CS-AD 220 – Spring 2016

Natural Language Processing

Session 16: 31-Mar-16

Prof. Nizar Habash

Some slides are adapted from Jurafsky and Martin's course slides on Speech and Language Processing

NYUAD Course CS-AD 220 – Spring 2016

Natural Language Processing

Assignment #3 : POS Tagging and Parsing

Assigned Mar 31, 2016 / Due Apr 17, 2016 (11:59pm)

I. Grading & Submission

This assignment is about the development of a dependency parser and a part-of-speech (POS) tagger for English. The assignment accounts for 15% of the full grade. It consists of five exercises. **There is also a bonus exercise that can count for up to 5% of the full grade**. The additional exercise consists of a parsing competition on an unseen test set. Participation earns 2%. The first, second and third ranked systems earn additional 3%, 2% and 1%, respectively.

Assignment #3 posted on NYU Classes

START EARLY!

DEADLINE PUSHED FORWARD TO APR 17

Moving Legislative Day Class

- Spring Break is March 18 – 25, 2016
- Sat March 26, 2016 is a Legislative *Thursday*
- Move to

Sat April 2, 2016 at 10am

Same Classroom C2-E049

Syntax

- By grammar, or syntax, we have in mind the kind of implicit knowledge of your native language that you had mastered by the time you were 3 years old without explicit instruction
- Not the kind of stuff you were later taught in “grammar” school
- Descriptive vs. Prescriptive Grammars

Syntax

- Why should you care?
- Grammars (and parsing) are key components in many applications
  - Grammar checkers
  - Dialogue management
  - Question answering
  - Information extraction
  - Machine translation

Syntax

- Key notions that we'll cover
  - Constituency
  - Dependency
- Key formalism
  - Context-free grammars
- Resources
  - Treebanks
- Parsing Algorithms
  - Constituency
  - Dependency

Constituency

- The basic idea here is that groups of words within utterances can be shown to act as single units.
- And in a given language, these units form coherent classes that can be be shown to behave in similar ways
  - With respect to their internal structure
  - And with respect to other units in the language

Multilingual Syntactic Variations

يقرأ الطالب المجتهد كتابا عن الصين في الصف

read the-student the-diligent a-book about china in the-classroom

---

the diligent student is reading a book about china in the classroom

---

这位勤奋的学生在教室读一本关于中国的书

this quant diligent *de* student in classroom read *one quant* about china *de* book

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	Arabic		English		Chinese	
Subj-Verb	V Subj	Subj V	Subj V		Subj … V	
Verb-PP	V…PP		V…PP		V PP	PP V
Adjectives	N Adj		Adj N		Adj de N	
Possessives	N Poss		N of Poss	Poss 's N	Poss de N	
Relatives	N Rel		N Rel		Rel de N	

English Constituency Tree

```
(S
  (NP (DT the) (JJ diligent) (NN student))
  (VP (VBZ is)
    (VP (VBG reading)
      (NP
        (NP (DT a) (NN book))
        (PP (IN about)
            (NP (NN china))))
      (PP (IN in)
          (NP (DT the) (NN classroom))))))
```

Arabic Constituency Tree

```
(S
  (VP (VBP yqrA/reads)
      (NP (DTNN AlTAlb/the-student) (DTJJ Almjthd/the-diligent))
      (NP
        (NP (NN ktAbA/a-book))
        (PP (IN En/about)
          (NP (DTNNP AlSyn/the-China))))
      (PP (IN fy/in)
          (NP (DTNN AlSf/the-classroom)))))
```

