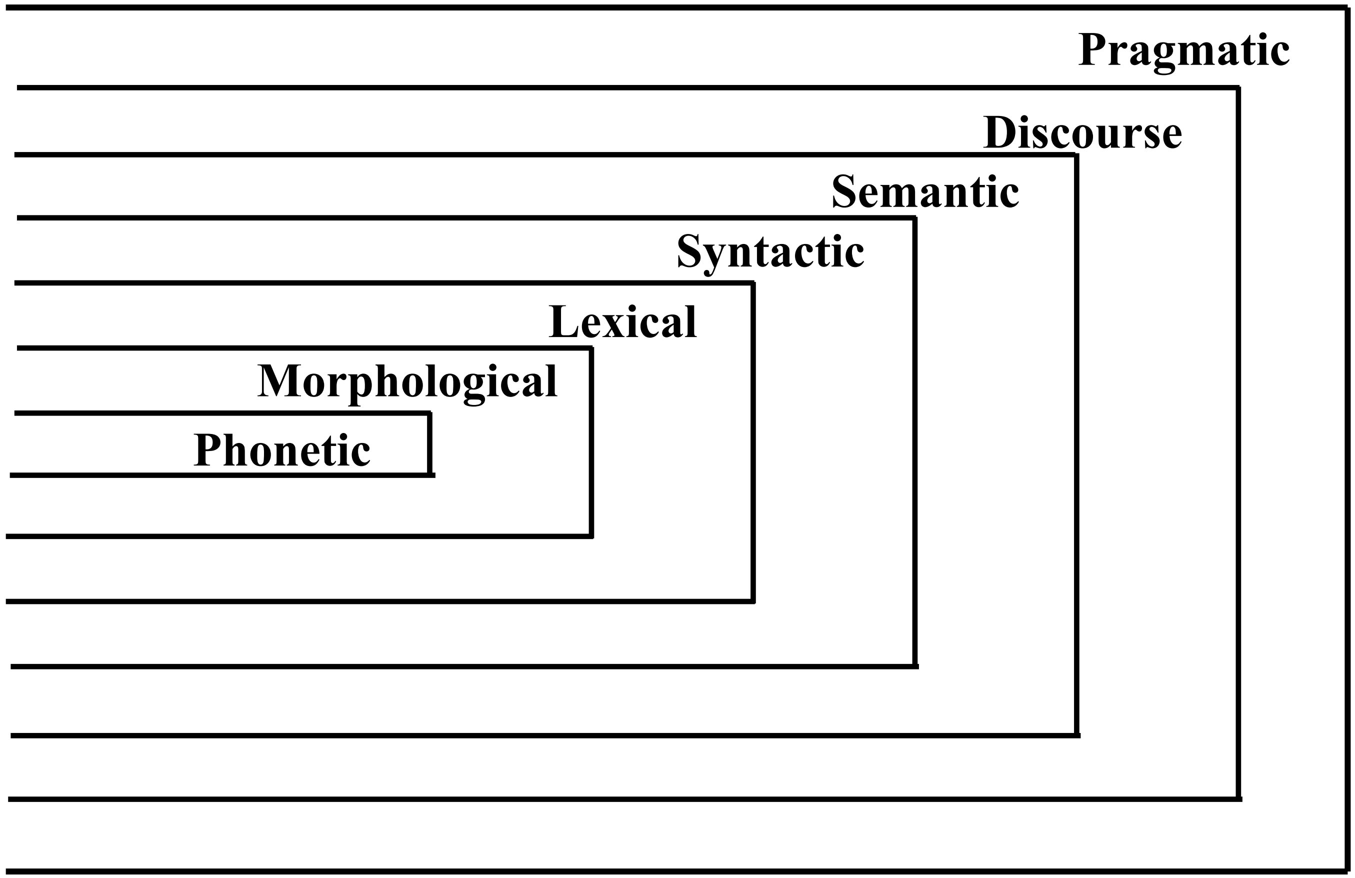
# Levels of Language
# used by
# Natural Language Processing

