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Compositional Semantics
Heinrich Heine University
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Model Answers to Problem Set 3

Reading: Heim and Kratzer, ch. 2

Question 1. What type of value is the extension of (i) a sentence? (ii) a proper name? (iii) an intransitive verb like "smokes"?

Answers: (i) Truth value; (ii) individual; (iii) characteristic function of a set of individuals.

Question 2. What are the three components of H&K's semantics for their fragment of English?

Answer: Inventory of denotations, lexicon, and rules for non-terminal nodes.

Question 3. What do Heim & Kratzer use bold-face type for? Why is $[\![\text{Ann}]\!]$ nonsense?

Answer: object language; the person Ann has no denotation.

Question 4. On p. 26, Heim and Kratzer say that using characteristic functions instead of sets makes certain things a little more cumbersome. What things are they talking about?

Answer: Relations of membership, overlap and inclusion, which can be expressed concisely using set-talk (with the symbols $\in$, $\cap$, and $\subset$), but require more lengthy formulations in function-talk.

Question 5. Why do Heim and Kratzer analyze the denotation of a transitive verb like "likes" as a function from individuals to functions from individuals to truth values? (p. 27)

Answer: In order to maintain Frege's conjecture, that all composition is Functional Application (FA). Since NPs have type e, and transitive verbs combine with two NPs, first the object and then the subject, to produce a complete sentence (type t), we can use FA at every step of the way if we treat the verb as type $\langle e, \langle e, t\rangle\rangle$. After the verb combines with the object via FA, the result is of type $\langle e, t\rangle$, and this can be used as the denotation of the VP, which can then combine with the subject (type e) via FA again to produce a value of type t.

Question 6. What is the label for that type (functions from individuals to functions from individuals to truth values)?

Answer: $\langle e, \langle e, t \rangle \rangle$

Question 7. Exercise 1, p. 31.

First, the characteristic functions:

$$f_{adores} = \begin{bmatrix} \langle \text{Maria}, \text{Maria} \rangle & \rightarrow & 1 \\ \langle \text{Maria}, \text{Jacob} \rangle & \rightarrow & 0 \\ \langle \text{Jacob}, \text{Maria} \rangle & \rightarrow & 1 \\ \langle \text{Jacob}, \text{Jacob} \rangle & \rightarrow & 0 \end{bmatrix}$$

$$f_{assigns\_to} = \begin{bmatrix} \langle \text{Maria}, \text{Maria}, \text{Maria} \rangle & \rightarrow & 0 \\ \langle \text{Maria}, \text{Maria}, \text{Jacob} \rangle & \rightarrow & 0 \\ \langle \text{Maria}, \text{Jacob}, \text{Maria} \rangle & \rightarrow & 1 \\ \langle \text{Maria}, \text{Jacob}, \text{Jacob} \rangle & \rightarrow & 0 \\ \langle \text{Jacob}, \text{Maria}, \text{Maria} \rangle & \rightarrow & 0 \\ \langle \text{Jacob}, \text{Maria}, \text{Jacob} \rangle & \rightarrow & 0 \\ \langle \text{Jacob}, \text{Jacob}, \text{Maria} \rangle & \rightarrow & 1 \\ \langle \text{Jacob}, \text{Jacob}, \text{Jacob} \rangle & \rightarrow & 0 \end{bmatrix}$$

Now, Schönfinkelizing them from right to left:

$$f'_{adores} = \begin{bmatrix} \text{Jacob} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & 0 \\ \text{Jacob} & \rightarrow & 0 \end{bmatrix} \\ \text{Maria} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & 1 \\ \text{Jacob} & \rightarrow & 1 \end{bmatrix} \end{bmatrix}$$

$$f'_{assigns\_to} = \begin{bmatrix} \text{Jacob} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & 0 \\ \text{Jacob} & \rightarrow & 0 \end{bmatrix} \\ \text{Jacob} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & 0 \\ \text{Jacob} & \rightarrow & 0 \end{bmatrix} \end{bmatrix} \\ \text{Maria} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & 0 \\ \text{Jacob} & \rightarrow & 0 \end{bmatrix} \\ \text{Jacob} & \rightarrow & \begin{bmatrix} \text{Maria} & \rightarrow & 1 \\ \text{Jacob} & \rightarrow & 1 \end{bmatrix} \end{bmatrix} \end{bmatrix}$$

The function f'_{adore} is an appropriate denotation for *adore*, because this verb combines with the object first and then the subject, so if the subject is S and the object is O, then the truth conditions for the sentence will be f'_{adores}(O)(S) which is equal to 1 if and only if $\langle$S,0$\rangle \in R_{adores}$. The relation R_{adores} is supposed to capture the idea that the first element adores the second, so the first element of the relation should correspond to the subject, and the second element should correspond to the object.

