Speech and Language
- purpose?
- a form of communication
- share with animals, vocalizations

The Problems
- speech production
- language comprehension
- language acquisition
- brain and language - neurolinguistics

Language Comprehension
- speech perception
- lexical access
- sentence processing
- discourse processing

Disciplines
- Psychoacoustics
  - Auditory processing
- Speech Perception
  - perception of speech signals
  - factors that affect speech processing
- Speech Production/Pathology
- Linguistics - study of language structure
  - universals - what do ALL/NO languages have?
  - structure of language - human cognition

Human Biological Suitability for Language
- vocal tract - rapid changes
- specialized hemispheric processing
- universal child development acquisition
  - maturational brain changes
  - no formal instruction

Psycholinguistics
- psychological and neuropsychological mechanisms that allow us to produce and comprehend language

Developmental Psycholinguistics
- What aspects of language learned first?
- Which are easy/difficult?
- Necessary components of the learning environment?
- Language acquisition - mind and brain?
Universals
• all humans use language
• complexity
  – all languages comparably complex
• arbitrary mapping from sounds to meaning
  – dog, perro, hund, chien
• discrete specialized signs
• infinite meanings from finite sign/symbol
• shared structure of all languages

Shared Structure
• phonological - sounds of the language
• morphological - conjunctions into words
• syntactic - grammar
• semantic - meaning
• pragmatic - practical aspects of meaning

Speech-Phonology
• Spectrograph
  – x axis time
  – y axis frequency
  – amplitude = intensity

Vocal apparatus
• like a wind and string instrument combined
• parts
  – air passage ways
  – air blocker structures
    • tongue, teeth, lips, nose
  – vocal cords - vibratory mechanism
**Phoneme**

- *(def)* - smallest segment of speech that if changed would change the meaning of the word.

- kinds
  - vowels
  - consonants

**Vowels**

- vocal tract open
- about 13 in English (between 3-46)
- fundamental frequency - *pitch* of the voice
  - resonance of the vocal tract

**Vowels**

- Give rise to formants in speech spectograph

\[
\begin{align*}
\text{frequency} & \quad \text{time} \quad \rightarrow \\
\text{time} & \quad \rightarrow \\
\end{align*}
\]

**Consonants**

- vocal tract closed
- 24 in English (Between 6-95)
- features of consonants
  - voicing
  - place of articulation
  - manner of articulation

**Voicing**

- vocal cords
  - vibrate -> voiced
    - e.g., *z*
  - do not vibrate -> unvoiced
    - e.g., *s, f*
- given voicing -> voice onset time
  - constriction of vocal tract - time - vibration
    - *da, ta, pa*
Place of Articulation
- Where the obstruction occurs
  - \( d, t \) - alveolar
  - \( m, w \) - labial
  - \( f \) - labiodental
  - \( s, z \) - dental
  - \( k \) - velar

Manner of articulation
- stop consonants
  - complete closure
    - e.g., \( ba, ma \)
- fricatives
  - partial closure - narrowing of the vocal tract
    - e.g., \( s, f, z \)

So……
- 13 vowels
- 24 consonants
- 35 sounds...
- Should be easy……

Why speech processing is difficult
- speaking rate
  - 15 phonemes per second - 67ms/phoneme
    - As low as 40 ms
- absence of clear boundaries
  - very little silence - and not at word breaks
  - coarticulation - phonemes very context dependent

- variability:
  - talker
  - context
  - speech type (whispering - all consonants)

- quality of information
  - 50% of words are unintelligible

- sloppiness
  - Jeet yet? = did you eat (jeet) yet?
• noise
  – speech signal is coincident with all other environmental "noise".....
    • contrast vision....
    • analogy to reading........
  – 2 kinds of noise
    • nonspeech sounds
    • other talkers....(challenge for the hearing impaired)

Attention
• ability to select one speech signal from many, and to switch
  – perceptual phenomenology
• Do we process other non-attended speech streams?
  – Cocktail party phenomenon.....
• implication
  – We separate sound sources
  – We monitor unattended sound sources

What is the information?
• The search for invariants.....
  – Are there invariants?
    • invariant something in the speech signal that unambiguously gives the phoneme regardless of speaker and phonemic context
    • as in vision....a feature in the image that unambiguously identifies a chair regardless of view, illumination and object context

Another example - even worse
• When vowels are the same....
  – e.g., da and ta....
  – formant structure is same/similar
  – place of articulation same/similar
  – formant transitions the same...
• How often do you confuse
  – Dad and Tad?
  – dab and tab?
What is the information?
- e.g., categorical perception
  - difference between /da/ and /ta/
    - both start with a vocal tract closure
    - alveolar ridge
    - both end with vowel formant structure
    - VOT
      - 17 ms /da/
      - 91 ms /ta/

How do we “learn” speech
- DeCasper & Spence (80’s)
  - newborn infants recognize their mother’s voice
  - Experience with sound starts pre-natally!
- Kuhl et al 1992
  - Young infants (3-4 months)
    - Perceive phonemic contrasts equally well
  - By about 6-8 months
    - LOSE ability to discriminate non-native language contrasts

Audiovisual speech
- MacDonald & McGurk (78)

Normal lip reading
- Kuhl & Meltzhoff (82)
  - 3-4 month old children paid more attention to videos with lips in sync with the audio
Morphemes

- meaning units of language
  - words and meaningful word components

- lexical access
  - word --> access the "dictionary"
    - turning the phonological/written representation into an "access code"
    - retrieve the meaning

