LING 364: Introduction to Formal Semantics

Lecture 4

January 24th

Administrivia

- Reminder:
  - Homework 1 due on Thursday
  - in my inbox (midnight deadline)
  - need clarification, help? ask questions now
- There *may* be another lab class this Thursday (a short one: *room is in demand*)
  - check your email
  - and the course homepage

Last Time

- **Computer lab class**:
  - First time with SWI-Prolog
  - *... as will become apparent during this course, it's a very convenient and powerful tool for expressing the rules of language*

Last Time

- Important Concepts
  - English to logic
    - **facts**
      - e.g. Mary is a baseball fan.➔ baseball_fan(mary).
      - **predicate**: baseball_fan
      - **argument**: mary
      - e.g. Mary likes John ➔ likes(mary,john).
      - **multiple arguments**: express **relations**
    - **inference rules**
      - e.g. snoring presupposes sleeping ➔
        sleeping(X) :- snoring(X).
      - **logic variable**: X
      - **if**: :-
      - note: *basically expresses idea*... snoring(X) ⇒ sleeping(X)

Last Time

- Important Concepts
  - **Prolog database**
    - the database represents a **scenario** or **possible world**
    - initially, the world is empty
    - we can **assert** and **retract** facts and rules
      - e.g. ?- assert(baseball_fan(mary)).
    - asserted facts and rules are true in that world
    - **Closed World Assumption**:
      - things that are not asserted or inferable are false (in this world)
    - can't have negated facts (or head of rules) in the database
      - e.g. ?- assert((\+ baseball_fan(mary))). *is not allowed*
      - e.g. ?- assert((\+ baseball_fan(X) :- hates(X,baseball)). *is not allowed*
      - e.g. ?- assert((baseball_fan(X) :- \+ hates(X,baseball)). ***is** allowed*

Last Time

- Important Concepts
  - finally, we can evaluate **logical queries** with respect to this database
    - e.g ?- baseball_fan(X).
    - is true provided world contains one or more baseball_fan/1 facts
    - is false otherwise
    - logic variable X is **bound** to the value produced by **matching** query to fact
    - **multiple matches** are possible: semicolon **;** (disjunction)
    - query may also match against the **head** of a rule
    - e.g. baseball_fan(X) :- loves(X,baseball).
    - results in **subquery**: ?- loves(X,baseball).
      - *means to prove* baseball_fan(X) *we have to in turn prove* loves(X,baseball)

Last Time

- Important Concepts
  - **negated queries** are ok
    - (though they return no answer other than Yes/No)
  - **query** ?- \+ baseball_fan(X). is *true if*
  - **subquery** ?- baseball_fan(X). *is not true*
  - ?- baseball_fan(X). would be not true for all possible worlds where there are no baseball fans
  - i.e. no baseball_fan/1 facts
  - **and** we have no rules that could be used to conclude baseball_fan/1 is true from **logical inference**
  - e.g. no world like
    - baseball_fan(X) :- loves(X,baseball).
    - loves(john,baseball).
    - loves(john,football).

Larger Picture

- Computer Lab homework
  - asks you to write Prolog facts, rules and queries corresponding to a series of English sentences and questions

- examples:
  - Mary is a student
  - Pete is a baseball fan
  - who is both a student and a baseball fan?
  - who is a baseball fan and not a student?

Larger Picture

- You're translating English into logical meaning

Mary is a student

who is a student?

student(mary).

?- student(X).

to do this you have to be able to parse and assign meaning to the English input

Larger Picture

- Goal: Formalize language so this can be done step by step

Mary is a student

who is a student?

student(mary).

?- student(X).

