Grammar

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Today's lecture

[continued from Monday's lecture]

What is syntax?

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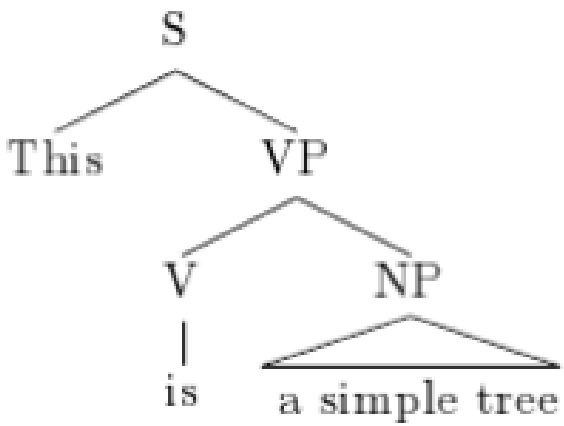
Definition

A basic construct of syntax is the structural description, a structure that shows word order, syntactic constituency, and labels for the constituents.

Structural description: tree



Structural description: bracketed structure

[This [is [a simple bracketed structure]]]

...with no labels.

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[$_S$ *This*[$_{VP}$[$_V$ *is*][$_{NP}$ *a simple bracketed structure*]]]

The labeled bracketed structure is equivalent to the tree structure.

Tree structures for linguistics

Definition

A tree is a graphical way of representing structural description; trees for NL are more precisely *ordered directed trees* with (nodes, labels and arcs).

Node	a component or unit of a tree.
Root node	the node with no ancestors (labeled by the start symbol.
Nonterminal node	a node with descendants.
Terminal/Leaf node	a node with no descendants (corresponding to the strings, or "words", of the language).

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Arc shows the constituency relation, but is untyped.

Label a symbol identifying the category of some node.

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In another sense, syntax is the set of rules by which well formed utterances are formed. (The term *grammar* is more general and refers to all aspects of language.)

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We can formalize the notion of syntax using ideas from **formal language theory**.

Formal language theory

Since natural language is rule-governed, not random, a grammar can be constructed to parse natural language, just as with compilers and machine languages.

Definition

Formal language theory, or the study of the properties of formal languages, gives a firm conceptual framework from which to study natural language.

Chomsky hierarchy

Definition

The Chomsky Hierarchy describes four classes of formal grammars that generate four corresponding classes of languages.

(We only talk about CFGs in Ling571, but see J&M Chap. 16 for an overview.)

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1. **Type 0**: Turing equivalent language/grammar
2. **Type 1**: context sensitive language/grammar
3. Type 2: context free language/grammar
4. **Type 3**: regular language/grammar

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Formal grammar

Definition

(Generalized) formal grammar A grammar is defined as $G = \langle N, \Sigma, P, S \rangle$ where:

- N is a set of non-terminal symbols, typically $S, A, B, \ldots$
- Σ is a set of terminals, typically $x, y, z, \ldots$
- P is a set of production rules
- S is the starting or goal variable from N, i.e., $S \in N$

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Sample grammar

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S -> NP VP
NP -> Det Noun
NP -> ProperNoun
VP -> Verb
VP -> Verb NP

Det -> the|a|that
Noun -> lamp|pig|dirt
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- Σ is a set of terminal symbols, typically $x, y, z, \ldots$ disjoint from N
- P is a set of production rules
- The productions P are of the form: $A \rightarrow \beta$, where:
  - A is a non-terminal $A \in N$
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Unpacking the definition

- A nonterminal symbol labels a syntactic part (constituent): *NP*, *VP*, *PP*, (*Noun*, *Verb*, *Det*)
- A starting symbol indicates which symbol has to come first; it labels the largest constituent or biggest part: *S*, *Root*, or *Top*
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Is this a valid CFG grammar?

