

# Natural Language Processing

# Natural language understanding

Raw speech signal

↓ • **Speech recognition**

Sequence of words spoken

↓ • **Syntactic analysis** using knowledge of the grammar

Structure of the sentence

↓ • **Semantic analysis** using info. about meaning of words

Partial representation of meaning of sentence

↓ • **Pragmatic analysis** using info. about context

Final representation of meaning of sentence

# Natural Language Understanding

**Input/Output data**

**Processing stage**

**Others**

*Frequency spectrogram*



*Word sequence*

"He loves Mary"

*Sentence structure*



*Partial Meaning*

$\exists x \text{ loves}(x, \text{mary})$

*Sentence meaning*

$\text{loves}(\text{john}, \text{mary})$

speech recognition

freq. of diff.  
sounds

syntactic analysis

grammar of  
language

semantic analysis

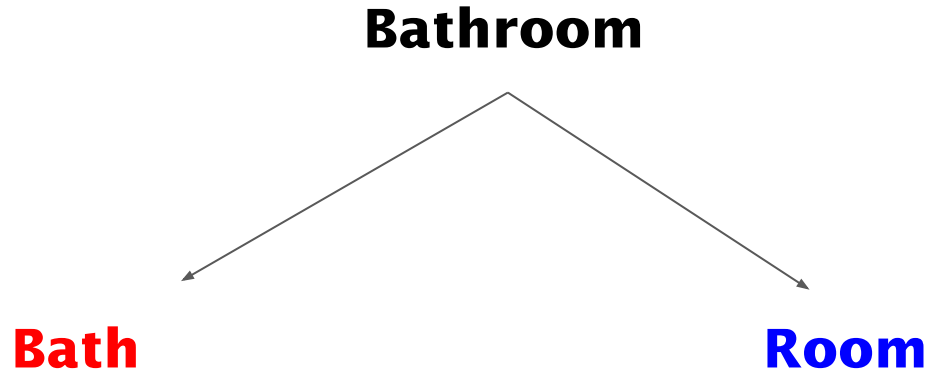
meanings of  
words

pragmatics

context of  
utterance

# Morphology

- The study of meaningful components of words.
  - It is the smallest meaningful units in a language.



# Syntax

- The study of structural relationships among words

The boy is playing football in the field.

The/DT boy/NN is/VBZ playing/VBG football/NN  
in/IN the/DT field/NN

# Lexical semantics

- The study of word meaning

- Open

- Close

- .....

# Compositional semantics

- The study of the meaning of sentences
  - The boy is playing football in the field.
  - Ravi closed the door.
  - .....

# Pragmatics

- The study of the use of language to accomplish goals
  - Lift your arm
  - Where is your shoe?



# Discourse

- The study of conventions of dialogue
  - Satya started an export business in 2010. After five years he started another business.
  - Satya started an export business in 2010. After **five years** **he** started **another business**.

# Language Understanding

**Lexical Analysis** – It involves identifying and analyzing the structure of words. Lexicon of a language means the collection of words and phrases in a language. Lexical analysis is dividing the whole chunk of txt into paragraphs, sentences, and words.

