LING 364: Introduction to Formal Semantics

Lecture 28

May 2nd

Administrivia

- **Homework 6**
  - was due at the beginning of class

Administrivia

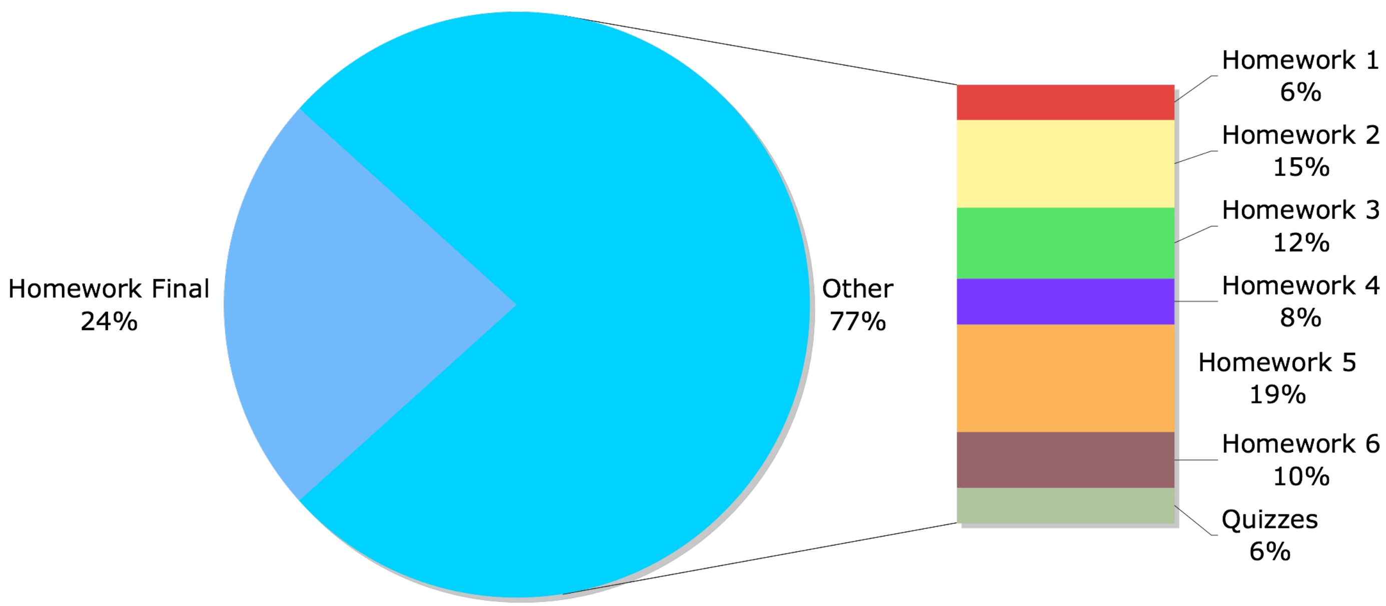
- **Today's Agenda:**
  - A Note on Grading and Course Objectives
  - Homework 6 Review
  - Homework Final
  - Class Evaluations

Back at the Beginning

- [*Lecture 1: Slide 13*]
- **Mix of homeworks and short quizzes**
  - **expect approx. 6 homework assignments**
    - longer and more in-depth in nature
    - worth many more points
  - a short quiz (just about) every week
    - gauge your understanding
- **Grading**
  - In total, homeworks will generally be worth much more than the short quizzes
    - about a 75-70% / 25-30% ratio
  - There may **or may not** be a final exam
    - depends on how the class is doing
    - *(if so) view it as an opportunity to improve your score*
    - if given, it will be a **take-home exam** worth about 25% of the grade due by midnight the next day

Grading

Points-wise



Course objectives were...

- Two goals:
  - (1) ***on the theoretical side***
  - Understand what is meant by **natural language semantics**
    - what does it mean to work out the “meaning” of a sentence, phrase or utterance
    - what quasi-technical terms like entailment, possible worlds, truth conditions, quantification, scope ambiguity, synonymy, presupposition, logical deduction, reference, inference rule etc. mean
    - the relation between natural language and formal logic
    - the relation between syntax and semantics with respect to formal grammars
    - awareness of issues and data
    - *etc*...

Course objectives were...