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Needs a start symbol and associated rule: $S \rightarrow NP\ VP$

Grammars and treebanks

Definition

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Thus, a treebank implicitly contains a grammar (grammars) of the language it contains.
Examples of treebanks:

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Corpora on Patas

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- Largest collection is the Linguistics Data Consortium (LDC) corpora.
- The NLTK comes with many corpora fragments as well.
- See the compling database to search for specific corpora: https://pongo.ling.washington.edu/db/index.php
  Perform a search for 'Treebank'

Penn Treebank (2 and 3)

```
cd /corpora/LDC/LDC99T42/RAW

(see readme.1st)

cd /corpora/LDC/LDC99T42/RAW/parsed/mrg/wsj/04$

(see wsj_0432.mrg)
```

Word classes

The number of word classes (pre-terminals) depends on the task and how fine you want to cut the pie (Tagged Brown corpus has 87 pre-terminal tags; Penn Treebank uses a 49-item pre-terminal tagset.) There's no right answer for NLP.

Definition

Closed class word: a function word in a grammar; there are relatively few of these in a language, though their frequency is very high.

Definition

Open class word: a content word in a grammar; there is an open-ended set of these, but their frequencies may be very low (cf. *home* with *octogenarian*).

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Definition

Noun is a class of lexical items that occur after determiners (*the*, *a*, ...) or adjectives, and can be subjects of sentences. Nouns often represent a person, place, thing, or idea.

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NNPS a plural proper noun
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VBN a participle form occurs after *was*, *were*, *has*, *had*, *have*, *got*, *get*, etc
he was $[_{VBN}$ *bitten] by a tiger*

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JJS a superlative adjective
the [$_{JJS}$ *biggest*] *one*

Adverbs

Definition

Adverbs modify verbs (and adjectives) to specify time, manner, place, or direction of the event.

RB an adverb can occur around the verb phrase or at the beginning/end of the clause

fast, quickly, really, here,

Other categories

DT determiner
a(n), the, that, those

MD modal
do, can, may

PRP pronoun
she, her, him, he, we

EX existential there
there are many fish

CD cardinal number
one, two, three

(see list in front cover of J&M)

Other common abbreviations

Symbol	Meaning	Symbol	Meaning
Det	determiner	NP	noun phrase
Noun	noun	VP	verb phrase
Nom	nominal	AP	adjective phrase
Pro	pronoun	PP	prepositional phrase
Aux	auxiliary		
Card	cardinal number		
Ord	ordinal number		
Quant	quantifier		

PTB phrase types

NP noun phrase including all constituents that depend on the noun head

- *VP*: verb phrase including all constituents that depend on the verb head
- *PP*: prepositional phrase
- *ADJP*: adjective phrase headed by an adjective
- *ADVP*: adverb phrase headed by an adverb
- *CONJP*: used to mark multi-word conjunctions
- *QP*: quantifier phrase, used inside *NPs*
- ...

PTB Clause types

The number of non-terminals (excluding pre-terminals) is generally small. In the Penn Treebank, there are, for example, 29 basic tags for syntactic constituents, including 5 basic clause types and 21 phrase-level constituents.

S	declaratives, passives, imperatives, questions with declarative order, (embedded) infinitive clauses, gerund classes
SINV	inverted clauses
SBAR	relative and subordinate clauses
SBARQ	Wh-questions
SQ	Y/N-questions, inside *SBARQ*
S-CLF	: it-cleft clauses
FRAG	stand-alone clauses, phrases without a predicate argument structure

Rules

Practical treebanks have a large number of rules. The Penn Treebank has more than 17,000! rules. Most of them are flat, and tailored for very specific sentences. The number rules seems to grow at a constant rate as the corpus grows. Not good, but we're stuck with it. (see Gaizauskas paper).

Largest number of rules for *S*, *NP*, and *VP*, but reduced ambiguity.

Strategy

The task in grammar writing is to choose the best elements for N and P. Consider constructing a grammar for named entities (noun phrases), or for a large corpus of sentences (1M+ words).

1. Settle on a tagset for pre-terminals (part-of-speech)
2. Tag data for part of speech
3. Identify larger clause patterns; come up with tags
4. Identify each phrase type; come up with tags
5. Fill in details for each phrase type
6. Identify major clause types
7. Address problematic cases

Instructions for homework

[see hw1 pdf on website]