Natural Language

• Communication: limited to specific messages
  – Bee dance
  – Bird calls

• Natural language (only humans?)
  – Discrete: Can be divided into components
  – Arbitrary: Words don’t resemble their meaning
  – Regular: Governed by a set of rules (grammar)
  – Productive: Novel combinations of words

• Attempts to teach language to animals
  – Spontaneous use and combination of symbols
    • Limited in number (never as good as 3 year old)
    • Never create new ones

• Feral children and Romanian orphans
  – Developmental window for language
Speech Components

• **Phonemes (phonetics and phonology)**
  – Sound units that distinguish between words

• **Morphemes (morphology)**
  – The smallest unit that is meaningful on its own

• **Lexicon**
  – Collection of all words in a given language (not meaning)
    • How to build words out of morphemes

• **Syntax (subset of grammar)**
  – Allowable combinations of words
  – A Grammar is all the rules that govern how a language works

• **Prosody (rhythm and pitch cues)**

• **Pragmatics (social conventions in speech)**
  – “do you know the time?”
The strangers talked to the players
Phones and Phonemes

- Phones (different speech sounds)
- Vowels
  - Don’t obstruct airflow
  - Shape and position of tongue
  - Voiced (Vibration of vocal chords)
- Consonants
  - Closing of mouth
  - Voicing ([f] vs. [v] or [z] vs. [s])
  - Manner of articulation
    - air through mouth [f] vs. nasal cavity [m]
    - air fully stopped [b] vs. restricted [z]
  - Place of articulation
    - bilabial: [b], [p] lips closed
    - labiodental: [f], [v]
    - Alveolar: [t], [d]
- Allophones
  - A set of phones corresponding to same phoneme
    - /p/ is [pʰ] in “pin” but [p] in “spin”
    - /r/ and /l/ in east Asian languages
Speech Segmentation

• Word and phoneme boundaries are illusory
  – speech is continuous
• Tremendous variability in phonemes
  – coarticulation (preparing for the next sound)
    • phonemes differ with different words and subsequent words
  – phonemes also differ with
    • talkers (male/female, native/non-native)
    • contexts (shouting, whispering)
    • accents
    • prosody
    • emotional states
    • rates of speech
Categorical Perception

• Phonemes are identified in an all-or-none manner
  – e.g., VOT for bilabial stop consonant (/b/ or /p/)
• Other animals have categorical perception
  – category boundaries defined by acoustics
• Learning can eliminate category boundaries
  – e.g., Japanese infants have cat. per. for /r/ vs. /l/
Phonology
(the rules for combining phonemes)

• Every language has different rules for allowable combinations of phonemes
  – can’t have [tl] in the same syllable
  – can have [tl] across syllables (e.g., “sweetly”)
  – plural is /s/ after /p/, /t/, /k/, /f/ otherwise /z/

• Other languages may allow these combinations
  – these rules don’t exist because of anatomical pronunciation difficulties
Sensory Integration
(vision and hearing)

- Massaro and Cohen (1983) demonstrated that we use visual information to interpret speech
  - McGurk effect (McGurk, 1976)
  - categorical perception for /b/ versus /d/
    - differ in the place of articulation
  - Sound: computer-synthesized speech from /b/ to /d/
  - Vision: watched a synchronized video of a talker saying /b/ or /d/
    - they didn’t realize there was a mismatch
    - what was “heard” was changed by what was seen
  - McGurk demo
  - Hearing can cause you to see things too
The Sound of a Word is Ambiguous

• Pollack and Picket (1964)
  – Spliced out words from conversations
    • Easily identified in sentence
    • Only 50% identified in isolation

• Context helps
  – Visual context (McGurk)
  – Sentence context
    • meaning
    • syntax
Phonemic Restoration Effect

• sentence context can cause you to hear things that aren’t there (Warren & Warren, 1970)
  – “The state governors met with the respective legi*latures convening in the capital city”
  – * is 120 ms portion replaced with a cough
  – only 1 of 20 people noticed
• Later parts of the sentence can cause you to “hear” things earlier in the sentence
  – It was found that the *eel was on the axle
  – It was found that the *eel was on the shoe
  – It was found that the *eel was on the orange
  – It was found that the *eel was on the table
    • people reported hearing wheel, heel, peel, or meal
Syntax

“Twas brillig, and the slithy toves did gyre and gimble in the wabe . . .”

