Networks of Neurons

Computational Cognitive Neuroscience
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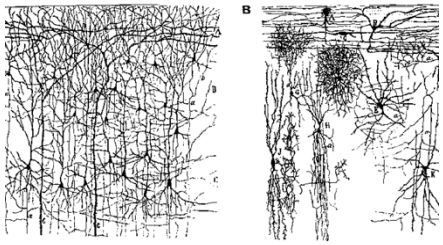
Networks

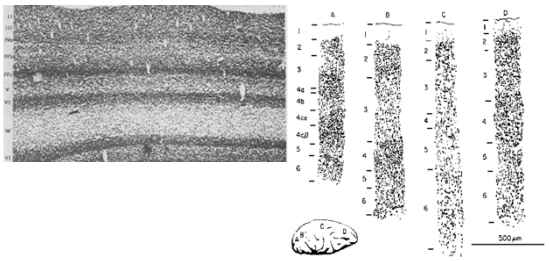
- Biology of Neocortex ("cortex")
- Categorization and Distributed Reps
- Bidirectional Excitation and Attractors
- Inhibitory Competition and Activity Regulation

Neurons: Excitatory and Inhibitory

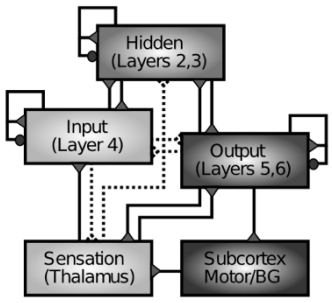


Excitatory = main info processing, long-range connections
Inhibitory = local, activity regulation and competition

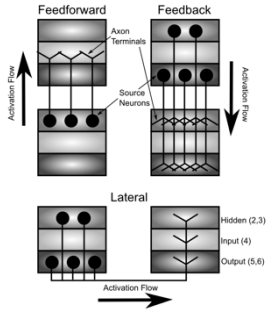
The 6 Layer Cake..



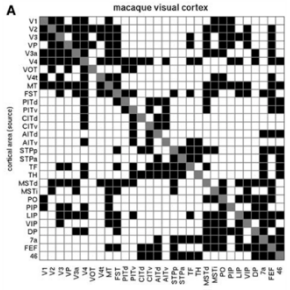
Is Actually Only 3..



Patterns of Connectivity



Bidirectional Symmetry



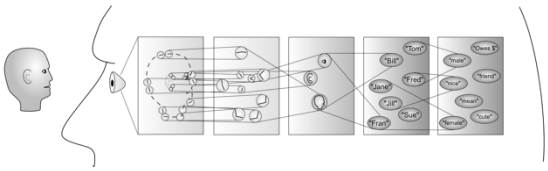
Biology => Function

- Feedforward excitation = categorization of inputs
- Feedback excitation = attractor dynamics
- Lateral inhibition = competition, activity regulation

We Think in Categories

(much easier than disconnected pixels..)

Hierarchy of Categories



The Chair Category

Getting the right ones is key..

- Two men are dead in a cabin in the woods. What happened??

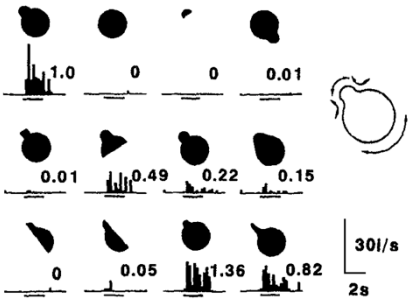
Categories are Interesting!

- What makes a mental categorization accurate? Is there something "real" about a "chair?"
- Stereotypes are mental categories..
- Can you encode multiple categories at the same time??

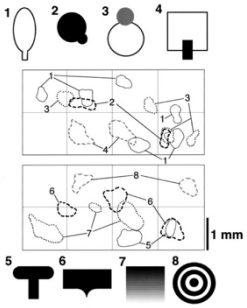
Distributed Representations

- Let a 1,000 categories bloom.. You've got the room in your head (billions of neurons)
- Each neuron can respond to multiple things (graded similarity)
- And each thing activates many neurons (who knows what is going to be relevant this time?)