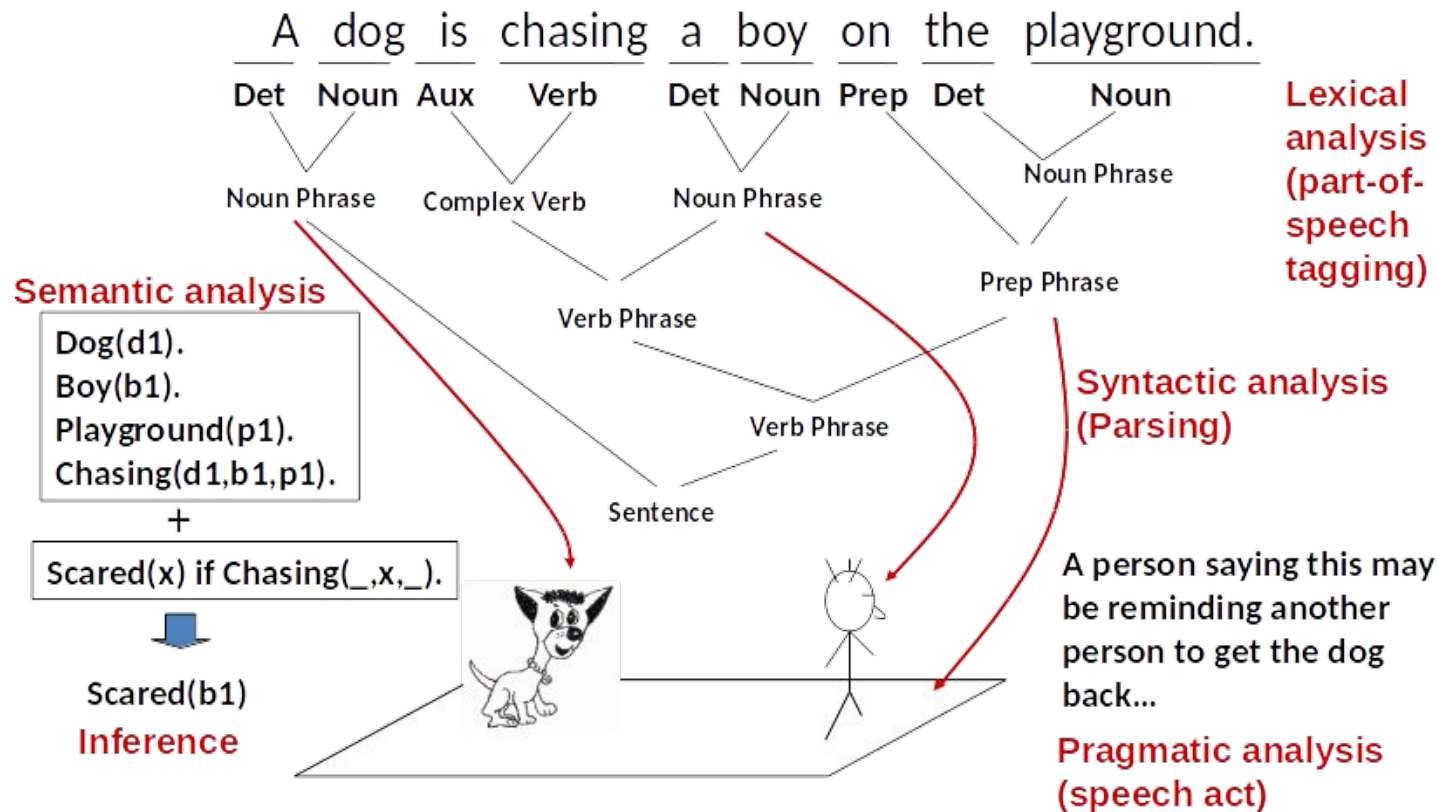
**Syntactic Analysis (Parsing)** – It involves analysis of words in the sentence for grammar and arranging words in a manner that shows the relationship among the words. The sentence such as “The school goes to boy” is rejected by English syntactic analyzer.

**Semantic Analysis** – It draws the exact meaning or the dictionary meaning from the text. The text is checked for meaningfulness. It is done by mapping syntactic structures and objects in the task domain. The semantic analyzer disregards sentence such as “hot ice-cream”.

**Discourse Integration** – The meaning of any sentence depends upon the meaning of the sentence just before it. In addition, it also brings about the meaning of immediately succeeding sentence.

**Pragmatic Analysis** – During this, what was said is re-interpreted on what it actually meant. It involves deriving those aspects of language which require real world knowledge.