- Two goals:
  - (2) ***on the practical side***
  - gain experience with **formal systems** and build something tangible
    - first-hand experience on how to write logic expressions
    - practice how to formalize notions
    - how to run logical deduction on computers
    - use and write grammars for semantics
    - we'll use SWI-Prolog
    - by the end of this course you will be able to write formal grammars integrating the computation of **meaning** as well as **syntax** for fragments of English

Nature of the Course

- **Formalization of natural language**
  - *involves*...
  - being mathematical
  - being used to thinking precisely with respect to manipulating formalisms
  - being comfortable with logic (lambda-calculus)
  - learning to write logic that runs on a computer (otherwise course would be mostly theoretical

Each of these can be challenging first time around

Homework 6 Review

Homework 6 Review

- A simple grammar for tense and time

```
sbar(R) --> adjunct(R1), s(R2), {append(R1,R2,R)}.
sbar(R) --> s(R).

s(R) --> np, vp(R).
np --> [i].
np --> [noah].
vp(R) --> v(R1,go), [for,a,hike],
    {append([(subset(e,t))],R1,R)}.
vp(R) --> v(R1,have), [a,rash],
    {append([intersect(e,t)],R1,R)}.

v([(t<s)],go) --> [went].
v([(t=s)],go) --> [go].
v([(s<t)],go) --> [will,go].

v([(t<s)],have) --> [had].
v([(t=s)],have) --> [have].
v([(s<t)],have) --> [will,have].
```

```
adjunct([(t<s),t=last_month(s)]) --> [last,month].
adjunct([(t<s),t=yesterday(s)]) --> [yesterday].
adjunct([(s=t),t=today(s)]) --> [today].
adjunct([(s<t),t=tomorrow(s)]) --> [tomorro

infer(R,[(Z<Y)]) :-
        select((X<Y),R,R1),
        select(subset(Z,X),R1,_).

% select(X,L,L’)
% selects X a member of list L,
% L’ is the list L with X removed
select(X,[X|L],L).
select(X,[Y|L],[Y|Lp]) :- select(X,L,Lp).
```

Homework 6 Review

- **Exercise 1:**
  - Tomorrow, I will go for a hike

```
infer(R,[(X<Z)]) :-
        select((X<Y),R,R1),
        select(subset(Z,Y),R1,_).
```

- **Run:**
  - ?- sbar(X,[tomorrow,i,will,go,for,a,hike],[]).
  - X = [s<t,t=tomorrow(s),subset(e,t),s<t] ? ;
  - no
  - ?- sbar(X,[tomorrow,i,will,go,for,a,hike],[]), **infer(X,Y).**
  - X = [s<t,t=tomorrow(s),subset(e,t),s<t],
  - Y = [s<e] ? ;
  - X = [s<t,t=tomorrow(s),subset(e,t),s<t],
  - Y = [s<e] ? ;
  - no