Larger Picture

- In just a few more lectures, we'll be able to do this...
- ... *quick demo*

to do this we have to be able to
(1) parse, and
(2) assign meaning to the English input

we'll be developing the tools and techniques to do this

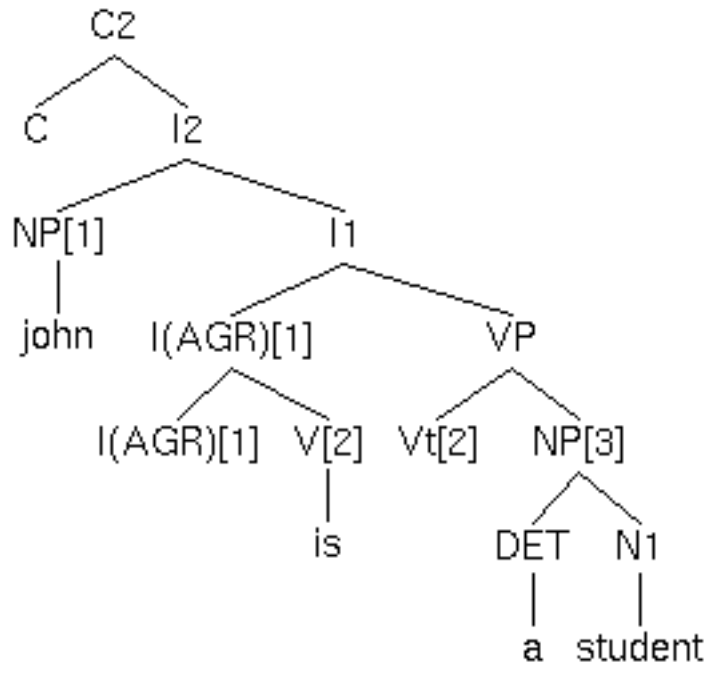
Today's Topic

- We begin with...
- **Syntax** (or *grammar*)
- **motivation**:
  - to understand a sentence, we also have to be able to "*diagram it*"
  - i.e. know its constituents
  - subject
  - verb or predicate
  - object

Syntactic Structure

- A formal grammar enables us to logically break down a sentence into its constituent parts

Parsing: john is a student
LF (1):

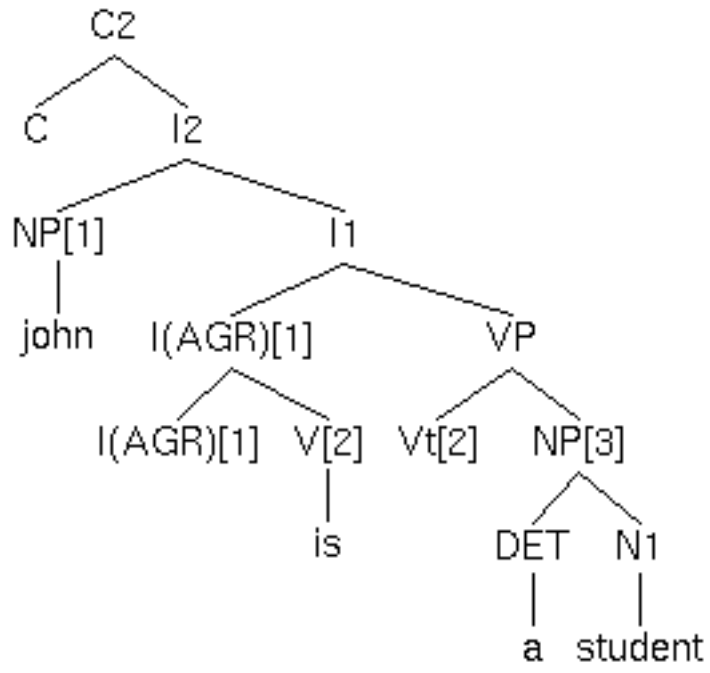


X-bar phrase structure
constituent labels
C2 = CP = S-bar (clause)
I2 = S (sentence)
VP = Verb Phrase
V = Verb
NP = Noun Phrase
DET = determiner
N1 = Noun (bar level 1)

Syntactic Structure

- A formal grammar enables us to logically break down a sentence into its constituent parts

