Informatics 2A: Tutorial Sheet 8 (Week 10)

Agreement; First order logic; Compositional semantics

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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 congratulates 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.

S → NP VP	{ NP.Sem(VP.Sem) }	t
VP → IV	{ IV.Sem }	$< e, t >$
VP → TV NP	{ λx. NP.Sem(TV.Sem(x)) }	$< e, t >$
NP → Det N	{ Det.Sem(N.Sem) }	$<< e, t >, t >$
NP → John	{ $\lambda P.P(John)$ }	$<< e, t >, t >$
NP → ice-cream	{ $\lambda P.P(\text{Ice-cream})$ }	$<< e, t >, t >$
Det → a | an	{ $\lambda Q.\lambda P.\exists x Q(x) \wedge P(x)$ }	$<< e, t >, << e, t >, t >>$
Det → every	{ $\lambda Q.\lambda P.\forall x Q(x) \Rightarrow P(x)$ }	$<< e, t >, << e, t >, t >>$
N → cat	{ $\lambda x.\text{cat}(x)$ }	$< e, t >$
N → ice-cream	{ $\lambda x.\text{ice-cream}(x)$ }	$< e, t >$
IV → runs	{ $\lambda x.\text{run}(x)$ }	$< e, t >$
TV → likes	{ $\lambda x.\lambda y.\text{like}(x, y)$ }	$< e, < e, t >>$

Indicate which of the semantic attachments make use of type raising.

Calculate the semantics of the following phrases and sentences, showing explicitly any β-reduction steps used to simplify λ-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