# Levels of Language Analysis

- Use the synchronic model to guide computational techniques to analyze text (as much as possible)



# Synchronic Model of Language

- The more exterior the level of language processing:
  - The larger the unit of analysis
    - phoneme-> morpheme -> word -> sentence -> text -> world
    - The less precise the language phenomena
  - The more free choice & variability
    - less rule-oriented, more exceptions to regularities
  - The more levels it presumes a knowledge of or reliance on
  - Theories used to explain the data move more into the areas of cognitive psychology and AI
- Lower levels of the model have been more thoroughly investigated and incorporated into NLP systems

# Speech Processing

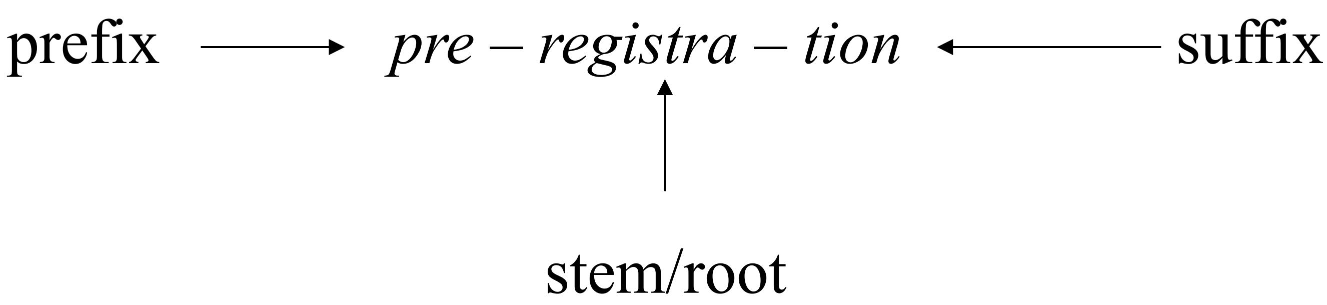
- Interpretation of speech sounds within & across words
- sound waves are analyzed and encoded into a digitized signal

Rules used in Phonological Analysis

1. Phonetic rules – sounds within words
2. Phonemic rules – variations of pronunciation when words are spoken together
3. Prosodic rules – fluctuation in stress and intonation across a sentence

# Morphological Analysis

- deals with the componential nature of lexical entities:



prefix → *pre – registra – tion* ← suffix

stem/root

- What features do inflections reveal in English?

Verbs → tense & number

Nouns → single/plural

Adjectives → comparison features

# Lexical

1. Part-of-speech (POS) tagging tags words with specific noun, verb, adjective and adverb types

*03/14/1999 (AFP)*… the extremist Harkatul Jihad group, reportedly backed by Saudi dissident Osama bin Laden ...

… the|DT extremist|JJ Harkatul_Jihad|NP group|NN ,|, reportedly|RB backed|VBD by|IN Saudi|NP dissident|NN Osama_bin_Laden|NP …

2. Productive rules which explain how new words are formed

   *highchair*

   *egghead*

# Word Level Meaning

- Usually given by online lexicon such as WordNet
- Word with senses
  - Example: launch
- Definitions
  - Noun sense 1: a large, usually motor-driven boat used for carrying people on rivers, lakes harbors, etc.
  - Verb sense 1: set up or found
- Synonyms
  - Verb sense 1: establish, set up, found

