Informatics 2A: Tutorial Sheet 8 (Week 10)
Agreement; First order logic; Compositional semantics

Shay Cohen

1. As noted in Lecture 25, present tense verbs in English agree with their subject in number (I sleep; he sleeps; they sleep). Another agreement constraint in English is that reflexive pronouns (e.g. herself, itself, themselves) must agree with the noun phrase they stand for in person, number and gender.

Using the machinery of CFGs with non-terminals and rules parameterized by suitable attributes as in Lecture 22, construct a grammar for a tiny fragment of English that includes three-word sentences containing a transitive verb, such as:

She washes herself
I wash myself
It prepares itself
You prepare yourselves
He congratulates himself
They congratulate themselves

but excludes sentences like

She washes himself
It prepares themselves
We congratulate ourselves

2. Choose a set of constants and predicates suitable for representing the following sentences in first order predicate logic as described in Lecture 24.

- Jumbo is an elephant.
- An elephant is a mammal.
- Every elephant has an owner.
- Everyone who owns an elephant sings it a song.
- Only one elephant danced.
- Every elephant did not dance.

Translate each of these sentences into a formula of FOPL. If you think a sentence is semantically ambiguous, give a first-order formula for each possible interpretation.

3. Consider the following context-free grammar with semantic attachments.
\[
\begin{align*}
S & \rightarrow \text{NP VP} & \{ \text{NP.Sem(VP.Sem)} \} & t \\
\text{VP} & \rightarrow \text{IV} & \{ \text{IV.Sem} \} & <e,t> \\
\text{VP} & \rightarrow \text{TV NP} & \{ \lambda x. \text{NP.Sem(TV.Sem(x))} \} & <e,t> \\
\text{NP} & \rightarrow \text{Det N} & \{ \text{Det.Sem(N.Sem)} \} & <<t>,t> \\
\text{NP} & \rightarrow \text{John} & \{ \lambda P.P(\text{John}) \} & <<t>,t> \\
\text{NP} & \rightarrow \text{ice-cream} & \{ \lambda P.P(\text{Ice-cream}) \} & <<t>,t> \\
\text{Det} & \rightarrow \text{a | an} & \{ \lambda Q.\lambda P.\exists x Q(x) \land P(x) \} & <<t>,<<t>,t>> \\
\text{Det} & \rightarrow \text{every} & \{ \lambda Q.\lambda P.\forall x Q(x) \Rightarrow P(x) \} & <<t>,<<t>,t>> \\
\text{N} & \rightarrow \text{cat} & \{ \lambda x.\text{cat}(x) \} & <e,t> \\
\text{N} & \rightarrow \text{ice-cream} & \{ \lambda x.\text{ice-cream}(x) \} & <e,t> \\
\text{IV} & \rightarrow \text{runs} & \{ \lambda x.\text{run}(x) \} & <e,t> \\
\text{TV} & \rightarrow \text{likes} & \{ \lambda x.\lambda y.\text{like}(x,y) \} & <e,<<t>,t>> \\
\end{align*}
\]

Indicate which of the semantic attachments make use of type raising.
Calculate the semantics of the following phrases and sentences, showing explicitly any \(\beta\)-reduction steps used to simplify \(\lambda\)-expressions.

- John runs
- likes ice-cream
- John likes ice-cream
- an ice-cream
- likes an ice-cream
- John likes an ice-cream
- every cat
- every cat likes ice-cream
- every cat likes an ice-cream