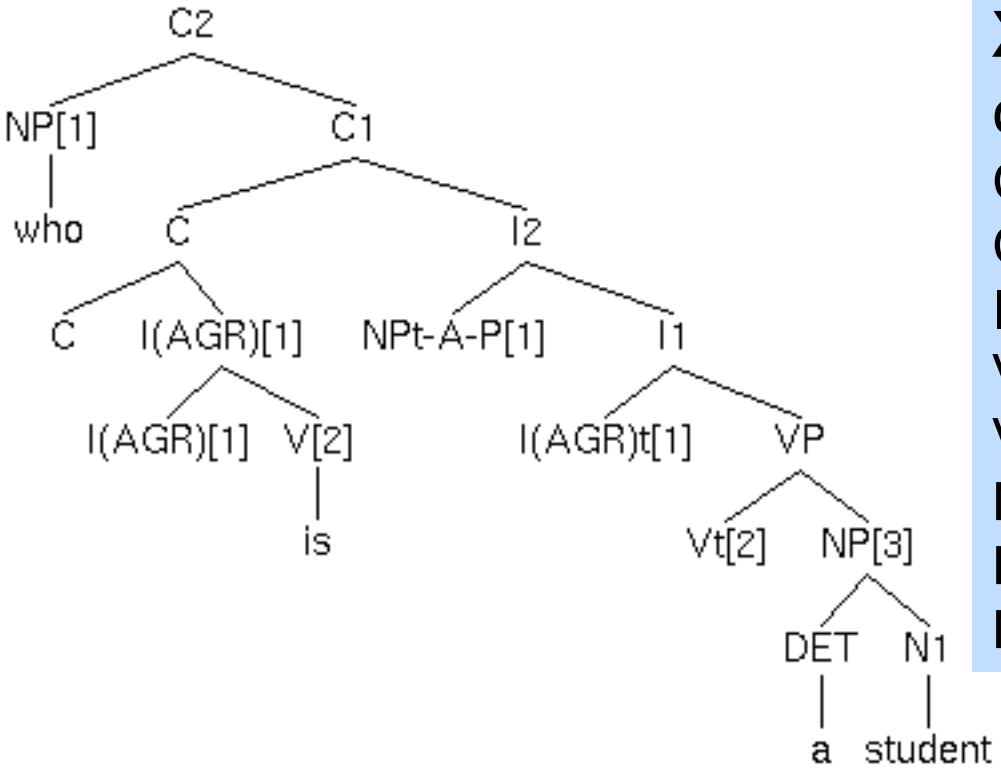
Parsing: john is a student
LF (1):



X-bar phrase structure
subject: $[_{I2}\ [_{NP}$ john] I1]
VP: *is a student*
copula: *is*
complement of VP:
$[_{NP}\ [_{DET}$ a]$[_{N1}$ student]]
(predicate NP)

Syntactic Structure

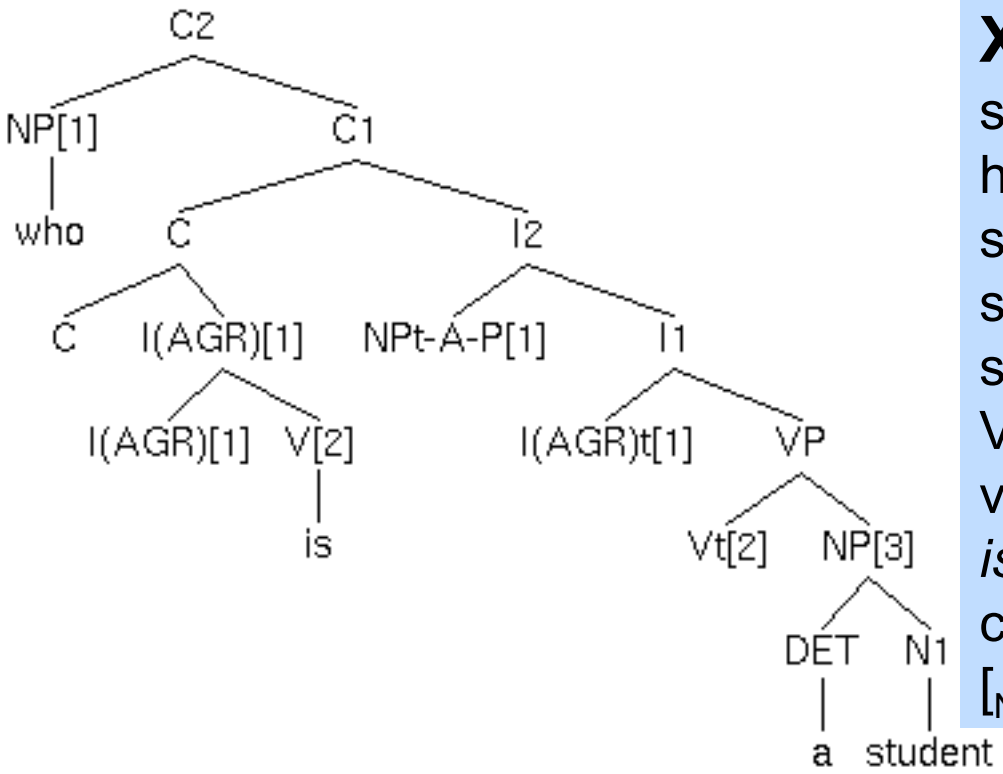
- A formal grammar enables us to logically break down a sentence into its constituent parts