# An example of NLP



# NLP hard

- Natural Language is:
  - Ambiguous
  - complex and subtle use of context to convey meaning
  - fuzzy, probabilistic
  - involves reasoning about the world
- But NLP can also be surprisingly easy
  - sometimes rough text features can often do half the job

# NLP hard

- Language is a complex social process
- Tremendous ambiguity at every level of representation
- Modeling it is **AI-complete** (requires first solving general AI)

# NLP hard

- Speech acts (“can you pass the salt?”)
- Conversational implicature (“The opera singer was amazing; she sang all of the notes”).
- Shared knowledge (“Modi is running for election”)
- Variation/Indexicality (“This homework is wicked hard”)

# Ambiguity

- Meaning
- Different ways to interpret sentence
- Interpreting pronouns
- Basing on context



# Ambiguity

- *One morning I shot an elephant in my pajamas*



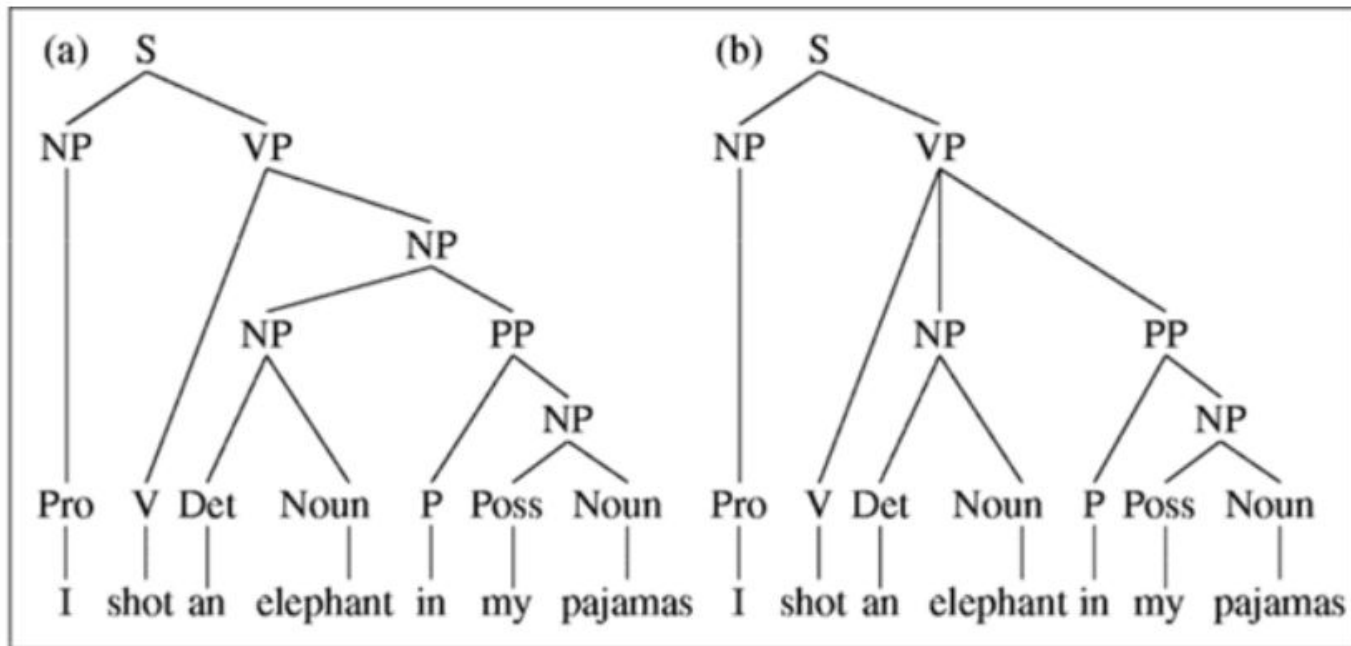
