP]]^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} = [[VP]] = \lambda x \in D_e \text{ . x is rich and x is a mobster and x is from Jersey} \quad \text{(4x AID)}$$

$$[[DP']]^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} [[\text{masculine}]]^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} ([[2]])^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} \quad \text{(FA)}$$

$$= [[\text{masculine}]] ([[2]])^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} \quad \text{(AID)}$$

$$= [[\text{masculine}]]^{\begin{bmatrix}1 \to \text{John}\\ 2 \to \text{Bill}\end{bmatrix}} (2) \quad \text{(TN2)}$$

$= [[\text{masculine}]] (\text{Bill})$

$= [x : x \in De \text{ and x is male. } x](\text{Bill}) \quad \text{(TN1)}$

$= \text{Bill}$

defined only if Bill is male

Solutions

[[S]]= [[VP]] ([[DP']])

= [$\lambda x \in D_e$. x is rich and x is a mobster and x is from Jersey] (Bill)

defined only if Bill is male **([[VP]], [[DP']])**

= 1 iff Bill is rich and Bill is a mobster and Bill is from Jersey

defined only if Bill is male

Check list

- Do you understand the rules?

  FA, PM, TN1,TN2, NN, AID

- Do you know how do the derivation using these rules?

  Truth-conditions/ definedness

- Do you know how do the derivation **top-down** vs. **bottom-up**?
- Do you know how to annotate the tree with semantic types?
- Do you understand how the logical operators work?

  [[not]]   [[or]]   [[and]]

Check list

- Do you know how to handle **adjustments to our system**? (Like in assignment 1, 3 and 4, 5...).

  Different rules, lexical entries, syntactic structure...

- What are the different layers of meaning?

  Entailment, presuppositions

  and how to test them.

The most important thing

Make sure to review all the slides and assignment 1-6.

If there is anything unclear, get to the bottom of it!

Special office hour:

This Friday 10-2pm.   Nikolausberger Weg 23, 1. Stock.

Write me a short email if you are coming by.

Good luck with the exam!