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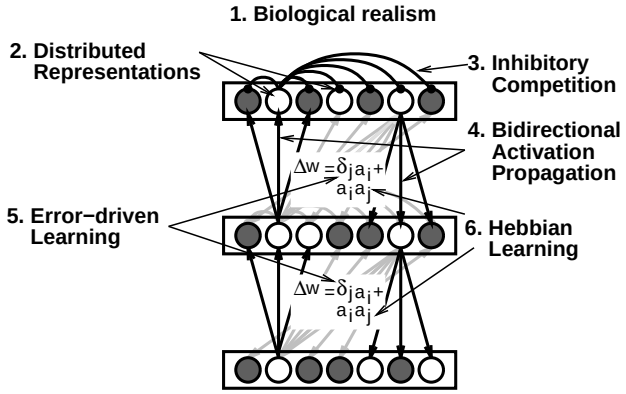
Large Scale Brain Area Functional Organization

Summary of Part I: Basic Mechanisms.

1. Structural & Dynamic Principles.
2. General Functions of Cortical Lobes, Subcortical Areas.
3. Functional Tradeoffs.
4. General Problems.

2

Summary of Part I: Basic Mechanisms



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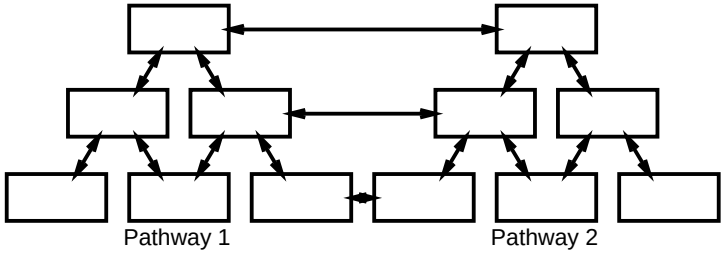
Structural Principles



- Hierarchical sequence of transformations.
- Specialized pathways.
- Intra-pathway interactions.
- Higher-level association areas.
- Large-scale distributed representation.

4

Dedicated & Content-Specific

Neurons are dedicated to specific content
(i.e., they are tuned to detect specific things)

Brain is not a general-purpose CPU.

Tradeoff between specificity & knowledge-dependency vs generality & flexibility.

Traditional symbolic AI fails because it lacks "common sense".

Time flies like an arrow.
Fruit flies like an apple.

Challenge: to build flexibility from neurons.

5 Dynamic Principles

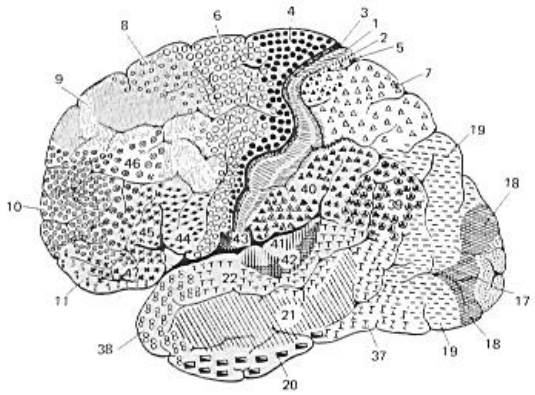
Basic mechanisms:

- Multiple constraint satisfaction (MCS).
- Attractors (amplification, bootstrapping, etc.)
- Inhibitory competition.

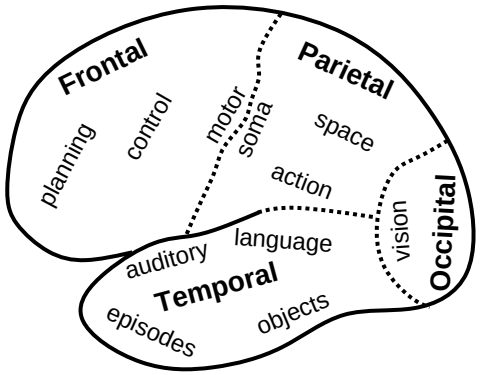
Cognitive implications:

- *Internal context* affects MCS, control.
- Mutual support produces *active memory*.
- Inhibition leads to *attention.*

6 Cortical Lobes



7 General Functions of the Cortical Lobes



8 Other Areas

Limbic system:

- Hippocampus (rapid learning).
- Cingulate cortex (response selection).
- Amygdala (emotions).