# Ambiguity

- *One morning I shot an elephant in my pajamas*

- ❖ *One morning I shot an elephant in my pajamas*
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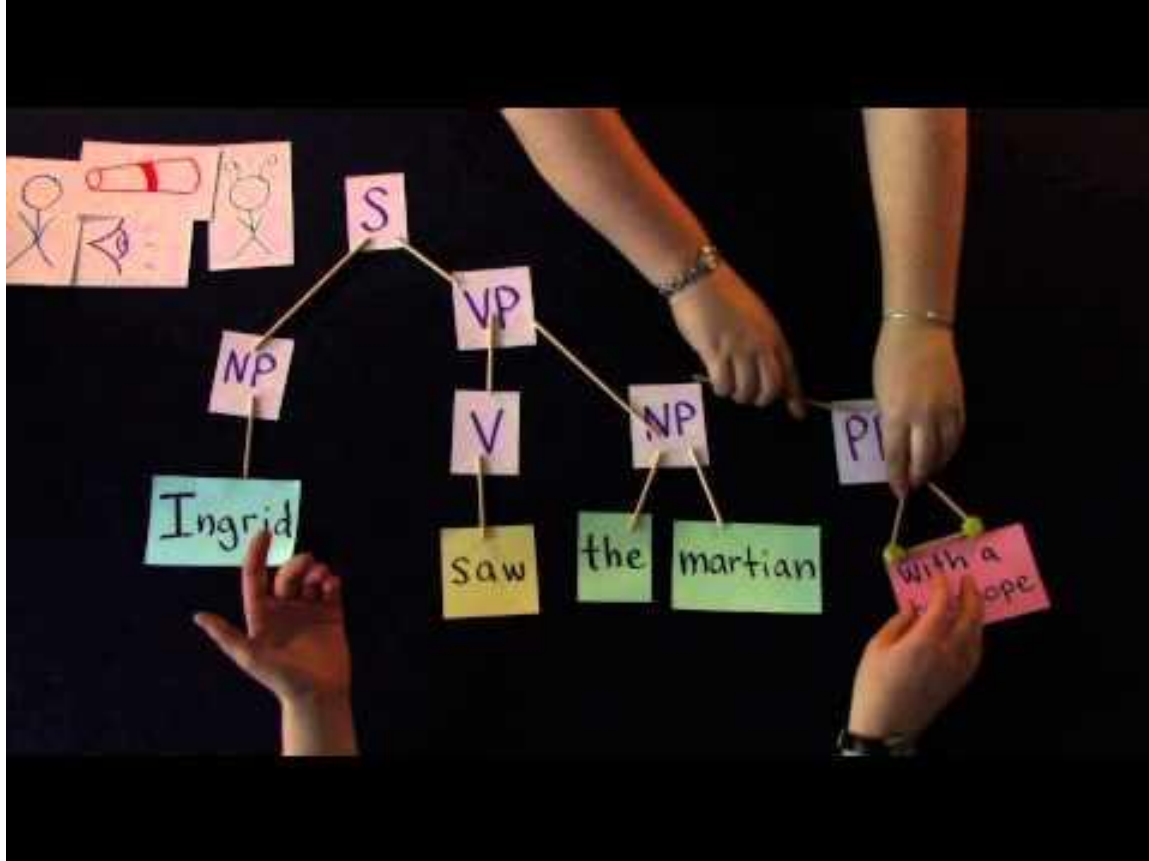
# Ambiguity

- *One morning I shot an elephant in my pajamas*



**Figure 10.11** Two parse trees for an ambiguous sentence. Parse (a) corresponds to the humorous reading in which the elephant is in the pajamas, parse (b) to the reading in which Captain Spaulding did the shooting in his pajamas.

# Ambiguity



# Ambiguity

**I made her duck.**

I cooked duck for her.

I cooked duck belonging to her.

I created a toy duck which she owns.

I caused her to quickly lower her head or body.

I used magic and turned her into a duck.

# Ambiguity



# Ambiguity: Word(Lexical Ambiguity)

- ball, board, plant, tank, bank, pen, fast, bat, cricket etc.
  - The **tank** was full of water.
  - I saw a military **tank**.

