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24.903  
Language & Structure III: Semantics and Pragmatics  
Spring 2003, 2-151, MW 1-2.30  
March 5, 2003  
Assignment 4, due in class on March 12

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1. Assume that the meaning of **spouse**,  $\llbracket spouse \rrbracket$ , is a function that maps (married) people to their spouses (which assumes monogamy), and that the meaning of **mother** is a function that maps people to their mother. Define the meaning of **mother in law** in terms of the meaning of **spouse** and **mother**, using the  $\lambda$  notation.

2. Let  $j$  be a constant of type  $e$ ;  $M$  of type  $\langle e, t \rangle$ ;  $S$  of type  $\langle \langle e, t \rangle, \langle e, t \rangle \rangle$ ; and  $R$  of type  $\langle \langle e, t \rangle, t \rangle$ . Furthermore  $x$  is a variable of type  $e$ , and  $Y$  is a variable of type  $\langle e, t \rangle$ . Determine which of the following sequences are well-formed expressions. If an expression is well-formed, give its type. Assume that the operator  $\wedge$  (and) requires both its arguments to be of type  $t$ .

- |                                  |  |
|----------------------------------|--|
| a. $\lambda x[M(x)](R)$          | h. $\lambda x[M(x) \wedge M(j)]$                       |
| b. $\lambda x[M(x)](j)$          | i. $(S(\lambda Y[Y(x)]))(M)$                           |
| c. $\lambda x[M(j)]$             | j. $\lambda Y[R(\lambda x[Y(x)])(M)]$                  |
| d. $S(\lambda x[M(x)])$          | k. $\lambda x[\lambda Y[Y(x)](M)](j)$                  |
| e. $\lambda Y[Y(j)](M)$          | l. $\lambda x[\lambda Y[Y(x)](j)](M)$                  |
| f. $\lambda x[\lambda Y[Y(x)]]$  | m. $\lambda x[\lambda Y[Y(x)](j)](M)$                  |
| g. $\lambda x[M(x) \wedge M(j)]$ | n. $\lambda Y[(S(\lambda x[M(x)]))(j) \wedge R(Y)](M)$ |

3. Reduce the following  $\lambda$  terms as far as possible. Note that these are  $\lambda$  terms that take functions as their arguments;  $f, g$  etc. have been used as variables over functions.

- a)  $\lambda f[f(3)](\lambda y[5 + y])$
- b)  $\lambda f[f(3)(4)](\lambda x\lambda y[x + y])$
- c)  $\lambda f\lambda g\lambda x[g(5)(f(2)(x))](\lambda x\lambda y[x + y])(\lambda x\lambda y[x - y])(8)$
- d)  $\lambda f[\lambda x[\text{the mother of } f(x)](Jo)](\lambda x[\text{the father of } x])$

4. Given a  $\lambda$  expressions, we can usually make inferences regarding the relationships between the types of the expressions that make up the  $\lambda$  expression. For example, if we assume the type of  $X$  to be  $\sigma$  and the type of  $Y$  to be  $\tau$ , then the type of  $\lambda X[Y]$  is  $\langle \sigma, \tau \rangle$ . Similarly if a function  $f$  applies to an argument  $x$  and  $x$  is of type  $\gamma$ , then the type of  $f$  must be of the format  $\langle \gamma, ?? \rangle$ .

Given this background what can you say about the type of  $f$  and the whole  $\lambda$  expression in:

$\lambda f[f(f)](\lambda f[f(f)])$

From Heim & Kratzer

1. Exercise on Page 66.

2. Exercise 1 on Page 67.

3. Exercise 2 on Page 67. Present both solutions.