X-bar phrase structure
constituent labels
C2 = CP = S-bar (clause)
C = complementizer
I2 = S (sentence)
VP = Verb Phrase
V = Verb
NP = Noun Phrase
DET = determiner
NPt = NP trace

Syntactic Structure

- A formal grammar enables us to logically break down a sentence into its constituent parts



X-bar phrase structure

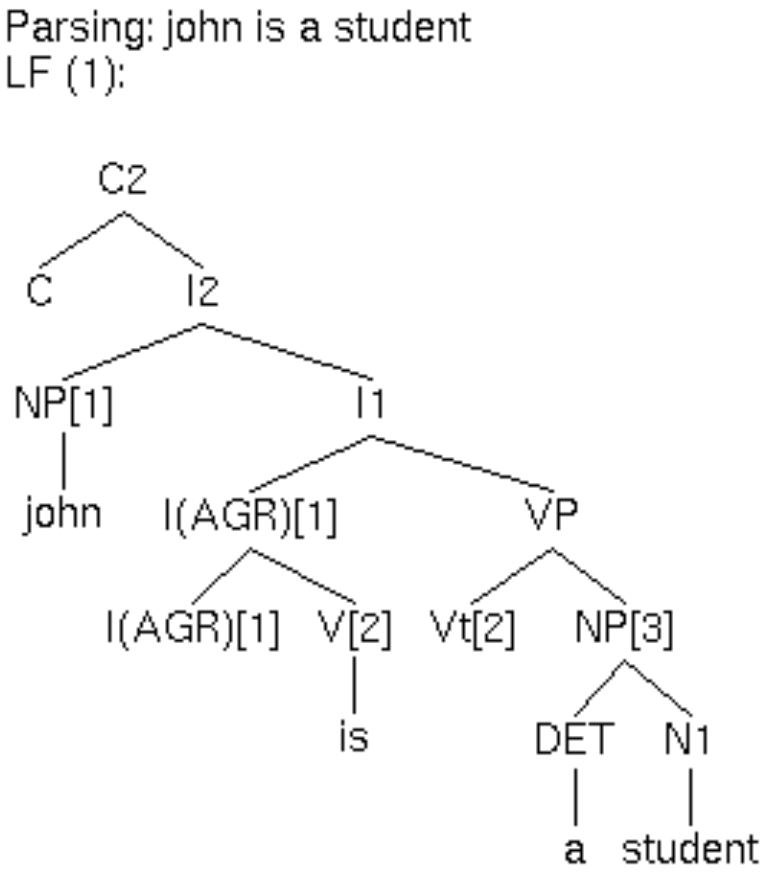
specifier of CP: [$_{CP}$ [$_{NP}$ who] C1]
head of CP: C: auxiliary verb *is*
subject: [$_{I2}$ [$_{NP}$ trace] I1]
subject is coindexed [1] with specifier of CP
VP: [$_{V}$trace] *a student*
verb (trace) is coindexed [2] with *is*
complement of VP:
[$_{NP}$ [$_{DET}$ a][$_{N1}$ student]]

