Today’s Outline

- Research paper
- Final exam: April 11 (Friday) 9a.m.
  VH-B
  – 5 short answers
- Lexical network of ‘facebook’ & ‘orange’
- Brain + Chapter 13 in Altmann’s book
- Grad school workshop

Research Paper

- 8-10 pages, double-spaced
- Review recent findings (5-8 recently published articles, 6-8 pages long)
- Suggest a future research direction based on your review (1-2 pages long).
- Research direction can be either theoretical or empirical, i.e., suggest a method
- Research should be completed
- Should be working on the long outline this week.
Network of ‘facebook’ & ‘orange’

My Brain

The Human Brain

http://www.medem.com/MEDEM/images/ama/ama_brain_stroke_lev20_thebraineffectsstroke_01.gif
What's in a human brain?

- Two classes of cells: Neurons and glial cells
- All neurons are connected to many others, number of connections can go up to 100,000!
- How many? estimated to be 100 billion
- No regeneration after birth! Neurons are re-organized with experience \( \rightarrow \) plasticity
- Glial cells play a supporting role for neurons, their general responsibility includes signal transmission and transportation of nutrients.

Structure of neuron and glial cell

![Structure of neuron and glial cell](http://en.wikipedia.org/wiki/Image:Neuron-no_labels.png)

Geschwind-Wernicke model

![Geschwind-Wernicke model](http://thebrain.mcgill.ca/flash/i/i_10/i_10_cr/i_10_cr_lan/i_10_cr_lan.html)
Geschwind-Wernicke model

- From aphasia literature
- Broca’s area -- left inferior frontal gyrus (LIFG)
- Leborgne, a.k.a. ‘Tan’ and Lelong
- Responsible for speech production
- Wernicke’s area -- posterior part of the superior temporal gyrus (STG)
- Responsible for language comprehension
- The two areas are connected by arcuate fasciculus (a bundle of myelinated neurons -- white matter)

Binder et al., 1997

New Research

- Dronkers et al., 2007
New Research

• Hickok & Poeppel, 2007

  • Green - spectrotemporal analysis
  • Yellow - phonological analysis
  • Pink - lexical interface (links phonological with semantic information)
  • Blue - sensorimotor interface and articulatory network

Wiring up a brain

• Connections between neurons reflect experience (or learning, as Altmann has put it)
• Our interpretation of words (meanings) reflect our unique pattern of activity reacting to that word
• Connectionism: construct a neural network that simulates the one in our brains. Feed input (experience) and compare the output to actual data obtained from behaviour
• computationally-intensive

Three principles

• Neurons send impulses to the connected ones.
  Rate of firing = strength of signal (activity of a neuron)
• Effects are bi-directional
  – excitatory: increase activity of connected neurons (+)
  – inhibitory: decrease activity of connected neurons (-)
• Connections change:
  – can regenerate
  – can die
Letter-to-sound Network

http://www.gamedev.net/reference/programming/features/vehiclenet/phoneme

same procedure across time

Elman’s work in the 1980s

- Michael Jordan: Memorize which network was output in experience.
- Elman’s extension:
  - Add copy neurons to the network
  - Each copy neuron is connected to 1 intermediary neuron
  - Duplicate the activation, so next time the same intermediary neuron is activated again, it will receive signal from 2 sources: 1 from the original and 1 from the copy
  - Make prediction based on previous experience
Ability of a Network

- Syntactic categories have unique activation pattern → distinguish nouns from verbs
- Nouns: animate (boy) vs. inanimate (book)
- Verbs: transitive (kick) vs. intransitive (dream)
- Conventional SVO
- Predict the occurrence of a certain syntactic categories

Predictions made by the Network

- Output memory reflects syntactic categories
- Intermediary neurons reflects the syntactic categories of the preceding word to make predictions that “match” the output memory
- The network changes according to the “quality” of previous predictions.
- Pattern of activation ≈ Internal representation

Language Network

- Variation in context gives rise to meaning
- Meaning is encoded by sound in the beginning of development
- Output pattern reflects the “probability” of occurrence of each word → experience-driven
- Our impatience in sentence comprehension is simply a consequence of our prediction-mechanism at work!
Context of Input

- Computational networks do not receive input from different modalities.
- Altmann predicted that the network would be able to predict, not only the subsequent words, but also subsequent phonemes based on learning.

Children as statisticians?

- Calculate the probability of each word's position in a sentence based on experience
- What's the denominator?
- Taking into account other words in the sentence
- Calculations become simpler when the network "groups" words into different syntactic categories → assigning a general probability to a category of words

Summary of Today's lecture

- Language processing involves a network of brain areas: frontal, temporal and parietal.
- The definite interplay of these areas is still a mystery.
- Neural network simulates human language processing to a certain extent, e.g., acquiring vocabulary, meaning and grammatical structures.
- Information is stored so to achieve making predictions.
- Experiential input is VERY limited and the applicability of findings to human development is unknown.