If

X < Y   s<t

and

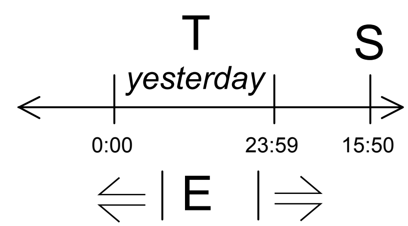
Z ⊆ **Y**   e⊆t

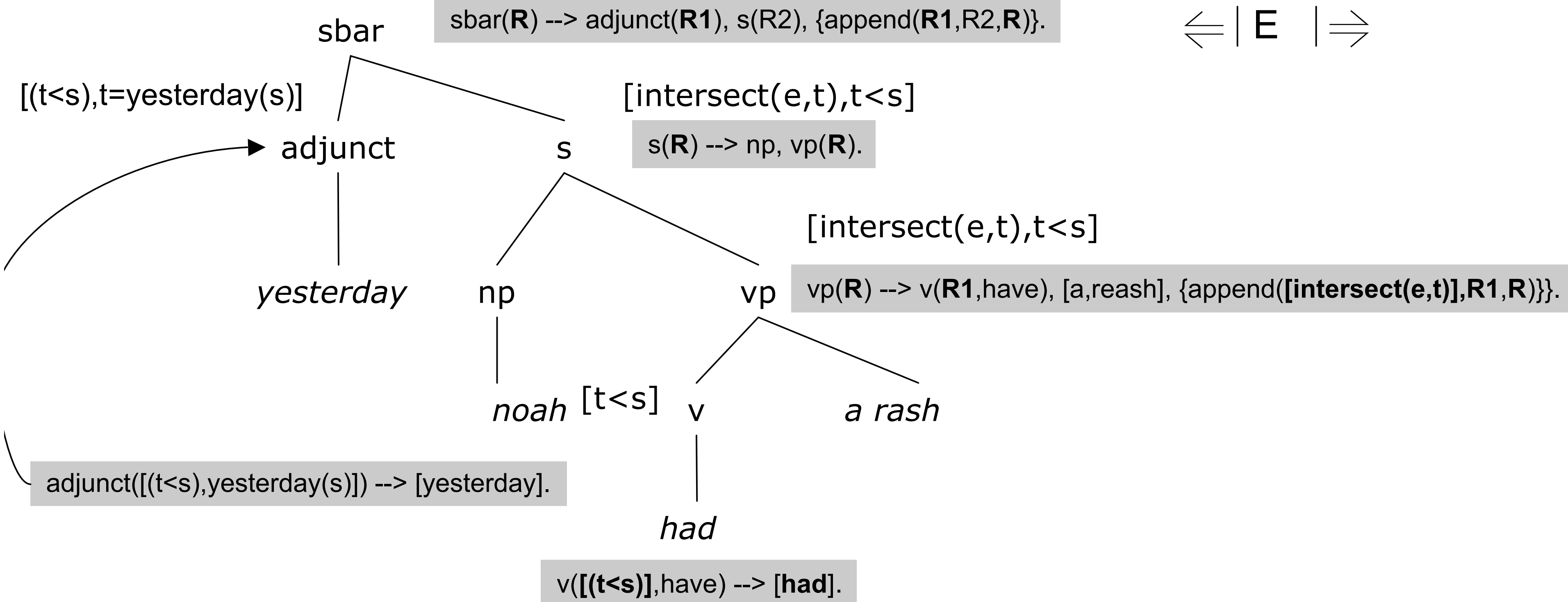
we can infer:

X < Z   s<e

Homework 6 Review

- **Exercise 2:**
  - Diagram "Yesterday, Noah had a rash"





Homework 6 Review

- **Exercise 3**: Inconsistency
- Explain formally what is wrong with the following sentences:
  - (i) # Yesterday, I will go for a hike
  - (ii) # Tomorrow, Noah had a rash

```
?- sbar(X,[yesterday,i,will,go,for,a,hike],[]), inconsistent(X).
X = [t<s,t=yesterday(s),subset(e,t),s<t] ? ;
X = [t<s,t=yesterday(s),subset(e,t),s<t] ? ;
no
?- sbar(X,[tomorrow,noah,had,a,rash],[]), inconsistent(X).
X = [s<t,t=tomorrow(s),intersect(e,t),t<s] ? ;
X = [s<t,t=tomorrow(s),intersect(e,t),t<s] ? ;
no
```

```
inconsistent(R) :-
        select((X<Y),R,R1),
        select((Y<X),R1,_).
```

Homework Final

Homework Final

- **Instructions**
  - 7 Questions
  - Due tomorrow by midnight in my mailbox
    - *deductions if you’re late*
    - *zero points if you are a day late*
  - Answer as many questions as you can in the time available
  - Attempt every question
  - It’s a second chance to show you understand the course material, homework reviews, etc.
    - Good luck!

Homework Final

- **Instructions**
  - *Do not panic.*
  - Consult referenced homework slides
  - Consult homework reviews
    - ***All*** *questions on this homework final can be answered with the knowledge in those lecture slides*
  - You may discuss the homework final
    - you must cite classmates or other sources

Question 1

- [Homework 1: Lecture 3]
- **Introduction to Prolog and Truth Conditions**
  - Let database fact p represent the proposition “All dogs bark”
    - [4pts] Construct the Prolog statement for “it is not the case that both all dogs bark and not all dogs bark”
    - [4pts] Show that the translated (into Prolog) statement is a **tautology**.
  - (Submit your Prolog run.)

Question 2

- [Homework 2: Lecture 8] **Phrase Structure and Meaning Grammars**
  - [8pts] Give a **phrase structure grammar** for the following sentences.
  - Why is John sad?
  - $[_{CP}$ $[_{Adv}$ why$][_{Cbar}$ $[_C$ is$][[_{IP}$ $[_{NP}$ John$][_{VP}$ $[_V$ *trace*$][_{AP}$ $[_{NP}$ *trace*$][_{Abar}$ $[_A$ sad$]]]]]]$
  - Why is John not sad?
  - $[_{CP}$ $[_{Adv}$ why$][_{Cbar}$ $[_C$ is$][[_{IP}$ $[_{NP}$ John$][_{NegP}$ $[_{Neg}$ not$][[_{VP}$ $[_V$ *trace*$][_{AP}$ $[_{NP}$ *trace*$][_{Abar}$ $[_A$ sad$]]]]]]]$
  - Why isn't John sad?
  - $[_{CP}$ $[_{Adv}$ why$][_{Cbar}$ $[_C$ isn't$][[_{IP}$ $[_{NP}$ John$][_{NegP}$ $[_{Neg}$ *trace*$][[_{VP}$ $[_V$ *trace*$][_{AP}$ $[_{NP}$ *trace*$][_{Abar}$ $[_A$ sad$]]]]]]]$

[Follow the bracketing given *exactly*. Treat *trace* as if it was a real word. Treat *isn't* as a single word in Prolog: `'isn\'t'`.]