English Constituency Tree

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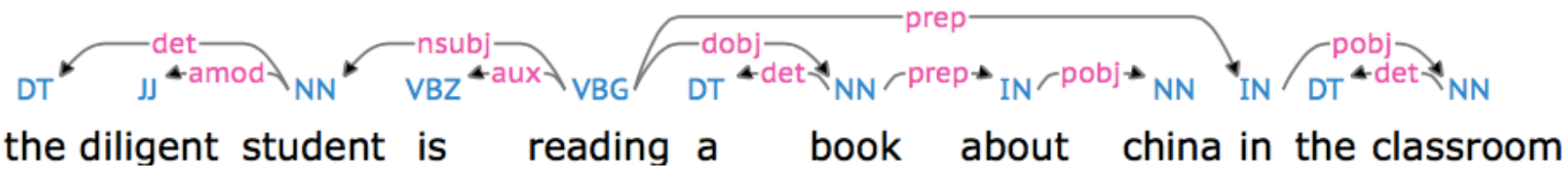
(S
  (NP (DT the) (JJ diligent) (NN student))
  (VP (VBZ is)
    (VP (VBG reading)
      (NP
        (NP (DT a) (NN book))
        (PP (IN about)
          (NP (NN china))))
      (PP (IN in)
        (NP (DT the) (NN classroom))))))
```

English Dependency Tree



Dependency created with http://www.cs.cmu.edu/~ark/TurboParser/

Constituency

- Internal structure
  - We can describe an internal structure to the class (might have to use disjunctions of somewhat unlike sub-classes to do this).
- External behavior
  - For example, we can say that noun phrases can come before verbs

Constituency

- For example, it makes sense to the say that the following are all ***noun phrases*** in English...

Harry the Horse	a high-class spot such as Mindy's
the Broadway coppers	the reason he comes into the Hot Box
they	three parties from Brooklyn

- Why? One piece of evidence is that they can all precede verbs.
  - This is external evidence

Grammars and Constituency

- Of course, there's nothing easy or obvious about how we come up with right set of constituents and the rules that govern how they combine...
- That's why there are so many different theories of grammar and competing analyses of the same data.
- The approach to grammar, and the analyses, adopted here are very generic (and don't correspond to any modern linguistic theory of grammar).

Context-Free Grammars

- Context-free grammars (CFGs)
  - Also known as
    - Phrase structure grammars
    - Backus-Naur form
- Consist of
  - Rules
  - Terminals
  - Non-terminals

Context-Free Grammars

- Terminals
  - We'll take these to be words (for now)
- Non-Terminals
  - The constituents in a language
    - Like noun phrase, verb phrase and sentence
