## **1** Semantic representations in type theory

Find formulas of type theory that represent the truth conditions of the following sentences as accurately as possible, and indicate the types of the constants. You can represent words that are connected by hyphens ("the-book," "lives-in" etc.) as single constants of an appropriate type. The comments in *italics* are hints that are meant to help you get the intended meaning of the sentences.

- 1. John gives Mary the-book.
- 2. Peter owns a red car.
- 3. The-president rarely sleeps.
- 4. The-president lives-in a very nice house.
- Mary eats only a sandwich.
  (and she doesn't eat anything else)
- Mary only EATS a sandwich.
  (and she doesn't do anything else with it)

## 2 Interpreting type theory

Compute the truth conditions of the following expressions. That is, derive statements of the form

 $[\![\mathsf{sleep}(\mathsf{peter})]\!]^{\mathsf{M},g} = 1 \text{ iff } V_{\mathsf{M}}(\mathsf{sleep})(V_{\mathsf{M}}(\mathsf{peter})) = 1$ 

for expressions of type t and statements of the form

 $[\![\mathsf{sleep}]\!]^{\mathsf{M},\mathfrak{g}} = V_{\mathsf{M}}(\mathsf{sleep})$ 

for (sub-) expressions of other types. You may abbreviate intermediate results appropriately, as long as you show the most important interpretation steps. student and work are constants of type  $\langle e, t \rangle$ , and  $\mathbf{p}^*$  and  $\mathbf{j}^*$  are constant of type *e*. Don't  $\beta$ -reduce anything for now.

- 1.  $(\lambda F \lambda G \neg \exists x (F(x) \land G(x)))(student)(work)$ "No student works."
- 2.  $(\lambda F(F(\mathbf{j}^*) \lor F(\mathbf{p}^*)))(work)$ "Either John or Peter works."

Then  $\beta$ -reduce the term (b) into a formula of first-order predicate logic (FOL) and compute its truth conditions as a FOL formula. Compare the two interpretations.

## 3 Semantics construction

Construct semantic representations for each of the following sentences using type theory. First give a representation for each word, counting word sequences that are connected by a hyphen as a single word. Then combine them compositionally into a representation for the whole sentence. Give the type of each term in your derivation. Use lambda abstraction as necessary, and  $\beta$ -reduce your results (including intermediate representations) as far as possible.

- 1. Every successful student works hard.
- 2. John says-that Peter is-a-criminal.

For extra credit, find an analysis in which "a criminal" is represented as  $\lambda P \exists x(criminal(x) \land P(x))$  as in the lecture. You will have to do something clever to represent "is" in this case.

3. Some students don't drink and drive.

(negation takes scope over conjunction)

Treat "don't" as a single word, and translate it into an appropriate  $\lambda$ -term involving a negation.

## 4 And

- 1. What type would you have to assign the semantic representation of "and" in each of the following sentences so the representation for the whole sentence gets type t?
  - (a) John sleeps and Mary works.
  - (b) John works hard and is-successful.
  - (c) All students and some professors work hard.
  - (d) John works quickly and thoroughly.
- 2. Represent the semantics of "and" in each sentence as a  $\lambda$ -term.

To be turned in by Tuesday, Mar. 15, 11:15