Fundamentals of Grammar
Phrase Structure Rules

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Today

content

- syntactic ambiguity
- phrase structure
- rules & trees
- recursion
- evidence for syntactic phrases
  - movement
  - pronominalization
  - coordination

remember

- hw3 due tomorrow night (practice version available)
Syntax

Definition
Syntax is the study of the organization of words into larger units (*phrases* and *sentences*).

evidence

- theoretical evidence (infinite language from finite rule set)
- syntactic ambiguity
syntactic ambiguity

Ambiguity resulting from the syntactic structure of the phrase or sentence.

- Our famous headlines examples:
  - SQUAD HELPS DOG BITE VICTIM
  - TEACHER STRIKES IDLE KIDS
  - HERSHEY BARS PROTEST
Phrase structure trees and brackets are notational equivalents.

```
hershey
  
bars  protest

hershey  bars

[hershey  [bars  protest]]  [[hershey  bars]  protest]
```

phrase structure trees

bracketed phrase structure
Phrase structure

Definition

A **phrase** is a string of (one or more) words that functions as **syntactic unit** (or constituent).

- [large [man’s hat]]
- [large [bowling ball]]
- [large [cheese pizza]]
- [[large man’s] hat]
- [[tiny woman’s] hat]
- [[young child’s] hat]
Phrases have **hierarchical structure**. Phrases can contain other phrases.

- [The book]
- [The book [ of [ stories ]]]
- [The book [ of [ stories [ about ants ]]]]
A phrase is built up around a single word (head), which extends it’s properties to the entire phrase.

Example

\[ S \ [NP \ The \ man] \ [VP \ sings \ [PP \ in \ [NP \ the \ shower \ ]]] \]

- these labelled brackets correspond to labelled nodes on a phrase structure tree
phrase structure

\[
[S \ [NP \ \text{The man}] \ [VP \ sings \ [PP \ in \ [NP \ \text{the shower}]]]]
\]

rules

Phrases are generated by rules of the grammar (phrase structure rules). In a tree, each subtree needs to correspond (ie “be licensed”) by a phrase structure rule in the grammar.
The phrase structure rules of a grammar (CFG) determine:

- which categories go into a phrase
- how these categories are ordered
- (by convention) which element is the head of the phrase

Example

\[ XP \rightarrow X \ Y \]

“XP consists of X followed by Y”

- for us, the “X” in “XP” is significant, it indicates that X is the head of this phrase (the right hand side of the rule needs an X!)
phrase structure rules

noun phrases

Alice               NP → N
the cat             NP → Det N
those two rabbits   NP → Det Num N
a mouse in a cup    NP → Det N PP

NP → (Det) (Num) N (PP)

generalizing PSRs (abbreviations)

It is traditional to abbreviate two (or more) rules into a single
rule using () to indicate optionality.
Likewise, we can also abbreviate sets of rules disjunctively
using large curly braces { }, or, in ASCII, using |.
(eg: VP → V { NP PP })
phrase structure rules

prepositional phrases

- in
  \[ PP \rightarrow P \]

- up a tree
  \[ PP \rightarrow P \ NP \]

- from a mouse in a cup
  \[ PP \rightarrow P \ NP \]

\[ PP \rightarrow P \ (NP) \]
verb phrases

*sleeps*  \[\text{VP} \rightarrow \text{V}\]

*found a bone*  \[\text{VP} \rightarrow \text{V} \ \text{NP}\]

*fell into the abyss*  \[\text{VP} \rightarrow \text{V} \ \text{PP}\]

*sang a song in the shower*  \[\text{VP} \rightarrow \text{V} \ \text{NP} \ \text{PP}\]

\[\text{VP} \rightarrow \text{V} \ \text{(NP)} \ \text{(PP)}\]
synactic ambiguity

[drink [tea [ with [ honey ]]]] [drink [tea ] [ with [ honey ]]]

VP
V
NP
drink
N
PP
tea
P
NP
with
N
honey

“The PP is a constituent of the NP vs ...of the VP.”
Some data:
The dog barked.
*The dog
*Barked
so S must contain at least an NP and VP
PSR for S:

\[ S \rightarrow \text{NP } \text{VP} \]
What phrase structure rules were used in this derivation?

$S \rightarrow NP \ VP$

$NP \rightarrow \text{Det} \ N$

$VP \rightarrow V \ NP$
structural ambiguity in sentences

“I hit the man with the hammer.”

(the man has the hammer)  (I have the hammer)

S

NP  VP

N  V  NP

I  hit  Det  N  PP

the man  P  NP

with  Det  N

th@hammer

S

NP  VP

N  V  NP  PP

I  hit  Det  N  P  NP

the manwith  Det  N  th@hammer
recursion

self reference in rules

- when a category appears on both the left and right side of a rule (or a pair of rules, transitively) in the same grammar, the set of structures generated by this grammar is non-finite

Example

- \( \text{NP} \rightarrow (\text{Det}) \text{ N} (\text{PP}) \)
- \( \text{PP} \rightarrow \text{ P (NP)} \)
- \[ [\text{NP} \ N \ [_{pp} \ P \ [_{np} \ N \ [_{pp} \ P \ [_{np} \ N \ [_{pp} \ P \ [_{np} \ N \ [_{pp} \ P \ ...]]]]]]]]] \]
a single rule can be recursive by self reference on both the right and left hand side:
\[ X \rightarrow XY \]

a grammar can be recursive by containing a set of rules which taken together allow “looping” rule application:
\[ X \rightarrow Y \]
\[ Y \rightarrow Z \]
\[ Z \rightarrow X \]

Note: recursivity in grammars does not yield phrases of infinite length! Any phrase generated will be of a finite length.

Recursivity in grammar does yield an infinity of phrases, a phrase can be found for any arbitrary length
Definition
Recursion: see “recursion”
recursive NP, PP in English

```
NP
   |    |    PP
Det  N  PP
   |    |    NP
   a  frog P
   |    |    NP
   on  Det N PP
   |    |    NP
   the log P
   |    |    NP
   in  Det N PP
   |    |    NP
   the hole P
   |    |    NP
   on  Det N PP
   |    |    NP
   the bottom P
   |    |    NP
   of  Det N
   |    |    the sea
```