- Rules
  - Rules are equations that consist of a single non-terminal on the left and any number of terminals and non-terminals on the right.

Some NP Rules

- Here are some rules for our noun phrases

$$
\begin{aligned}
NP &\rightarrow Det\ Nominal \\
NP &\rightarrow ProperNoun \\
Nominal &\rightarrow Noun \mid Nominal\ Noun
\end{aligned}
$$

Some NP Rules

- Here are some rules for our noun phrases

$$
\begin{aligned}
NP &\rightarrow Det\ Nominal \\
NP &\rightarrow ProperNoun \\
Nominal &\rightarrow Noun \mid Nominal\ Noun
\end{aligned}
$$

- Together, these describe two kinds of NPs.
  - One that consists of a determiner followed by a nominal
  - And another that says that proper names are NPs.
  - The third rule illustrates two things
    - An explicit disjunction
      - Two kinds of nominals
    - A recursive definition
      - Same non-terminal on the right and left-side of the rule

A Simple Grammar

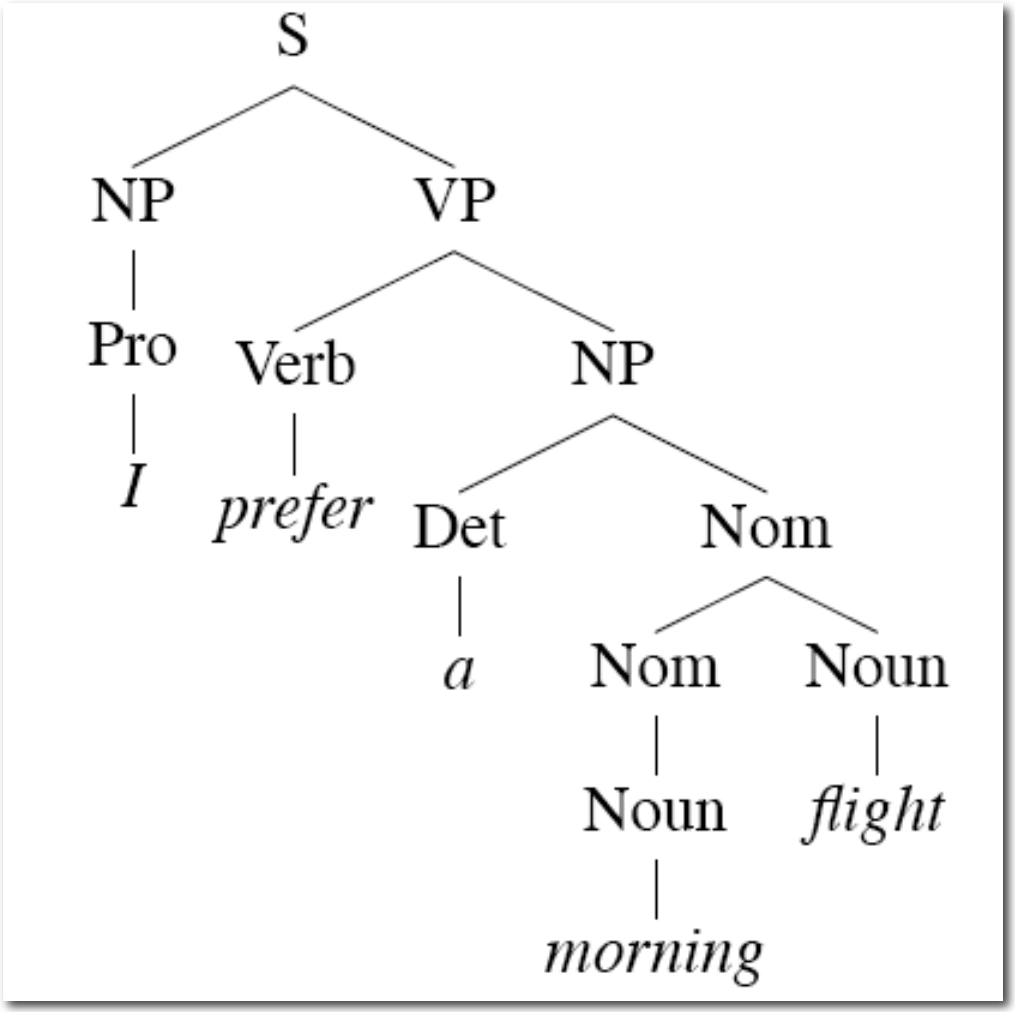
Grammar Rules			Examples
S	→	*NP VP*	I + want a morning flight
NP	→	*Pronoun*	I
	|	*Proper-Noun*	Los Angeles
	|	*Det Nominal*	a + flight
Nominal	→	*Nominal Noun*	morning + flight
	|	*Noun*	flights
VP	→	*Verb*	do
	|	*Verb NP*	want + a flight
	|	*Verb NP PP*	leave + Boston + in the morning
	|	*Verb PP*	leaving + on Thursday
PP	→	*Preposition NP*	from + Los Angeles

Generativity

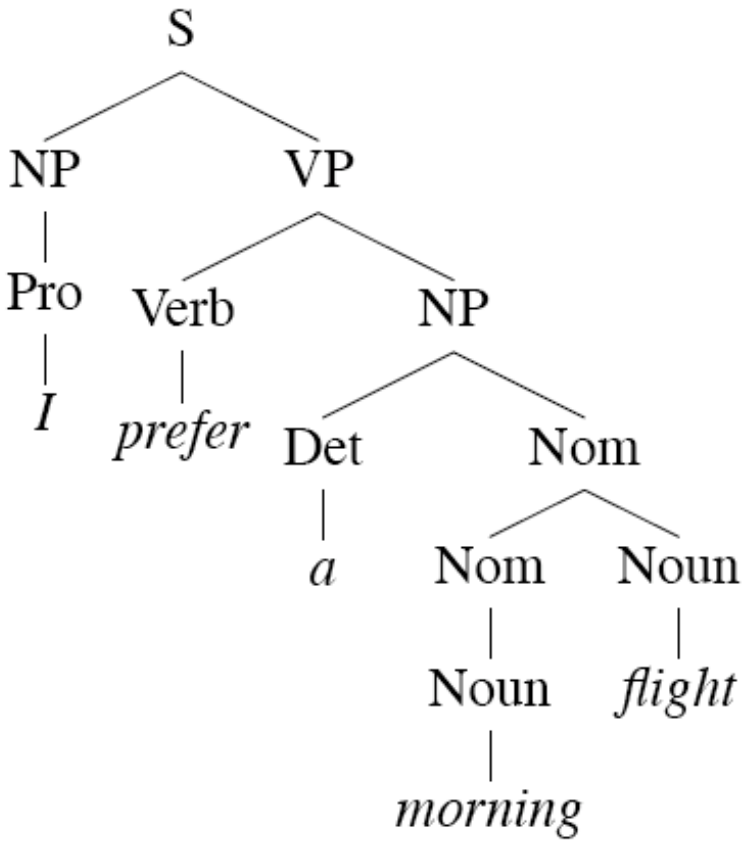
- As with FSAs and FSTs, you can view these rules as either analysis or synthesis machines
  - Generate strings in the language
  - Reject strings not in the language
  - Impose structures (trees) on strings in the language

Derivations

- A derivation is a sequence of rules applied to a string that *accounts* for that string
  - Covers all the elements in the string
  - Covers only the elements in the string



Equivalent Forms