But with *assign (to)*, the verb would combine with the direct object (call it DO) first, and then the indirect object (IO), and then the subject (S). So the truth conditions for the sentence will end up as $f'_{assigns\_to}$(DO)(IO)(S). This will be equal to 1 whenever $\langle$S,IO,DO$\rangle \in R_{assigns_to}$. But $R_{assigns\_to}$ is supposed to capture the idea that the first element assigns the second element to the third element. So the first element should correspond to the subject, the second element should correspond to the *direct* object (not the indirect object), and the third element should correspond to the *indirect* object (not the direct object).

Question 8. How do Heim and Kratzer propose to interpret an expression of the form $[\lambda\alpha : \phi.\gamma]$ (p. 36–7)?

Read "$[\lambda\alpha : \phi.\gamma]$" as either (i) or (ii), whichever makes sense.
(i) "the function which maps every α such that ϕ to γ"
(ii) "the function which maps every α such that ϕ to 1, if γ, and to 0 otherwise"

Question 9. Exercise 2, p. 39.

(a) [λx $\in$D . [λy $\in$D . [λz $\in$D . z introduced x to y]]](Ann)(Sue)
= [λy $\in$D . [λz $\in$D . z introduced Ann to y]](Sue)
= λz $\in$D . z introduced Ann to Sue

(b) [λx $\in$D . [λy $\in$D . [λz $\in$D . z introduced x to y](Ann)](Sue)]
= [λx $\in$D . [λy $\in$D . Ann introduced x to y](Sue)]
= λx $\in$D . Ann introduced x to Sue

(c) [λx $\in$D . [λy $\in$D . [λz $\in$D . z introduced x to y](Ann)]](Sue)
= [λx $\in$D . [λy $\in$D . Ann introduced x to y]](Sue)
= λy $\in$D . Ann introduced Sue to y

(d) [λx $\in$D . [λy $\in$D . [λz $\in$D . z introduced x to y]](Ann)](Sue)
= [λx $\in$D . [λz $\in$D . z introduced x to Ann]](Sue)
= [λz $\in$D . z introduced Sue to Ann]

(e) [λf $\in$D$_{\langle e,t\rangle}$. [λx $\in$D$_e$. f(x) = 1 and x is gray]]([λy $\in$D$_e$. y is a cat])
= [λx $\in$D$_e$. [λy $\in$D$_e$. y is a cat](x) = 1 and x is gray]
= λx $\in$D$_e$. x is a cat and x is gray

(f) [λf $\in$D$_{\langle e,\langle e,t\rangle\rangle}$. [λx $\in$D$_e$. f(x)(Ann) = 1]]([λy $\in$D$_e$. [λz $\in$D$_e$. z saw y]])
= [λx $\in$D$_e$. [λy $\in$D$_e$. [λz $\in$D$_e$. z saw y]](x)(Ann) = 1]
= [λx $\in$D$_e$. [λz $\in$D$_e$. z saw x](Ann) = 1]
= λx $\in$D$_e$. Ann saw x

(g) [λx $\in|N$. [λy $\in|N$. y $>$ 3 and y $<$ 7](x)]
= λx $\in|N$. x $>$ 3 and x $<$ 7

(h) $[\lambda z \in |N . [\lambda y \in |N . [\lambda x \in |N . x > 3 \text{ and } x < 7](y)](z)]$
$= [\lambda z . [\lambda y \in |N . y > 3 \text{ and } y < 7](z)]$
$= \lambda z \in |N . z > 3 \text{ and } z < 7$

Question 10. Exercise 4, p. 40.

(a) $[\lambda f \in D_{\langle e,t\rangle} . [\lambda x \in D_e . f(x) = 1$ and x is gray$]] \in D_{\langle\langle e,t\rangle,\langle e,t\rangle\rangle}$

(b) $[\lambda f \in D_{\langle e,\langle e,t\rangle\rangle} . [\lambda x \in D_e . f(x)(Ann) = 1]] \in D_{\langle\langle e,\langle e,t\rangle\rangle,\langle e,t\rangle\rangle}$

(c) $[\lambda y \in D_e . [\lambda f \in D_{\langle e,t\rangle} . [\lambda x \in D_e . f(x) = 1$ and x is in y$]]] \in D_{\langle e,\langle\langle e,t\rangle,\langle e,t\rangle\rangle\rangle}$

(d) $[\lambda f \in D_{\langle e,t\rangle}$. there is some $x \in D_e$ such that $f(x) = 1] \in D_{\langle\langle e,t\rangle,t\rangle}$

(e) $[\lambda f \in D_{\langle e,t\rangle}$. Mary$] \in D_{\langle\langle e,t\rangle,e\rangle}$

(f) $[\lambda f \in D_{\langle e,t\rangle} . [\lambda g \in D_{\langle e,t\rangle}$. there is no $x \in D_e$ such that $f(x) =1$ and $g(x) = 1]] \in D_{\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle}$