

1

## Neural Networks (Psych 3032/4254)

TTh 1:00 - 2:50, Fall 2001

Frontier Hall **157!**

1. Introductions.
2. Syllabus.
3. Background cards.
4. Neural nets intro.
5. Simulation intro.

2

## Background Cards

1. Name, email, major, year.
2. Basic take on modeling (-, 0, +).
3. Math? (calculus, linear algebra, Bayesian stats, etc.) .
4. Neuroscience?
5. Computer? (platforms, programming)
6. Interest in individual projects?  
(1=definitely not - 7=definitely)
7. Hope to get out of the course?

3

## The Most Interesting Thing in the Universe...

The human brain is the most interesting object in the universe!

(I challenge you to think of anything else *more* interesting)

It is also the most complex!

Computer models help us deal with this complexity.

4

## Physical Reductionism

*Reductionism*: explaining in terms of underlying mechanisms.

What mechanisms for cognition? CPU & RAM? Logic? Lisp? Productions?

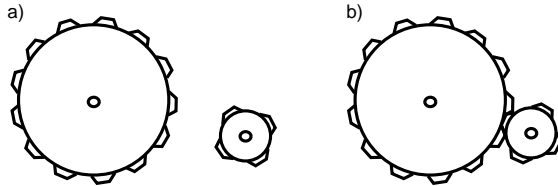
*Physical Reductionism*: mechanism is the *brain*.

5

## Reconstructionism

Putting the reduced pieces back together.

Critical when there are billions of such pieces (neurons). Computer simulations are essential. Emergent properties:



6

## Complexity and Levels of Analysis

The brain is very complex: billions of neurons, 5,000 x billion synapses, changing every nanosecond.

*Need to abstract away from this complexity!*

Is there some simpler, higher level for describing what the brain does during cognition?

7

## In a Computer Program..

You can have three levels of abstraction (Marr):

**Computational:** what is overall goal?

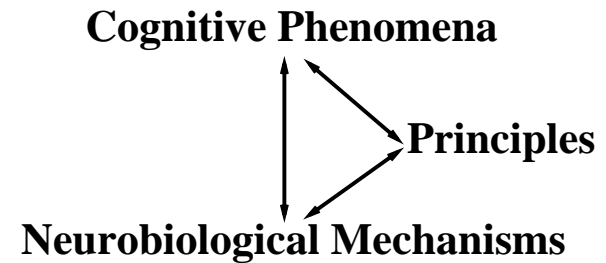
**Algorithmic:** what strategy?

**Implementational:** how to physically encode?

Can we focus only on 1st two levels? *Only if you assume a particular implementation!*

8

Our Levels



9

## Neurobiological Mechanisms and Principles

**Neurons:** serve as *detectors*, signal with *activity*.

**Networks:** link, coordinate, amplify, and select patterns of activity over neurons.

**Learning:** organizes networks to perform *tasks* & develop good *models* of environment.

10

## Psychological Phenomena

**Visual encoding:** A network views natural scenes (mountains, trees, etc.), and develops brain-like ways of encoding them using principles of learning.

**Spatial attention:** Taking advantage of interactions between two different streams of visual processing, a model focuses its attention in different locations in space, and simulates normal and brain-damaged people.

**Episodic memory:** Replicating the structure of the *hippocampus*, a model forms new episodic memories and solves human memory tasks.

**Working memory:** A neural network with specialized biological mechanisms simulates our *working memory* capacities (e.g., the ability to juggle a bunch of numbers while doing mental multiplication, e.g.,  $42 \times 17$ ).

11

## Psychological Phenomena

**Word reading:** A network learns to read and pronounce nearly 3,000 English words, and *generalizes* to novel nonwords (e.g., “mave” or “nust”) just like people do. Damaging a reading model simulates various forms of dyslexia.

**Semantic representation:** A network “reads” every paragraph in a textbook, acquiring a surprisingly good *semantic* understanding by noting which words tend to be used together or in similar contexts.

**Task directed behavior:** A network simulates the “executive” part of the brain, the *prefrontal cortex*, which keeps us focused on performing the task at hand and protects us from distraction.

12

## Advantages of Simulation Method

Potential Traps/Problems

13

### Advantages of Simulation Method

- Help us understand phenomena:
  - Provides novel insights.
  - Effects of brain damage/drugs.
  - Can explain *why* things are (function).
- Deal with complexity, span levels.
- Explicit:
  - Deconstruct psychological constructs.
  - Makes novel predictions.
  - Forces accountability in simulating data.
  - Completeness in all problem aspects.
- Allows control.
- Forces consistency & unity in framework.

14

### Potential Traps/Problems

- Too simple.
- Too complex.
  - Which properties are relevant?
- Can do anything:
  - Too many degrees of freedom.
  - Indeterminacy problem.
- Reductionistic.