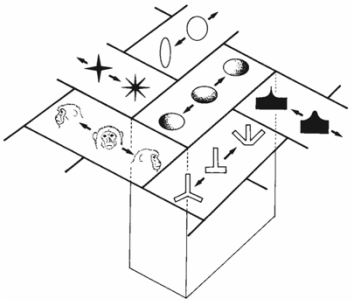
Graded Responses



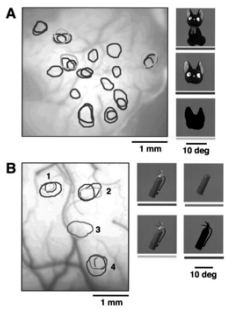
Distributed Patterns



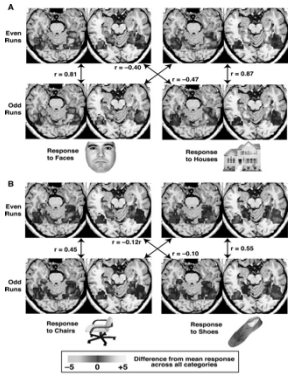
Topographic Organization



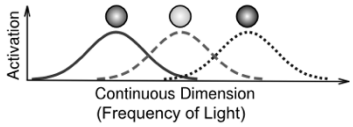
Distributed Parts



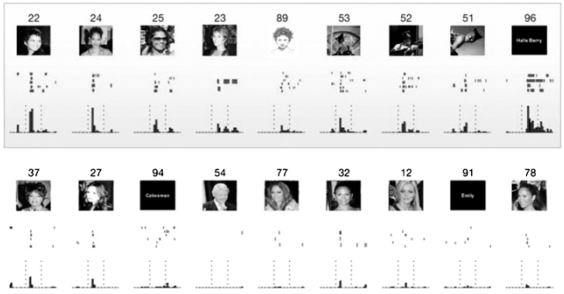
Not Just Monkeys



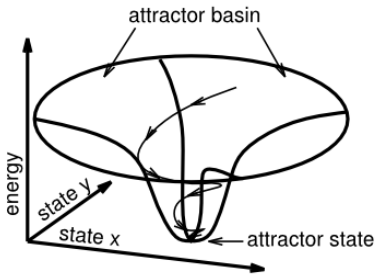
Coarse Coding Efficiency



Localist Representations?

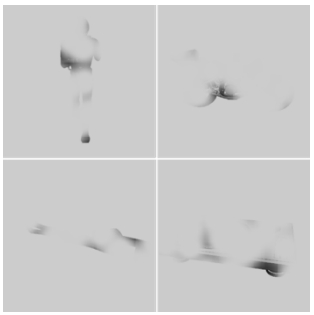


Bidirectional Excitatory Dynamics

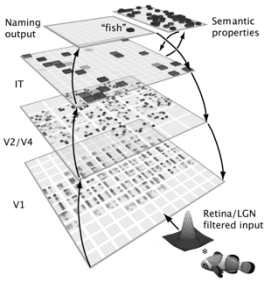


Top-down Ambiguity Resolution

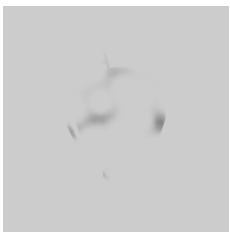
What Are These?

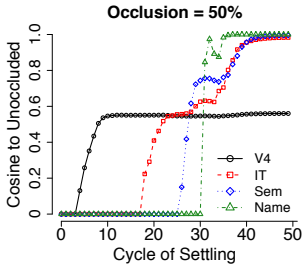


A Big Network Model..



Bidirectional Dynamics

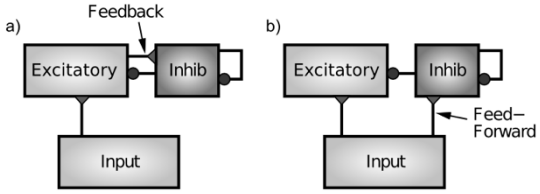




Inhibition

- Competition: selection pressure, survival of the "fittest", picking the best detector for the job..
- Interacts with learning: "rich get richer" (but also narrower – no hogging the inputs please!)
- "Sparse distributed representations"
- (and also essential for controlling activity, like an air conditioner)

Feedforward and Feedback Inhib



- Feedback "**reacts**" (AC comes on after it gets hot enough)
- Feedforward "**anticipates**" (e.g., if AC measured outdoor temp, or weather forecast)

kWTA Approximation