Phrase trees

PSY 200

Greg Francis

Lecture 26

Dr. Francis says something new!

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Language

- Conveys information
- Allows us to know about things we have never experienced
  - moon flights
  - mating habits of tigers,…
- How do we do it?
- Two key aspects

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Library of Babel

- Library of Babel https://libraryofbabel.info
- Every combination of 3,200 characters (about a page of text)
  - It includes:
    - » Gibberish (mostly)
    - » All songs
    - » All essays (includes those you wrote)
    - » An accurate description of everything you will ever do
    - » A proof that P=NP (if it exists)
    - » Lies about you and your mother
- Grammatically corrects phrases are small subset of the possibilities

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Library of Babel

- Example texts

Symbols and grammar

- Symbols
  - words are arbitrary
  - the sound “dog” has nothing to do with dogs
  - compare driving on parkway to parking on driveway, blueberries and cranberries, hamburger…
- Grammar
  - the order of words matters
  - Dog bites man. vs. Man bites dog.

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Grammar

- Discrete combinatorial system
  - combinations of words
- How many combinations?
- Grammatically corrects phrases are small subset of the possibilities
  - Even so, it allows you to communicate almost *everything*
- If interrupted in the middle of a sentence, you have (approximately) 10 choices for the next word
- If sentences average around 20 words, that means there are around 10^20 unique sentences

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Grammar

- But in fact, there are infinitely many different sentences
  - there is no limit to how long a sentence can be
- For any sentence I give you, you can always make it longer by adding something like
  - Professor Francis said that, "…."

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Vastness

- It is amazing how powerful language is
- You have probably never heard the following sentence
  - moreover, it is probably its first utterance in human history, but you understand it anyhow

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Grammar

- You not only understand language, you *sense* when a sentence is ungrammatical
  - Is raining.
  - The child seems sleeping.
  - Sally poured the glass with water.
  - It's a flying finches, they are.
  - Rarely is the question asked: Is our children learning? (a joking George W. Bush)

Sometimes you still understand what was meant!

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Grammar

- You can also have sentences without meaning that are perceived as grammatical
  - Colorless green ideas sleep furiously.
  - If we don't succeed, we run the risk of failure. (a not joking Dan Quayle)
  - 'Twas brillig, and the slithy toves
    Did gyre and gimble in the wabe:
    All mimsy were the borogoves,
    And the mome raths outgrabe.

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Grammar

- These properties of language suggest that your knowledge about language grammar is a basic component of language systems
- It is *distinct* from both meaning and understanding
- Much of linguistics explores the rules of language
  - we are interested in how people perceive grammar
  - this is different from the grammar rules you may have learned in school!
    - » Which often focus on forming sentences that are *easy* to understand

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Modern linguistics

- Noam Chomsky used the properties of grammar to demonstrate that language is quite different from other types of learning that might occur
  - it's not like learning to play a piano
  - or learning about statistical regularities in the environment (stimulus-response)

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Nonsense sentences

- Think about the sentence
  - Colorless green ideas sleep furiously.
- What is the probability that in normal life you would hear the word "green" follow the word "colorless"?
  - it must be close to zero
- But we recognize it as a grammatically correct sentence!

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Statistics

- If you just learned the statistical combinations of words, you might think something like this was a grammatical sentence

> House to ask for is to earn our living by working towards a goal for his team in old New York was a wonderful place wasn't it even pleasant to talk about and laugh hard when he tells lies he should not tell me the reason why you are is evident

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Statistics

- The previous paragraph creates coherent groups of 4 words at a time (generator made sure 4 words were with high probability)
- Maybe by including a larger number of words grouped together you can insure that every sentence is appropriate
- Actually you cannot
  - Because sentences have no maximum length

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Long-term dependencies

- Language has rules that determine what types of words can be used and when
- A word choice early in a sentence can have an effect at the end of a sentence

How Ann Salisbury can claim that Pam Dawber's anger **at not receiving** her fair share of **acclaim** for Mork and Mindy's success derives from a fragile ego *escapes* me.

1) "at not receiving" --> noun "acclaim"
2) "anger" --> "derives" (singular)
3) "How" --> "escapes" (number)

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Long-term dependencies

- Chomsky demonstrated that long term dependencies can be *very* long
  - Consider "If…then…" and "Either…or…" sentences

If the girl eats ice cream, then the boy eats hot dogs.

Either the girl eats ice cream, or the boy eats hot dogs.

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Recursion

- In fact, *any* sentence can go inside the "if…then" part of a sentence
  - embed a sentence in a sentence
- Thus the following is a (ugly) valid sentence

Either if the girl eats ice cream, then the boy eats ice cream, or if the girl eats ice cream then the boy eats candy.

  - recursion cannot be learned by statistics, it has to be based on rules

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Phrases

- Every sentence is built out of phrases

The happy boy eats candy.

The first three words form a unit called a noun phrase (NP)

The happy boy

What identifies a noun phrase?

