Language

Computational Cognitive Neuroscience
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Language Involves all of Cognition

Perception: hearing & reading words
Attention: picking out words, speakers from many
Motor: speech, writing, etc
Memory: semantics, specific content -- how do you encode plot of a book?
Executive Function: maintaining context, planning speech, syntax structure...

Language is Special

- Symbols
- Syntax
- Temporally-extended sequences
- Cultural transmission
- Embedded levels of structure:
  - "The horse raced past the barn fell"
  - "Isn't it true that example-sentences that people that you know produce are more likely to be accepted?"

Language Controversies

- How special is language: just co-opting existing neural mechs vs. innate language modules?
- Rules vs. regularities: is there anything special about rule-like behavior in language?
  - Spelling to sound: Exceptions also have sub-rules...
  - Overregularization (add "-ed" = "goed") -- evidence of rule system coming online?
  - Truly variable-like behavior? Generative, abstract.

What is Truly Novel?

- Pure syntax: "Adj Adj Noun Verb Adverb"
- "Colorless green ideas sleep furiously"
  - But: "Newly formed bland ideas are inexpressible in an infurinating way."
  - "It can only be the thought of venture to come, which prompts us in the autumn to buy these dormant white lumps of vegetable matter covered by a brown papery skin, and lovingly to plant them and care for them. It is a marvel to me that under this cover they are labouring unseen at such a rate within to give us the sudden awesome beauty of spring flowering bulbs. While winter reigns the earth repose but these colourless ideas sleep furiously."
- "'Twas brillig, and the slithy toves.."
  - But each word has some overlap with real words..

Time and Language

- Distributed representation broken down and sent over a sequential channel:
  - The summer is a fun time for going to the beach, dancing, ...
Distributed Reps of Words

I can't believe that I used to wear a t-shirt that read 'I could actually use that in the right place'. The rest can be a total mess and you can still read it without a problem. This is because the human mind does not read every letter by itself, but the word as a whole. Aaamig, huh? Yes, and I always spell things was important! See if your friends can read this too.

Biology of Language

Acquired Dyslexia

- **Phonological**: nonword ("nust") errors
- **Deep**: phon + semantic errors ("dog" -> "cat") + visual errors ("dog" -> "dot")
- **Surface**: exception ("yacht") errors + visual errors + impaired semantic access

Reading: The “Triangle Model”

NOTE: There is no single "lexicon", no "word units"
Regularities & Exceptions

- Pronounce "bint"
- (c.f., mint, hint vs. mind, find vs. pint)
- English pronunciation has partial, context-dependent regularities ("rules")[2]

Reading = Object Recognition

- Invariance: b = "b" regardless
- Context dependence: i depends on neighbors (just like any visual features in object)

Nonword Performance

Regularity tests (Glishko): bint → /bint/

Pseudo-homophones (McCann & Besner):
physe → /f/yes/, choyce → /chye/,

Matched regularity/exception cases (Tanenhan):
High freq: poes → /poes/, goes → /goes/, does → /d/ez/
Low freq: mose → /mose/, poes → /poes/, lose → /luz/

<table>
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<tr>
<th>Nonword Set</th>
<th>Model</th>
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<th>People</th>
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Word Statistics

- Can you infer word meaning from the company it keeps??
  - Yes! Latent Semantic Analysis (LSA)
- Just like V1 RF model – extract statistical structure from natural correlations in language

Semantics

Multiple Choice Quiz
Sentences and Syntax

Is this how it really works??

Those Pesky Time Flies..

- Time flies like an arrow.
- Fruit flies like a banana.
- The slippers were found by the nosy dog.
- The slippers were found by the sleeping dog.
- Syntax depends on semantics very deeply..

The “Gestalt” Alternative

- Just try to get the gist of what the sentence is saying:
  - G. W. Bush:
    - “Families is where our nation finds hope, where wings take dream.”
  - Does this really work? How?

Sentence Gestalt Model

SG Toy World

- People: busdriver (adult male), teacher, (adult female), schoolgirl, pitcher (boy), adult, child, someone also used.
- Actions: eat, drink, stir, spread, kiss, give, hit, throw, drive, rise.
- Objects: spot (the dog), steak, soup, ice cream, crackers, jelly, iced tea, kool aid, spoon, knife, finger, rose, bat (animal), bat (baseball), ball (sphere), ball (party), bus, pitcher, fur.
- Locations: kitchen, living room, shed, park.

SG Example/Probe Sentences

- Active semantic: The schoolgirl stirred the kool-aid with a spoon. (kool-aid can only be the patient, not the agent of this sentence)
- Active syntactic: The busdriver gave the rose to the teacher. (teacher could be either patient or agent — word order syntax determines it).
- Passive semantic: The jelly was spread by the busdriver with the knife. (jelly can’t be agent, so must be patient)
- Passive syntactic: The teacher was kissed by the busdriver. vs. The busdriver kissed the teacher. (either teacher or busdriver could be agent, syntax alone determines which it is).
- Word ambiguity: The busdriver threw the ball in the park. The teacher threw the ball in the living room. (ball is ambiguous, but semantically, busdriver throws balls in park, while teacher throws balls in living room)
SG Example/Probe Sentences

- **Concept instantiation**: The teacher kissed someone. (male). (teacher always kisses a male -- has model picked up on this?)
- **Role elaboration**: The schoolgirl ate crackers. (with finger). The schoolgirl ate. (soup) (these are predominant cases)
- **Online update**: The child ate soup with daintiness vs. The pitcher ate soup with daintiness. (schoolgirl usually eats soup, so ambiguous child is resolved as schoolgirl in first case after seeing soup, but specific input of pitcher in second case prevents this updating).
- **Conflict**: The adult drank iced-tea in the kitchen (living-room). (iced-tea is always had in the living room).