Others:

- Thalamus (sensory input, attention).
- Midbrain neuromods: VTA - dopamine.

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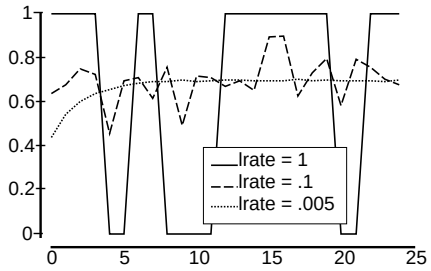
10 Functional Tradeoffs: Slow *vs* Fast Learning

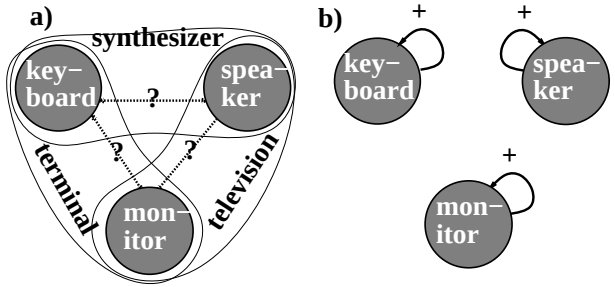


Learning must be *slow* to capture (statistical) structure of environment (averaging).

But you also have to be able to learn rapidly.

Tradeoff solved by two systems: cortex learns slowly, hippocampus learns rapidly.

11 Functional Tradeoffs: Active Memory *vs* Overlapping Distributed Representations



Overlapping distrib reps useful for capturing info about world.

But overlap/interconnectivity cause spread, not useful for maintaining info over time.

Tradeoff solved by two systems: PC has overlapping distributed representations, FC is isolated for maintenance.

FC important for *control* via maintained activations.

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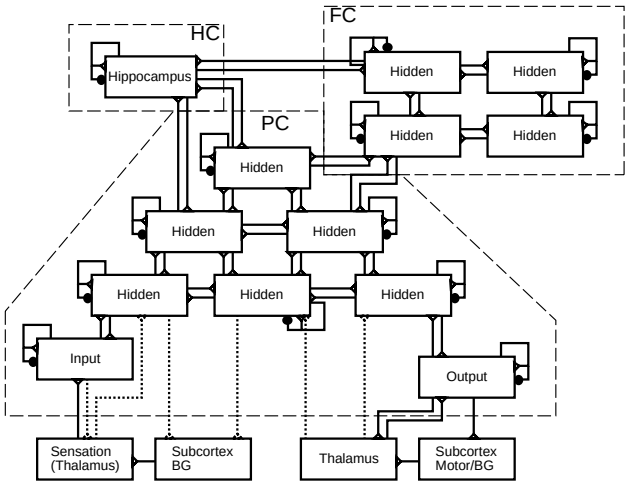
A Cognitive Architecture



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General Problems

But first:

- Don't throw the baby out w/the bathwater!
- Nobody's perfect!

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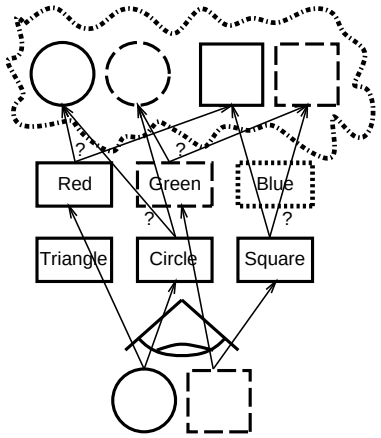
The Binding Problem



16 The Binding Problem

Potential solutions:

- Attention
- Encode conjunctions
- Dynamics (oscillations)
- Nobody's perfect...

17 Other General Problems

- Representing multiple instances of the same thing (attention + counting, location)
- Comparing reps (overlap – multiple digits, settling in shared weights – goodness, PMC-PFC)
- Nobody's perfect...

18 Recursion and Subroutine-like processing

- In middle of processing, need to perform same processing (recursion) or different processing (subroutine)
- Easy in standard serial computer (store current state, call subroutine w/appropriate arguments)
- Harder when data and processing not separated!
- HCMP, PFC
- Nobody's perfect...
  The mouse the cat the dog bit chased squeaked.

19 Generalization

- How to recognize new inputs given dedicated, specialized reps?
- Distributed reps
- Abstraction
- Nobody's perfect...
- Baby-bathwater...