This is *not* the same analysis you did in grammar school!

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Phrases

- *All* noun phrases obey certain rules
  - *rewrite rules*

    NP-->(det)A*N
  - *NP -- noun phrase*
  - *det -- determinant: "the", "a", "an"*
  - *A -- adjective*
  - *N -- noun*
  - *( ) -- optional*
  - ** -- as many as you want*

the happy boy

the boy

John

the tall slender woman

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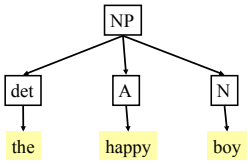
Phrase tree

- It helps to describe rules as phrase trees
- Specifies both *what* can be used in the phrase and *where* it must be used



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Phrases

- Similarly, there are rules for all sorts of phrases in a language
- There may be many ways to rewrite a phrase!

S-->NP VP

VP-->V NP

S -- sentence
NP -- noun phrase
VP -- verb phrase

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Lexicon

- We also need a mental dictionary (lexicon) that specifies parts of speech
  - N --> boy, girl, candy, hot dogs, ice cream,…
  - V --> eats, likes, bites,…
  - det --> a, the, one,…
  - A --> lucky, tall,...

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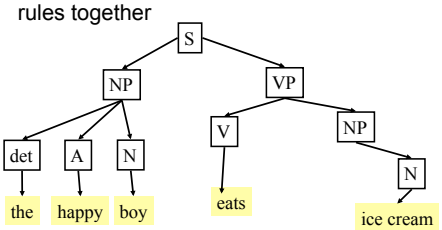
Phrase tree

- With rewrite rules and a mental dictionary, you can create a sentence by linking the rules together



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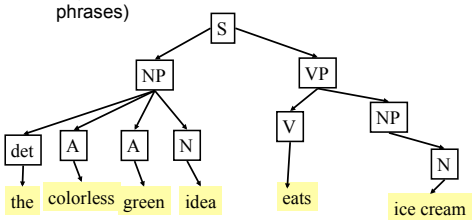
Sockets

- In a phrase tree, a phrase is like a component that snaps into the right place
  - any appropriate phrase works! (even nonsense phrases)



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Usefulness

- It is important to appreciate how the phrase tree approach simplifies the description of language
- Consider how we learn a new word and know how to use it
- If you learn that a word is a noun, you can *immediately* use that noun in many different ways

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Learning phrases

- You do not have to relearn the role of the word "boy" for each use

The *boy* eats candy.

I like the happy *boy.*

I gave the new *boy* a cookie.

The happy *boy*' s cat eats candy.

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Long term dependencies

- Phrase trees have no problems with long-term dependencies and recursion
- The rewrite rules provide the *structure* needed to insure the right if-then combination

S--> either S or S

S--> if S then S

S -- sentence
either -- the word "either"
or -- the word "or"
if -- the word "if"
then -- the word "then"

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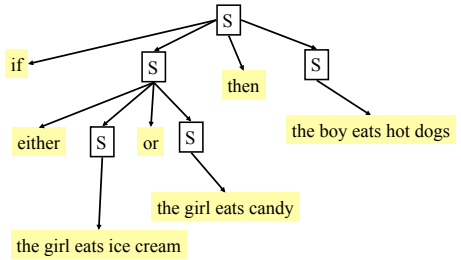
Phrase tree

- A phrase tree can handle this type of sentence



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Significance

- Rules and phrase trees allow us to identify fundamental characteristics about how humans communicate
- Consider all the ways you might communicate
  - Morse code, 0-1' s, English, Spanish, tapping toes, beeps,..
  - an infinite number of ways to create a language

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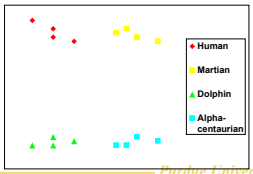
Language similarity

- *All* human languages are **very** similar, compared to the possibilities
- In some sort of *language space* all our 6000 languages are clustered together



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Language universals

- There are several types of universals
- For example, in English the normal pattern of sentences is
  - Subject-Verb-Object
  - (There are exceptions: "*A bear he shot.*")
- This pattern is true for most of the world's languages
  - 98% of languages have the Subject before the Object (the Verb location varies across languages)
  - 80% of languages have the Subject before the Verb (the Object location varies across languages)

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Language universals

- Most language universals involve a co-appearance of linguistic features
- For example, if a language's preferred word order is Subject-Object-Verb
  - the language is likely to form questions by adding some words at the *end* of the question
- If a language's preferred word order is Subject-Verb-Object (like English)
  - the language is likely to form questions by adding some words at the *beginning* of the question
  - "Where did he…?", "When did they…?"

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Conclusions

- Language consists of
  - symbols (words)
  - grammar (rules)
- Language is best described as phrase trees
  - explains long term dependencies
- Language universals

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Next time

- Words
- Mental lexicon
- Morphology
- Structure
- CogLab on Word superiority due!

- *What is the plural of "walkman"?*

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