```
(S (NP (Pro I))
   (VP (Verb prefer)
       (NP (Det a)
           (Nom (Nom (Noun morning))
                (Noun flight)))))
```

```
(S
  (NP
    I/Pro)
  (VP
    prefer/Verb
    (NP
       A/Det
       (Nom
            (Nom
               morning/Noun)
            flight/Noun))))
```

```
(S (NP (Pro I)) (VP (Verb prefer) (NP (Det a) (Nom (Nom (Noun morning)) (Noun flight)))))
```

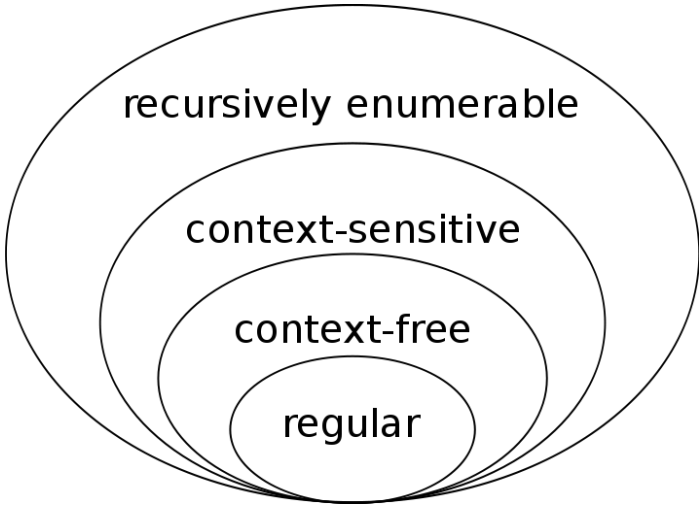
Definition

- More formally, a CFG consists of

N	a set of **non-terminal symbols** (or **variables**)
Σ	a set of **terminal symbols** (disjoint from N)
R	a set of **rules** or productions, each of the form $A \rightarrow \beta$, where A is a non-terminal, β is a string of symbols from the infinite set of strings $(\Sigma \cup N)*$
S	a designated **start symbol**

Parsing

- Parsing is the process of taking a string and a grammar and returning a (multiple?) parse tree(s) for that string
- It is completely analogous to running a finite-state transducer with a tape
  - It's just more powerful
  - *There are languages we can capture with CFGs that we can't capture with finite-states*
  - *Chomsky Language Hierarchy*
    - *E.g. $a^n b^n$ is a context-free language*



An English Grammar Fragment

- Sentences
- Noun phrases
  - Agreement
- Verb phrases
  - Subcategorization

Sentence Types

- Declaratives: *A plane left.*

  S → NP VP

- Imperatives: *Leave!*

  S → VP

- Yes-No Questions: *Did the plane leave?*

  S → Aux NP VP

- WH Questions: *When did the plane leave?*

  S → WH-NP Aux NP VP

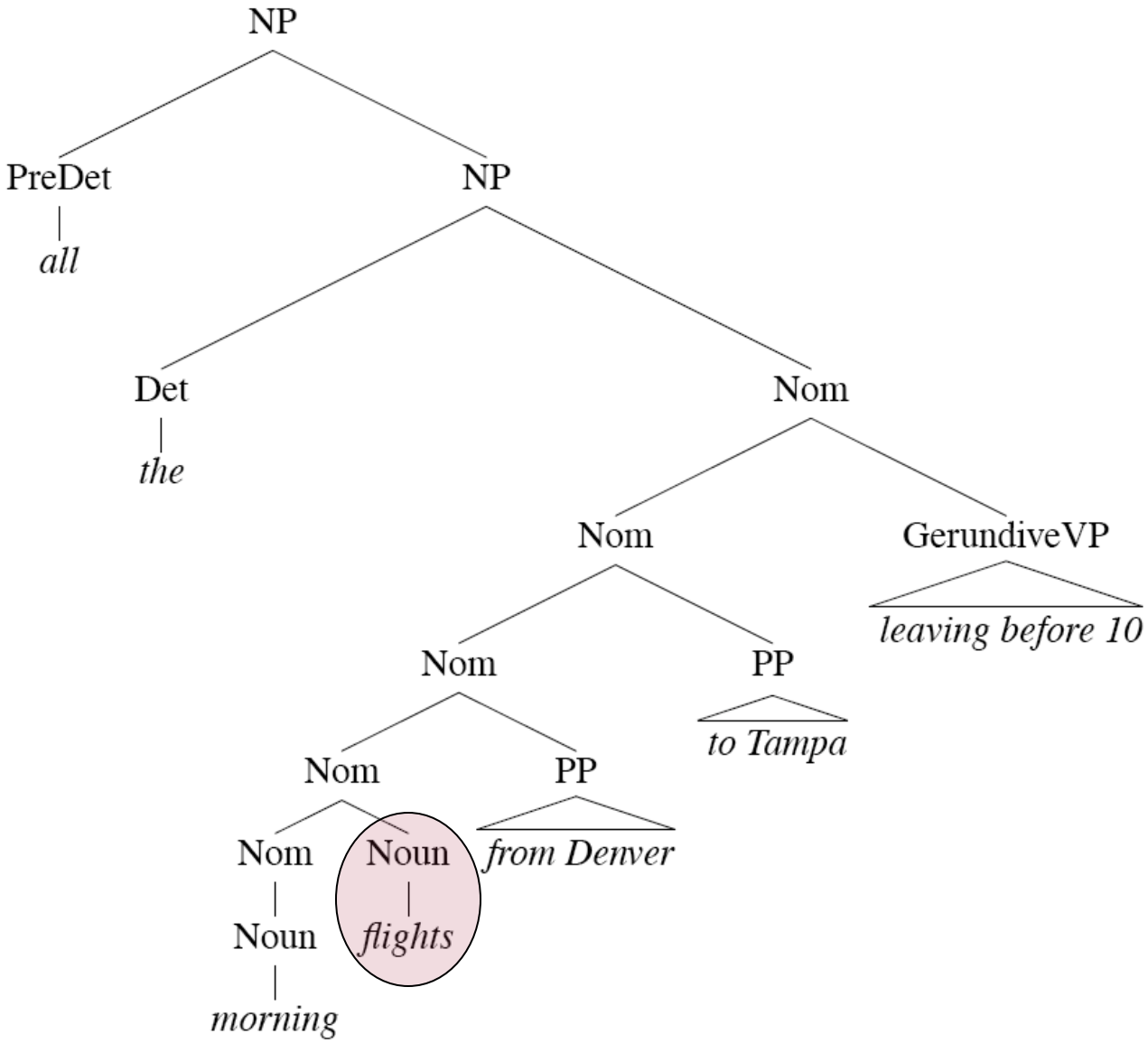
Noun Phrases

- Let's consider the following rule in more detail...

  NP → Det Nominal

- Most of the complexity of English noun phrases is hidden in this rule.
- Consider the derivation for the following example
  - *All the morning flights from Denver to Tampa leaving before 10*

Noun Phrases



NP Structure

- Clearly this NP is really about *flights.* That's the central criticial noun in this NP. Let's call that the *head*.