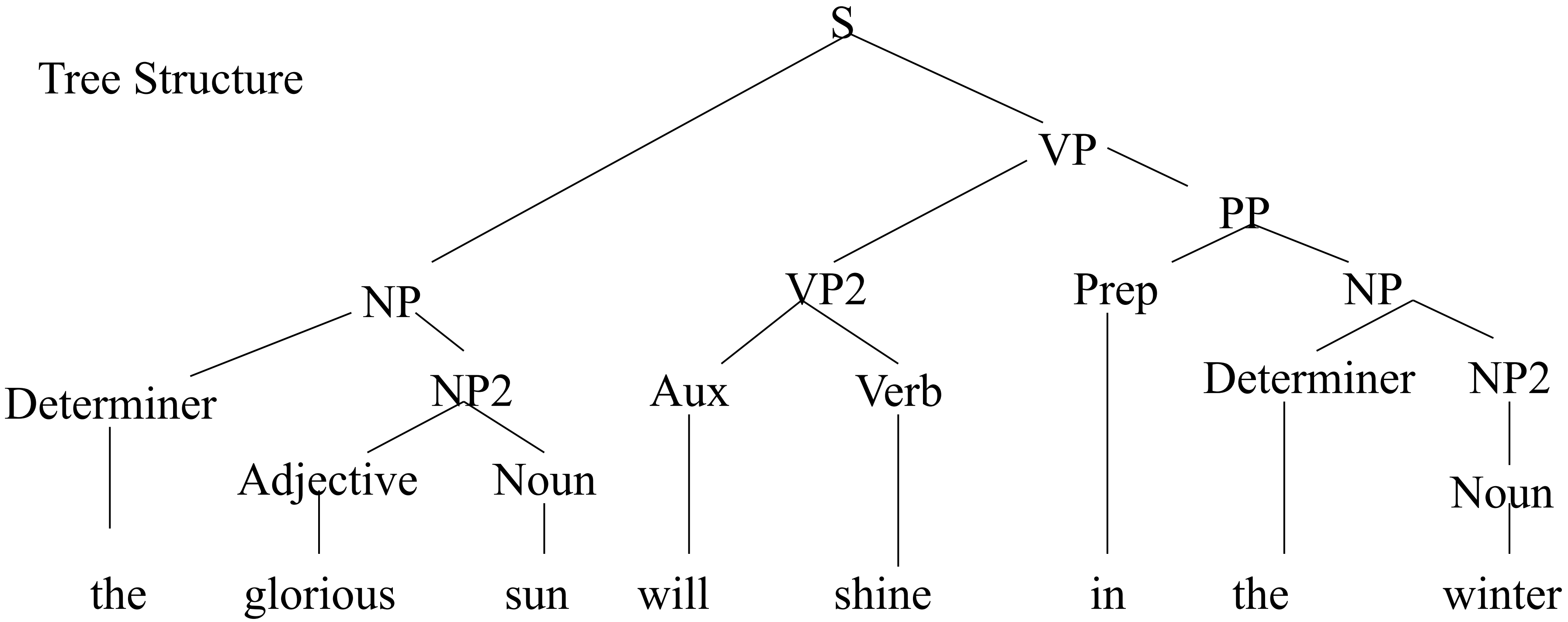
# Syntactic Analysis

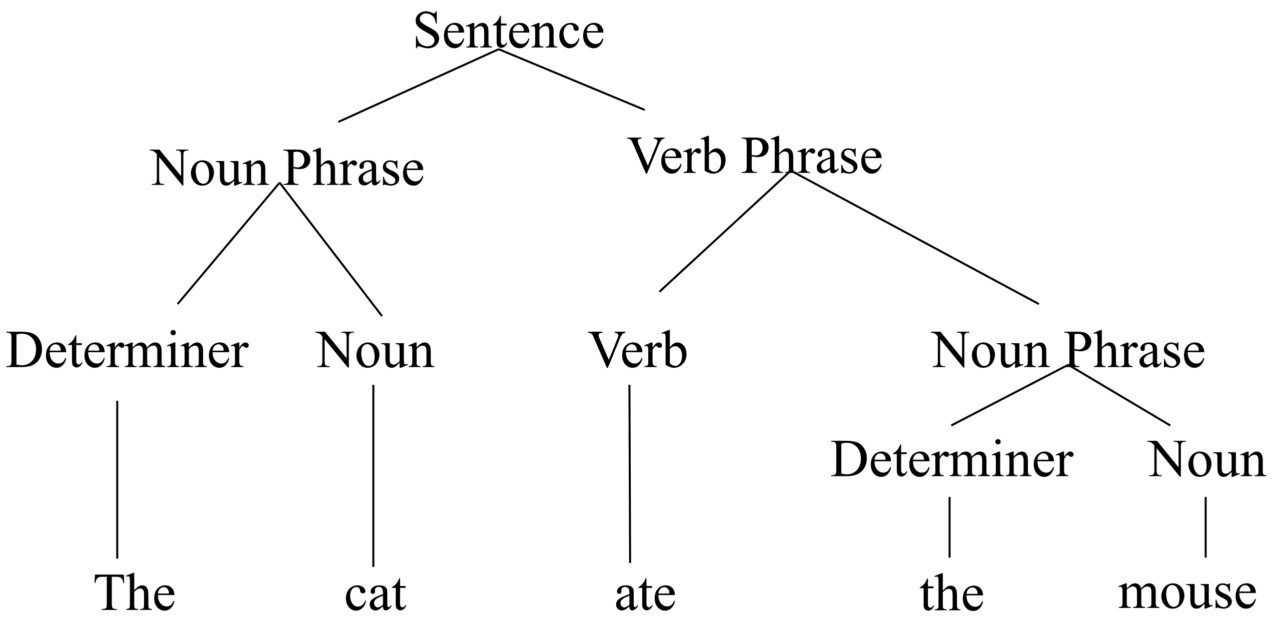
- analyzing of words in a sentence so as to uncover the grammatical structure of the sentence

- requires both a grammar and a parser

- produces a de-linearized representation of a sentence which reveals dependency relationships between words

Tree Structure





Sentence

Noun Phrase

Verb Phrase

Determiner

Noun

Verb

Noun Phrase

Determiner

Noun

The

cat

ate

the

mouse

The phase structure rules underlying this analysis are as follows:

Sentence → Noun Phrase Verb Phrase

Noun Phrase → Determiner Noun

Verb Phrase → Verb Noun Phrase

Determiner = The

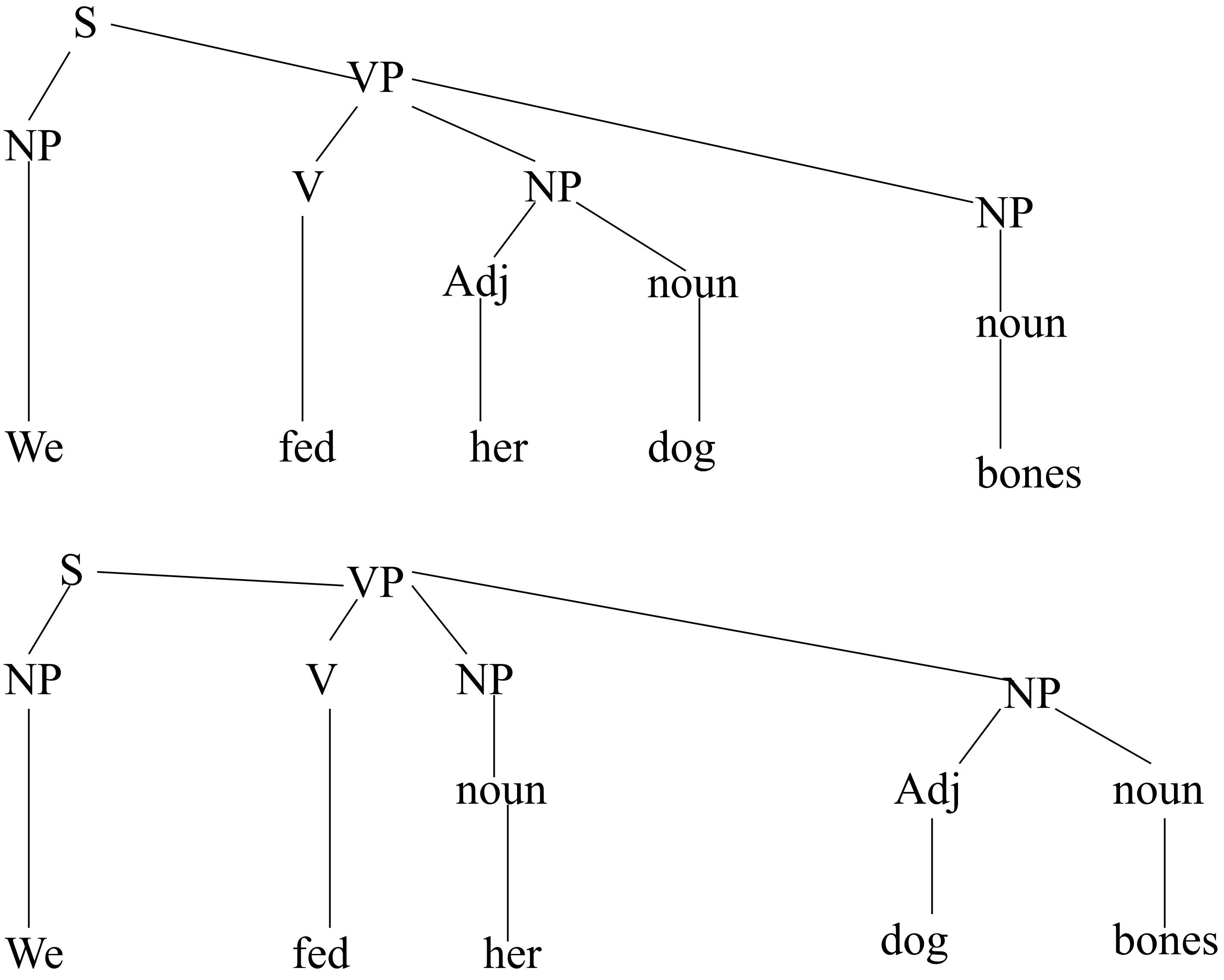
Noun = cat

Noun = mouse

Verb = ate

**Parsing a sentence using simple phrase structure rules**

# Syntactic Ambiguity:  We fed her dog bones



# Semantics

- Determining possible meanings of a sentence
  - Interactions among words affect lexico-semantic interpretation
- Capturing meaning of a sentence in a knowledge representation formalism

# Semantic Role Labeling (SRL) Problem

- In a sentence, a verb and its semantic roles form a proposition; the verb can be called the predicate and the roles are known as arguments.
- Given a target verb, the Semantic Role Labeling task is to identify and label each semantic role present in the sentence.

*When Disney offered to pay Mr. Steinberg a premium for his shares, the New York investor didn't demand the company also pay a premium to other shareholders.*

Example roles for the verb "pay", using roles more specific than theta roles:

When [$_{\text{payer}}$ Disney] offered to [$_{\text{V}}$ pay] [$_{\text{recipient}}$ Mr. Steinberg] [$_{\text{money}}$ a premium] for [$_{\text{commodity}}$ his shares], the New York investor …

# Semantic Relation Extraction

Coca-Cola Enterprises, Inc. said its Atlanta Coca-Cola Bottling Co. unit and its CEO, John Smith, is a target of an investigation into alleged antitrust violations in the soft-drink industry by a federal grand jury in Atlanta.