Question 2

- [Homework 2: Lecture 8]
- **Phrase Structure and Meaning Grammars**
  - [3pts] Show your grammar works.
  - Why is John sad?
    - ?- cp(PS,[why,is,john,trace,trace,sad],[]).
  - Why is John not sad?
    - ?- cp(PS,[why,is,john,not,trace,trace,sad],[]).
  - Why isn’t John sad?
    - ?- cp(PS,[why,’isn\’t’,john,trace,trace,trace,sad],[]).
  - (Submit your runs.)

Question 2

- [Homework 2: Lecture 8]
- **Phrase Structure and Meaning Grammars**
  - [6pts] Modify your rules involving trace to allow **empty categories** as follows:
    - **Old rule:** x(x(trace)) --> [trace].
    - **New rule:** x(x(trace)) --> [].
  - Show your new rules work.
  - How many parses for each of the following queries?
  - Why is John sad?
    - ?- cp(PS,[why,is,john,sad],[]).
  - Why is John not sad?
    - ?- cp(PS,[why,is,john,not,sad],[]).
  - Why isn’t John sad?
    - ?- cp(PS,[why,’isn\’t’,john,sad],[]).
  - (Submit your runs.)

Question 3

- [Homework 3: Lecture 13]
- **Phrase Structure and Meaning Grammars Contd.**
- [8pts] Give a meaning grammar for sentence/meaning pairs:
  - `dog(shelby).` Shelby is a dog
  - `(white(shelby),dog(shelby)).` Shelby is a white dog
  - [Assume *white* is an **intersective adjective**.]
- [6pts] Evaluate your generated meanings against the Prolog versions of the following possible worlds:
  - (A) Shelby is a dog and Shelby is white
  - (B) Shelby is a dog and Shelby is brown
- (Submit your runs and possible worlds.)

Question 4

- [Homework 4: Lecture 18] **Plural and Mass Terms.**
- Assume the **lattice-style definition** for the plural *dogs*:
  - :- dynamic dog/1.
  - dogs(Plural) :- findall(X,dog(X),L), plural(L,Plural).
  - plural(L,X+Y) :- selectone(X,L,L1), selectone(Y,L1,_).
  - plural(L,X+PL) :- selectone(X,L,L1), plural(L1,PL).
  - selectone(X,[X|L],L).
  - selectone(X,[Y|L],L2) :- selectone(X,L,L2).
- [4pts] Give a Prolog query for "*two dogs*"
- [4pts] Give a Prolog query for "*two or more dogs*"
- [4pts] Give a Prolog query for "*not more than two dogs*"

Question 5

- [Homework 5: Lecture 22]
- **Truth Tables and Quantification.**
- Assume the Prolog definitions given in HW 5 for logical implication (⇒) and negation (¬)
- [8pts] Are P⇒Q and ¬Q⇒¬P equivalent?
- Prove your answer using Prolog truth tables
- (Submit your Prolog query and run.)

P	¬P
T	F
F	T

P	⇒	Q
T	T	T
F	T	T
F	T	F
T	F	F

Question 6

- [Homework 5: Lecture 22]
- **Truth Tables and Quantification.**
- Define |S| to be the size of set S
  - examples:
  - |{a,b}| = 2
  - |{a,b,c}| / 2 > |{a}|
- [10pts] Give the set-theoretic, i.e. **Generalized Quantifier-based**, semantics for the sentences:
  - Most men smoke
  - Most smokers are men
- (You may use set notation or Prolog notation.)
- (There is no need to run a Prolog query.)

Question 7

- [Homework 6: Lecture 27]
- **Tense and Aspect.**
- [8pts] Give the relations between S, E, T for the sentences:
  - John had left yesterday
  - John has left
- [3pts] According to the theory, what is semantically odd about?
  - # John has left yesterday

Summary

- **Total: 82 pts**
  - Q1: 8pts
  - Q2: 19pts
  - Q3: 14pts
  - Q4: 12pts
  - Q5: 8pts
  - Q6: 10pts
  - Q7: 11pts