- We can dissect this kind of NP into the stuff that can come before the head, and the stuff that can come after it.

Determiners

- Noun phrases can start with determiners...
- Determiners can be
  - Simple lexical items: *the, this, a, an*, etc.
    - A car
  - Or simple possessives
    - John's car
  - Or complex recursive versions of that
    - John's sister's husband's son's car

Nominals

- Contains the head and any pre- and post-modifiers of the head.
  - Pre-
    - Quantifiers, cardinals, ordinals...
      - Three cars
    - Adjectives and APs
      - large cars
    - Ordering constraints
      - Three large cars
      - ?large three cars

Postmodifiers

- Three kinds
  - Prepositional phrases
    - From Seattle
  - Non-finite clauses
    - Arriving before noon
  - Relative clauses
    - That serve breakfast
- Same general (recursive) rule to handle these
  - *Nominal → Nominal PP*
  - *Nominal → Nominal GerundVP*
  - *Nominal → Nominal RelClause*

Agreement

- By ***agreement***, we have in mind constraints that hold among various constituents that take part in a rule or set of rules
- For example, in English, determiners and the head nouns in NPs have to agree in their number.

This flight

Those flights

*This flights

*Those flight

Problem

- Our earlier NP rules are clearly deficient since they don't capture this constraint
  - *NP → Det Nominal*
    - Accepts, and assigns correct structures, to grammatical examples (*this flight*)
    - But its also happy with incorrect examples (*these flight)
  - Such a rule is said to *overgenerate.*
  - We'll come back to this in a bit

Verb Phrases

- English *VP*s consist of a head verb along with 0 or more following constituents which we'll call *arguments*.

$VP \rightarrow Verb$ disappear
$VP \rightarrow Verb\ NP$ prefer a morning flight
$VP \rightarrow Verb\ NP\ PP$ leave Boston in the morning
$VP \rightarrow Verb\ PP$ leaving on Thursday

Subcategorization

- But, even though there are many valid VP rules in English, not all verbs are allowed to participate in all those VP rules.