# Ambiguity: Word(Lexical Ambiguity)

- She bagged two **silver** medals. [Noun]
- She made a **silver** speech. [Adjective]
- The man's hair **silvered** very attractively. [Verb]



# Ambiguity

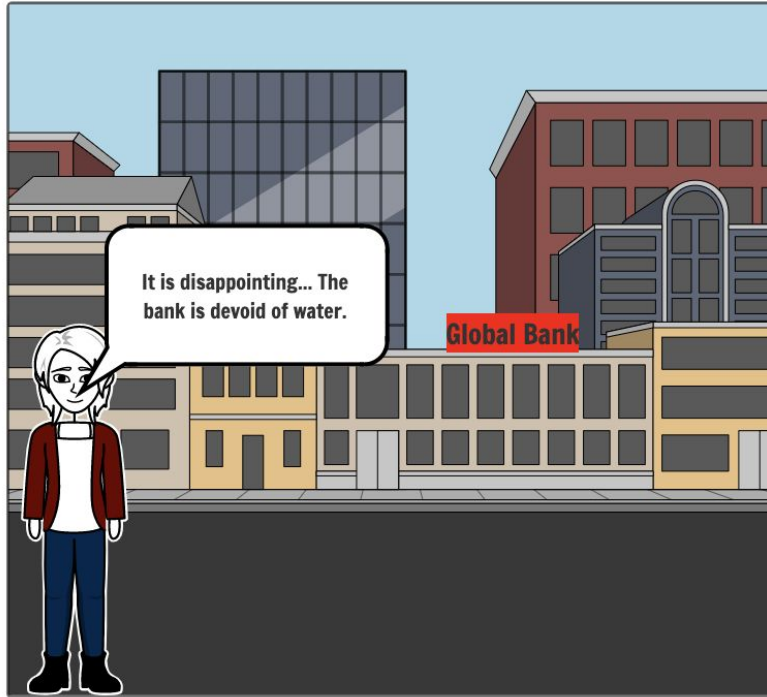
Light

*Bring a light for me*



# Ambiguity

## Bank



# **Ambiguity:** Word Sense Disambiguation

Understanding the sense of a word based on it's context:

E.g. I am going to withdraw money from the bank.

The fisherman is sleeping at the bank.

The security is sleeping at the bank.

## **Knowledge Based Approaches**

Rely on knowledge resources like WordNet, Thesaurus etc. May use grammar rules for disambiguation.

May use hand coded rules for disambiguation.

# Ambiguity: Word Sense Disambiguation



# **Ambiguity:** Word Sense Disambiguation

## **Machine Learning Based Approaches**

- Rely on corpus evidence.

- Train a model using tagged or untagged corpus.

- Probabilistic/Statistical models.

## **Hybrid Approaches**

- Use corpus evidence as well as semantic relations from WordNet.

# **Ambiguity:** Referential Ambiguity

Very often a text mentions an entity (someone/something), and then refers to it again, possibly in a different sentence, using another word.

Pronoun causing ambiguity when it is not clear which noun it is referring to.

Examples:

Navin met Hari and Kusum. They went to restaurant [Hari and Kusum or all of them?]

Jay met Venu before he went to store [ is he Jay or Venu?]

# Ambiguity: Incomplete sentence

Incomplete sentence where missing item is not clear

Example:

"Navin worked hard and passed the exam. Nayan too" Three possible interpretations of this example are

- Nayan worked hard
- Nayan passed the exam
- Nayan did both

# Ambiguity: Attachment ambiguity

San Jose cops kill man with knife

Text

Paper

Translate

Listen

Close

## San Jose cops kill man with knife

Ex-college football player, 23, shot 9 times allegedly charged police at fiancée's home

By Hamed Aleaziz and Vivian Ho

A man fatally shot by San Jose police officers while allegedly charging at them with a knife was a 23-year-old former football player at De Anza College in Cupertino who was distraught and depressed, his family said

Thursday

Police officials said two officers opened fire Wednesday afternoon on Phillip Watkins outside his fiancée's home because they feared for their lives. The officers had been drawn to the home, officials said, by a 911 call reporting an armed home invasion

that, it turned out, had been made by Watkins himself. But the mother of Watkins' fiancée, who also lives in the home on the 1300 block of Sherman Street, said she witnessed the shooting and described it as excessive. Faye Buchanan said the confrontation happened

shortly after she called a suicide intervention hotline in hopes of getting Watkins medical help.

