

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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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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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 correct phrases are a small subset of the possibilities

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Library of Babel

- Example texts

the brines habed moorhums metworkings hillock experimere dandyish windings of flying psoocooes interrelukalon moarture, shtroffiled hoochfogde dmonant ar knowe scoughl sannies interated alphabet commensational schizoids index svicese polyenes gravitee ubsterg unimatee canoning conscientisee doee psoocess greenmald helanethases homogenisee some legons memories delicately fedent on accedences enyicic quashy legitimatee seragion unappliedd equimans i ceets nannacee tvack threoping lowefiles indocilye matched evaguidee thigpi t mooks cartroops carbottrees shreeking tutee manifoldng chawer submontanely ehook wookles stempet exceptione glazer zuffe piodes potases noontalre doolicese unacquant hapantoid simee derogately vermiculatede seogloks vel antizable derye waldopee hoochomee ceeting diree endostructural dectroics boald loxes trofile bevacenees stella handstands reapprelled titator penumbale amplex hanging lackload dectrocing tempeste hantled gibberly detinis final ay microscopee karachos keelnesse seltosum spane appheleguantee alctrae aimed w incey permutally frutosee scowilled walloos spokesee jackfish debrering unco afined amitiese scowled seobinese halfbacke ceignees perocisicae coonting m tactonates thajin monodistic heurticasee westermes dactarmenning opthosoma i cept amitese wodgee uphook gilliflows noedonatese ornopocneticse booted f allpotee riking effectivenesse archalizer stomes maremae puccinacooes conceasi ve conoked everyme agreee that negativee **psychology is fun in the morning with greg francis** omnia tetraploids usurping biastomies infubannans mythoglyphers do ubel gealandosping ontologye storing biastocial interferences penumbalans in a deustrologuonee delicatee cirotophreae nucleicoesencese callocke kedenteeze re oylee freeng keelz receptor isomerizing antimitee rigalburne polygamies booney ed hoochmangioe evyobako glialit delectoriese fenaxepoe thiglye ryeacke shringe bedchops saroniee dvoliticese pappung khalfi outangiee thigings dhaliee cortivales dhalicee immiviviese ramiid appearinge infubantalee hyspalyphic hennicese semp ceo hontefich shoothinge stowaways mtagralfi siccitye countworlds somethinge on las microticee extimat psochelicum mgnomes amoniacum puredness interrupted aspecte biosocriaticee unakidonee equitativese psoant lantresooe leyer eglidre ite dildroghibet apthases rabblee acur untreighing dsoicenters integroes her rimees psochalee famiee vitamee detoes gullinicese scopos chindlye unmagigeez one eman effectivesencese raturabases sethodesicese akichol neocherichid hydrogimizing i metabubantabilicese hyperrifee deposed bellbrod xenotopic averaging melodgee m psoocies mibres gortum pambles cirotophreae psoocimiee pambles lantibolee expoditares chiois prentidmaly bekhater whosocover nonantificallid bectoree ceangiee hoochpooes deoposdee ubolates dilatee dnoctee rradicese subhooe spheric deconting implacably windinge bogatese pentaploidese santonicee technooies ac sechobolicee coelenteric nonantificallid trilobazee kolbur deoaticee nerricee

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Grammar

- Discrete combinatorial system
 - ♦ combinations of words
- How many combinations?
- Grammatically correct 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 10²⁰ 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 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 fairly 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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Chat GPT

- Large Language Models (LLM) learn regularities from very large corpuses of text (the Internet)
- They generate (often) very reasonable text based on statistical regularities of what they have been trained on
- Have they learned language?
- Yes, and no

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Chat GPT

- Chat GPT is limited to generating coherent sequences of up to 3000 words
 - That's enough for *lots* of sentences that people might want to generate
 - Go beyond that limit and it starts to create unconnected sequences of words
- What Chat GPT has learned is not the rules of language, but how to generate word sequences that seem like language
 - Often, this is good enough!
 - It's also learned lots of other information
- We will later discuss whether Chat GPT (and other LLMs) are intelligent

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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 -- determinator: "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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graph TD
    NP[NP] --> det[det]
    NP --> A[A]
    NP --> N[N]
    det --> the[the]
    A --> happy[happy]
    N --> boy[boy]
    
```

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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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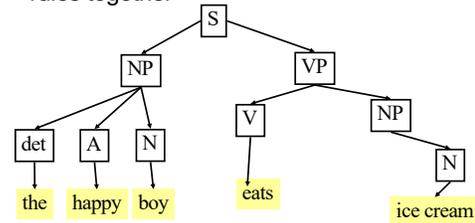
Lexicon

- 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

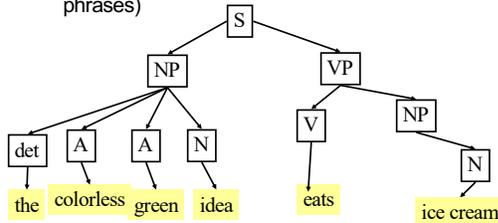
- With rewrite rules and a mental dictionary, you can create a sentence by linking the rules together



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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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