- We can subcategorize the verbs in a language according to the sets of VP rules that they participate in.
- This is a modern take on the traditional notion of transitive/intransitive.
- Modern grammars may have 100s or such classes.

Subcategorization

- Sneeze: John sneezed
- Find: Please find [a flight to NY]$_{NP}$
- Give: Give [me]$_{NP}$[a cheaper fare]$_{NP}$
- Help: Can you help [me]$_{NP}$[with a flight]$_{PP}$
- Prefer: I prefer [to leave earlier]$_{TO\text{-}VP}$
- Told: I was told [United has a flight]$_{S}$
- …

Subcategorization

- *John sneezed the book
- *I prefer United has a flight
- *Give with a flight

- As with agreement phenomena, we need a way to formally express the constraints

Why?

- Right now, the various rules for VPs *overgenerate*.
  - They permit the presence of strings containing verbs and arguments that don't go together
  - For example
  - VP -> V NP therefore

    Sneezed the book is a VP since "sneeze" is a verb and "the book" is a valid NP

Possible CFG Solution

- Possible solution for agreement.
- Can use the same trick for all the verb/ VP classes.

- SgS -> SgNP SgVP
- PlS -> PlNp PlVP
- SgNP -> SgDet SgNom
- PlNP -> PlDet PlNom
- PlVP -> PlV NP
- SgVP ->SgV Np
- …

CFG Solution for Agreement

- It works and stays within the power of CFGs
- But it's ugly
- And it doesn't scale all that well because of the interaction among the various constraints explodes the number of rules in our grammar.

The Point

- CFGs appear to be just about what we need to account for a lot of basic syntactic structure in English.
- But there are problems
  - That can be dealt with adequately, although not elegantly, by staying within the CFG framework.
- There are simpler, more elegant, solutions that take us out of the CFG framework (beyond its formal power)
  - Lexical Functional Grammar (LFG), Head-Driven Phrase Structure Grammar (HPSG), Construction grammar, XTAG, etc.

Next Time

Sat April 2, 2016 at 10am

Same Classroom C2-E049

No reading assigned