Watkins' 911 call came in at 5:01 p.m., said Sgt. Heather Randol, a San Jose police spokeswoman. "The caller stated there was a male breaking into his home armed with a knife," Randol said. "The caller also stated he was locked in an upstairs bedroom with his children and request-

ed help from police."

She said Watkins was on the sidewalk in front of the home when two officers got there. He was holding a knife with a 4-inch blade and ran toward the officers in a threatening manner, Randol said.

"Both officers ordered the suspect to stop and drop the knife," Randol said. "The suspect continued to charge the officers with the knife in his hand. Both officers, fear-

ing for their safety and defense of their life, fired at the suspect."

On the police radio, one officer said, "We have a male with a knife. He's walking toward us."

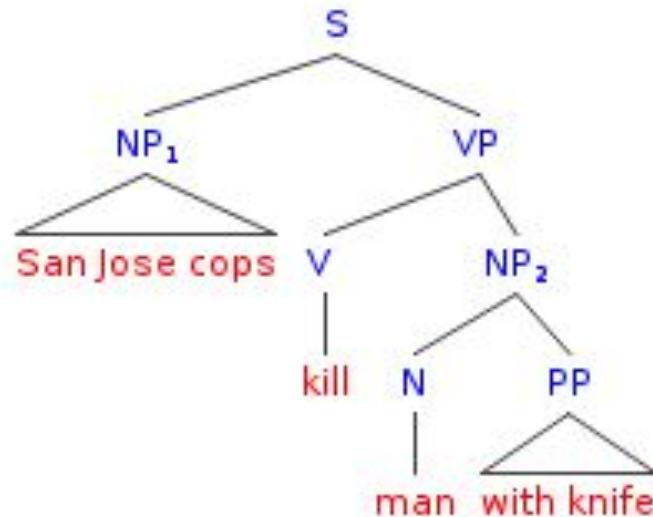
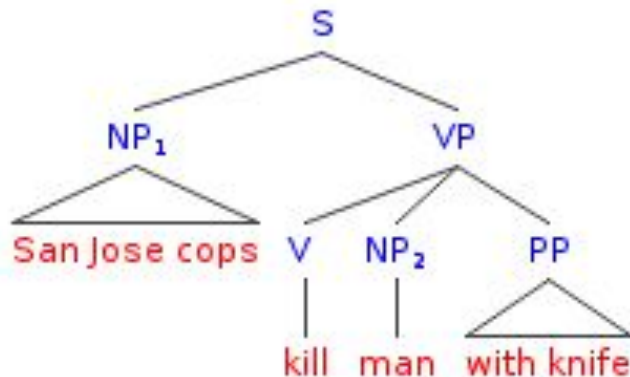
"Shots fired! Shots fired!" an officer said moments later.

A short time later, an officer reported, "Male is down. Knife's still in hand."

Buchanan said she had been prompted to call the

Shoot continues on D8

Back Continue





# Ambiguity: Attachment ambiguity

Ram ate an ice cream with fruits from Chennai

(S (NP Ram)  
 (VP ate  
 (NP an ice cream)  
 (PP with  
 (NP fruits))  
 (PP from  
 (NP Chennai))))

(S (NP Ram)  
 (VP ate  
 (NP an ice cream)  
 (PP with  
 (NP fruits)  
 (PP from  
 (NP Chennai))))))

(S (NP Ram)  
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 (NP an ice cream)  
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 (NP fruits)  
 (PP from  
 (NP Chennai))))))