Extracted Relations:

| | | |
|---|---|---|
| Owns | Coca-cola Enterprises, Inc. | Coca-cola Bottling Co. |
| Employs | Coca-cola Enterprises, Inc. | John Smith |
| Location | Coca-cola Bottling Co. | Atlanta |
| Location | federal grand jury | Atlanta |

# Discourse

- determining meaning in texts longer than a sentence

- making connections between component sentences
  - multi-sentence texts are not just concatenated sentences to be interpreted singly
  - Documents may have distinct patterns in different sections: introduction, conclusions, methodology, etc.
  - Text in dialogs has distinct forms according to position in the dialog

- interpretation of later-mentioned entities depends on interpretation of earlier-mentioned entities – ‘anaphora’

# Anaphora (coreference) resolution

- Excerpt from story by Farhad Manjoo of Slate “Siri vs. Google”

> “Google Voice Search isn’t close to realizing that vision, but it’s not impossibly far off either. Huffman points out that Google’s app can already hold very small conversations. It understands pronouns, so if you ask, “Who is Barack Obama?” and then ask, “Who is his wife?”, it knows that his refers to Obama. And most important, it gives you the correct answer.
>
> I just tried the same set of queries with Siri. First, she correctly identified the president. But when I asked, “Who is his wife?” she shot back, “What is your wife’s name?” That’s not what I asked. Actually, it’s really, really far off. And there aren’t any signs that Apple’s voice assistant is going to get much closer any time soon.”

# Anaphora (coreference) resolution

The city councilors refused the demonstrators a permit because **they** feared violence.

The city councilors refused the demonstrators a permit because **they** advocated revolution.

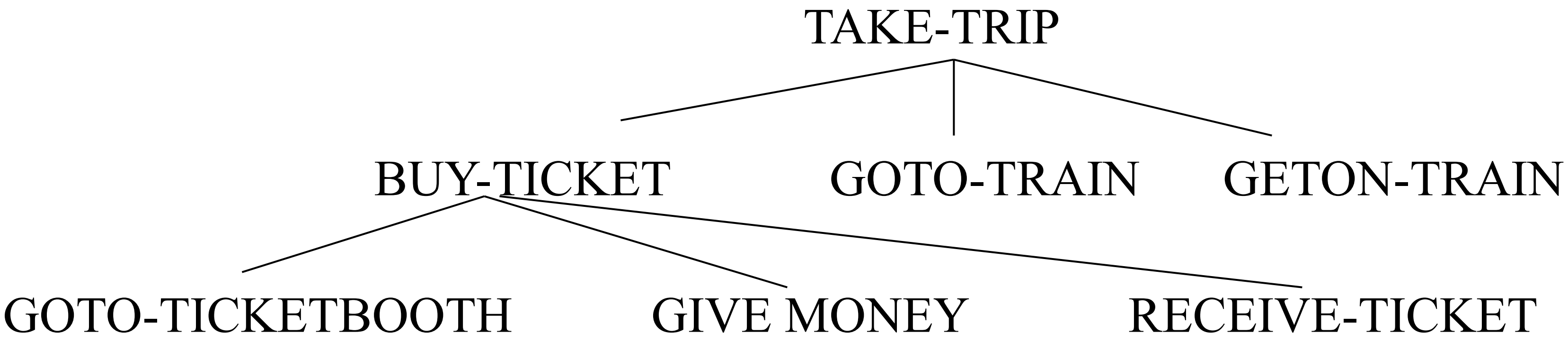
# Pragmatics

- The purposeful use of language in situations
  - A functional perspective

- Those aspects of language which require context for understanding

- Goal is to explain how extra meaning is *read into* texts without actually being encoded in them

- Requires much world knowledge
  - Understanding of intentions / plans / goals



TAKE-TRIP

BUY-TICKET

GOTO-TRAIN

GETON-TRAIN

GOTO-TICKETBOOTH

GIVE MONEY

RECEIVE-TICKET

Sketch of a commonsense task plan to take a trip

# Techniques for NLP Analysis

- Corpus Statistics
  - Frequencies of words
  - Frequencies of word pairs, using co-occurrence or semantic measures
- Classification or other Machine Learning
  - Use NLP to produce features, also known as attributes, of the text
  - Classify the text according to a set of labels
    - Classify customer reviews as positive or negative
    - Classify news articles according to topic