Bill Katz’ Challenge

- Think of a word in English with only 1 meaning…..
  - sofa

Models of Lexical Access

- A dictionary with 3 keys
  - phonemic
  - orthographic
  - semantic

- model types
  - parallel
  - serial

Models

- Serial models
  - Autonomous search model (Forster, 76)
    - keys
      - orthographic
      - phonological
      - semantic
  - like library
    - get to the right shelf…then search

Parallel Models

- Logogen model (Morton, 69)
  - activate word to a threshold
  - logogen is like a scorecard…highest wins
    - pool all possible information
Parallel Models (continued)

• connectionist model (McClelland & Rumelhart, 81)
  – nodes
    • visual feature units
    • letter units
    • word units
    • semantic units
  – connections - excitatory, inhibitory
    • letter combinations that go together…etc.

Syntax

• grammatical class
  – noun, verb, adjective, adverb etc
    • location in brain (Damasio & Damasio, 92)
• rules of order
  – constituent structure
  – hierarchical organization
  – thematic roles

Interaction between lexical access and syntax

Time flies like an arrow

Fruit flies like a banana

Semantics

• Meaning…what is the meaning of meaning?

• Theories
  – reference theories
  – image theories
  – truth conditional semantics

Pragmatics

• Practical aspects of language that lie beyond its linguistic elements
• prosody
  – What are you doing?
  – Well that’s great!
• usage
  – Hi sweetie, what’s up? (recipient)
  – What did you say? (meaning)
  – This creature has an exoskeleton. (appropriateness)
Cooperative Principle (Grice, 75)
- quality - utterances should be true and based on evidence
- quantity - informative as possible but not more than required
- relation - relevant to the goals of the conversation
- manner - clear, unambiguous, and orderly

Kinds of speech acts
- representatives - facts
  - “today is Labor Day”
- directives - commands
  - “Don’t be late!”
- commissives - future action
  - “I will…”
- expressives - psychological state
  - “I’m tired”
- declaratives - change world state
  - “You are fired”

Language & (Thought?)
Byrnes & Gelman (91)
- innate human capacity for language
  - Chomsky
- language and concepts
  - Piaget, etc.
- language & theories of the world
  - Sapir (29) Whorf (56) and others
- language and social interaction
  - Vygotsky

Chomsky
- nativist - language is innate
- language is like an “organ” in the brain
- you don’t learn it….
  - Development …maturation analogy

Language consists of ...
- Deep structures
  - underlying meanings
- Surface structures
  - actual utterances
Grammatical Rules

- Phrase structure rules
  - basic components of the phrase
  - how to combine to embody the deep structure

- Transformational rules
  - modifications that retain deep structure and specify the surface structure
    - Susan gave him the book
    - The book was given to him by Susan

Assumptions

Language & Learning

- grammars - complex rules that determine allowable utterances
  - enormous numbers of utterances possible
  - we cannot memorize all possible sentences

- Despite the complexity of the task, and the low quality input, the process of learning language is fairly uniform across speakers and complete by an astonishing age = 4 yrs.
  - Note = difference between unstructured learning input and highly structured syntax elements that we acquire

Chomsky’s Conclusions

- Children receive impoverished input
  - errors, slippage, laziness
  - knowledge > stimulus we have to learn with
  - Therefore, children could not induce the structure of language from the stimulus using general learning principles

- Children have “inborn” outline of what language will be like that guides them in learning

- Language develops - like any other organ, liver or visual system
Language and Concepts—Piaget

- interaction between conceptual structure and language
  - Language is a window into the mind.…
- language maps onto complex conceptual structure - understanding co-dependent
- 3 points in development where language may play a role

3 points in development

(language always minor factor)

- transition
  - from sensorimotor intelligence
    - action, perception, here and now
  - to representational intelligence
    - evoke absent situations, memory, imagination and future situations and plans

- transition
  - from preoperational thinking
  - to concrete operations
  - 7-8 years (logic of classes, relations)
  - linguistic advances (prediction, negation, inflection)

- transition
  - from concrete operations
  - to formal operations
  - language provides a necessary but not sufficient set of prerequisites for propositional logic

Language and Theory of Mind

- Sapir (1929) and Whorf (1956)
  - Language (grammatical categories) construct implicit theories of the world
    - Ontology, causality domains (Wellman, 90)
- Child as “theoretician”
  - current developmental work

Whorf (56)

- Linguistic relativity
  - Structural differences between language systems will be paralleled by non-linguistic cognitive differences between the speakers of two languages (Brown, 76)
- Linguistic determinism
  - The structure of anyone’s language strongly influences or fully determines the world view he will acquire as he learns the language. (Brown, 76)
Current

- Extreme view
  - No one believes…

- Though linguistic constraints can help to redirect attention to different kinds of taxonomies as we learn and to deal with exceptions

Language and Social Interaction

Vygotsky

- role of input and social exchange

- Piaget & Vygotsky agree
  - egocentric and communicative speech
  - egocentric decreases between 3-7 years
  - grammar precedes logic ("that is a girl!")
  - language & thought distinct representations

Vygotsky

- Language and thought distinct origins

- At 2 years of age - they converge
  - thought becomes verbal
  - speech becomes rational

- Overlap of speech and thought
  - verbal thought

Vygotsky

- Speech is social from the beginning…

- Even egocentric speech…which declines without others present

- For Piaget speech becomes more social as the child gets older