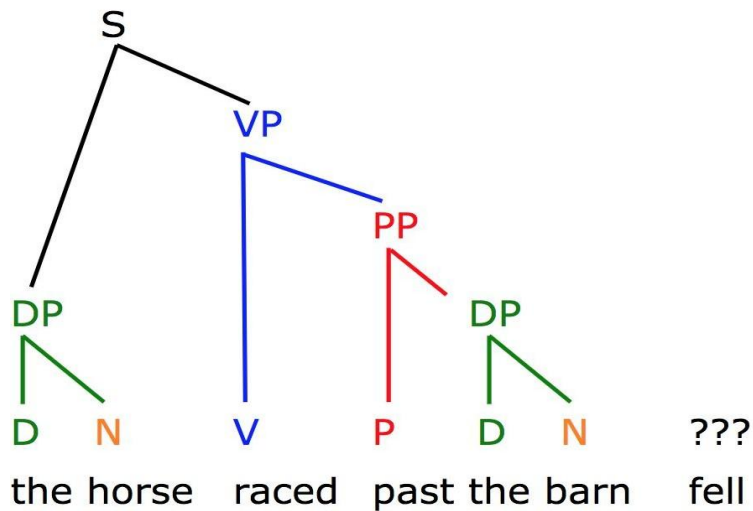
(S (NP Ram)  
 (VP ate  
 (NP an ice cream)  
 (PP with  
 (NP (NP fruits)  
 (PP from  
 (NP Chennai))))))

(S (NP Ram)  
 (VP ate  
 (NP (NP an ice cream)  
 (PP with  
 (NP fruits)))  
 (PP from  
 (NP Chennai))))

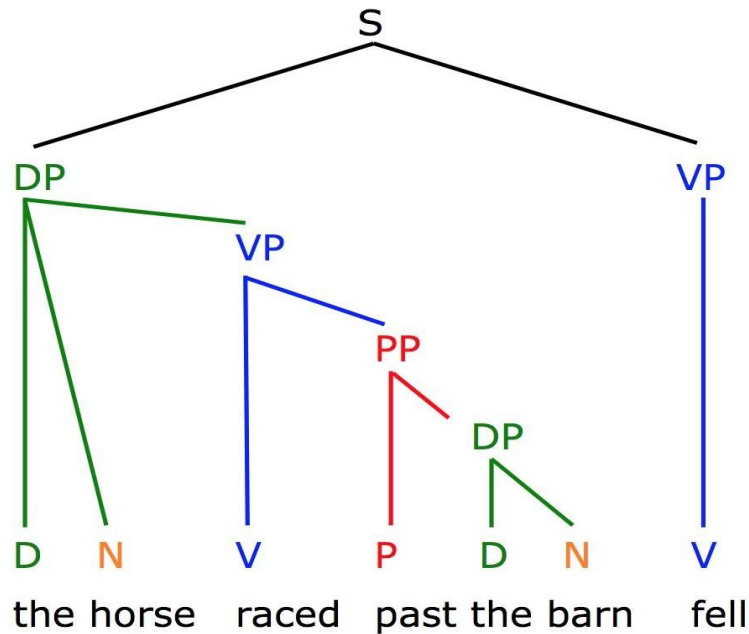
(S (NP Ram)  
 (VP ate  
 (NP (NP an ice cream)  
 (PP with  
 (NP (NP fruits)  
 (PP from  
 (NP Chennai))))))

# Grammatical Structure

The ungrammatical structure



The grammatical structure



# Structural Problems

- Beverly Hills
- Beverly Sills
- The box is in the pen
- The pen is in the box
- Mary and Sue are mothers
- Mary and Sue are sisters
- Every American has a mother
- Every American has a president
- We gave the monkeys the bananas because they were hungry
- We gave the monkeys the bananas because they were over-ripe

# Ambiguity



<https://www.youtube.com/watch?v=ldT2g2qDQnQ>