- Syntax is descriptive
  - Not prescriptive
- Tree diagram
  - Hierarchical
    - constituents
  - Substitution
    - Still legal
Preposing: SVO vs OSV
(only whole phrases can be moved)
He wants to discuss sex with Jay Leno.
I saw the gorilla in my pajamas.
The shooting of the hunters was terrible.
They are roasting chickens.
Visiting relatives can be awful.
Two computers were reported stolen by the TV announcer.
Garden Path Sentences

- Parsing occurs “on the fly” rather than waiting til the end (minimal attachment vs late closure)
  - The cotton shirts are made from comes from Arizona
  - Fat people eat accumulates
  - The horse raced past the barn fell

One phrase
Because he ran the second mile he was able to finish quickly.

Because he ran the second mile went quickly.

Two phrases
Factors leading down the Garden Path

• People assume active voice
  – The secretary applauded for his efforts was soon promoted

• Meaning matters
  – The detectives examined by the reporter revealed the truth about the robbery
  – The evidence examined by the reporter revealed the truth about the robbery

• Situational context matters
  – Put the apple on the towel into the box
Eye Movements
(attention is typically where the eyes are looking)

• We move our eyes 150,000 to 200,000 times a day
• There are two basic types of eye movements
  – smooth pursuit
    • only when tracking a moving object
  – saccadic
    • rapid jump to an entirely new view (i.e. a saccade)
• During an eye movement, we don’t see much
  – Parts of the visual scene can be changed during eye movements without people noticing

Around the fixation point only four to five letters are seen with 100% acuity.
Saccadic Eye Movements During Reading
(UMass Eyetracking lab)

• On average, move 7 to 9 letters with each saccade
• Perceptual span is the number of letters perceived during fixation while reading
  – Biased to the right (4 left and 15 to the right)
  – Can’t identify a word that lies beyond 8 letters to the right, but can figure out where to move next from spaces between words
• Short words and frequent/expected words are often skipped
• Regressions occur with complicated sentence structures
  – “the horse raced past the barn fell”

Roadside joggers endure sweat, pain and angry drivers in the name of fitness. A healthy body may seem reward...
Fixation Duration

- Factors that increase duration
  - word length
  - word infrequency
  - syntactically anomalous words
  - content words (vs function words)

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Flywheels are one of the oldest mechanical devices known to man. Every internal combustion engine contains a small flywheel that converts the jerky motion of the pistons into the smooth flow of energy that powers the drive shaft.

Neuropsychology of Language
(aphasia = language/speech disorder)

- In 1861, Pierre Paul Broca reported the case of “Tan”
  - normal comprehension, but poor production
  - left frontal lobe
  - Broca’s or expressive aphasia
- In 1874, Carl Wernicke found a different language disorder
  - fluent production, but poor comprehension
  - left temporal-parietal lobe
  - Wernicke’s or receptive aphasia
Semantic vs. Syntactic Anomalies

N400: “He drinks his coffee with cream and dog”

LAN: “He prefers to solve problems herself”
N400 reflect meaning violation
(not just word violation)

Correct: The Dutch trains are yellow and very crowded.
Semantic violation: The Dutch trains are sour and very crowded.
World knowledge violation: The Dutch trains are white and very crowded.
Language and Cognition

- Whorfian hypothesis (Whorf, 1956)
  - Language directs and constrains thought and perception
- Testing the Whorfian hypothesis
  - The Dani only have black (mili) and white (mola) words
    - Rosch (1973) did not find any differences in their color perception
    - Recent evidence finds a color categorical perception effect
  - Other effects of language
    - space/time metaphors
    - active/passive use and accidents