Syntactic Structure

- We could but don't have to specifically use X-bar phrase structure to diagram sentences
  - *idea that all phrases have regular internal structure*
  - [$_{XP}$ *specifier* [$_{X1}$ [$_{X}$ *head*] *complement*]]
  - X = {C,I,V,N,A,P,..}

  - so long as we're able to identify (recover) configurations and (implied) grammatical positions
    - subject
    - object
    - verb (predicate)

Phrase Structure Rules



- **Simple rules:**
- SBar → S
- S → NP VP
- VP → V NP
- V → is
- NP → DET N
- NP → ProperNoun
- ProperNoun → John
- DET → a
- N → student

subject

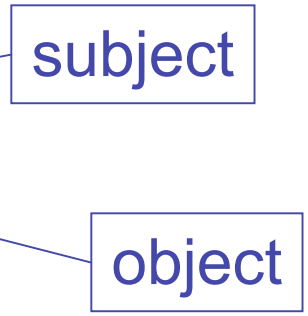
object

Phrase Structure Rules

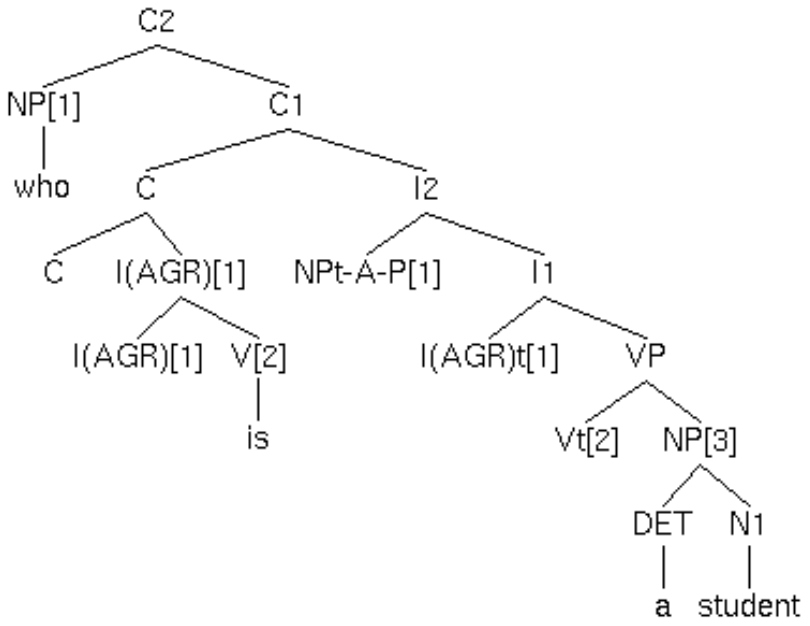
- John is a [$_{pred}$ student]
- John [$_{pred}$ likes] Mary
- John is [$_{pred}$ happy]

- which is the **predicate**?
  - V (main verb: *likes*)
  - V_{aux} *is* (copula carries little meaning)
  - complement of copula is the predicate
- Note:
  - *gotta be careful*
  - John is **the** student

- **Simple rules:**
- SBar → S
- S → NP VP
- VP → V NP
- V → is
- NP → DET N
- NP → ProperNoun
- ProperNoun → John
- DET → a
- N → student



Phrase Structure Rules



- **Rules**:
- SBar → WhNoun Aux S
- WhNoun → who
- Aux → is
- S → NPtrace VP
- NPtrace →ε
- VP → Vtrace NP
- Vtrace →ε
- NP → DET N
- DET → a
- N → student

subject

empty

object

plus associations by coindexation between traces and contentful items

Phrase Structure Rules

- To come...
  - a very cool thing we'll be using is that Prolog has a grammar rule system built into it
    - i.e. we can ask Prolog to do the diagramming for us
    - ... of course, we have to supply the phrase structure rules

Reading Assignment(s)

- for later this week
  - handout
  - Chapter 2: *Putting a Meaning Together from Pieces*
  - we will discuss it on Thursday
- are you comfortable diagramming sentences?
  - if not, grab any grammar/syntax book
  - or search the web:
    - http://en.wikipedia.org/wiki/Phrase_structure_rules
- Thursday
  - there will be a 15 minute quiz at the end of class