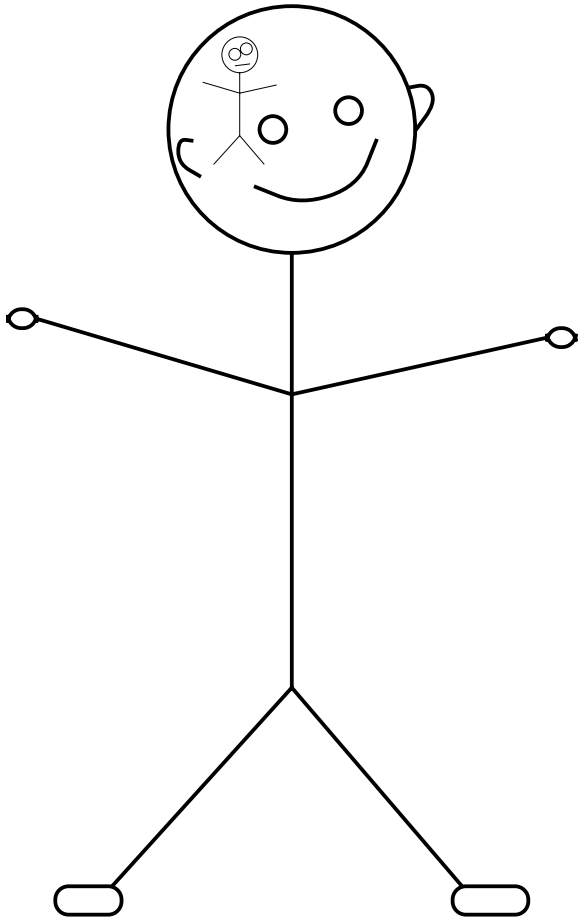
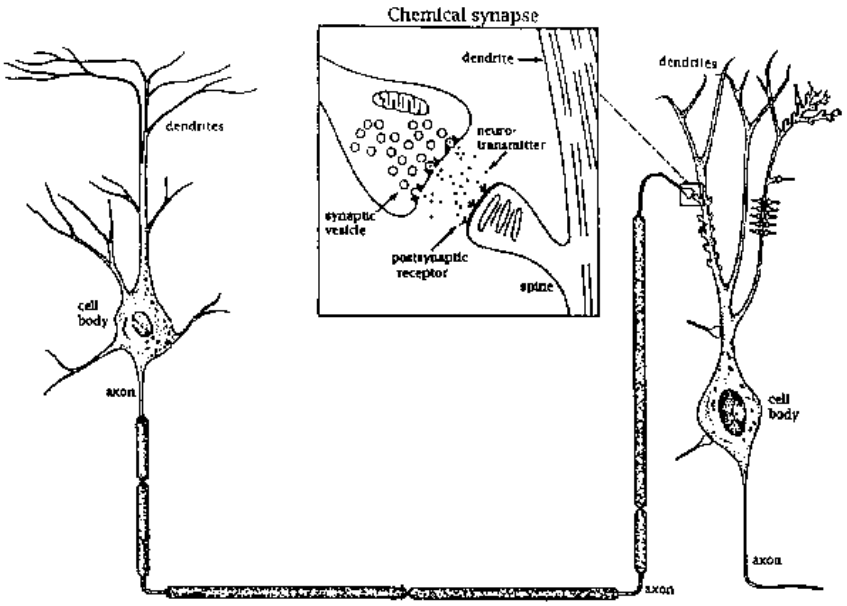
You and Your Homunculus:

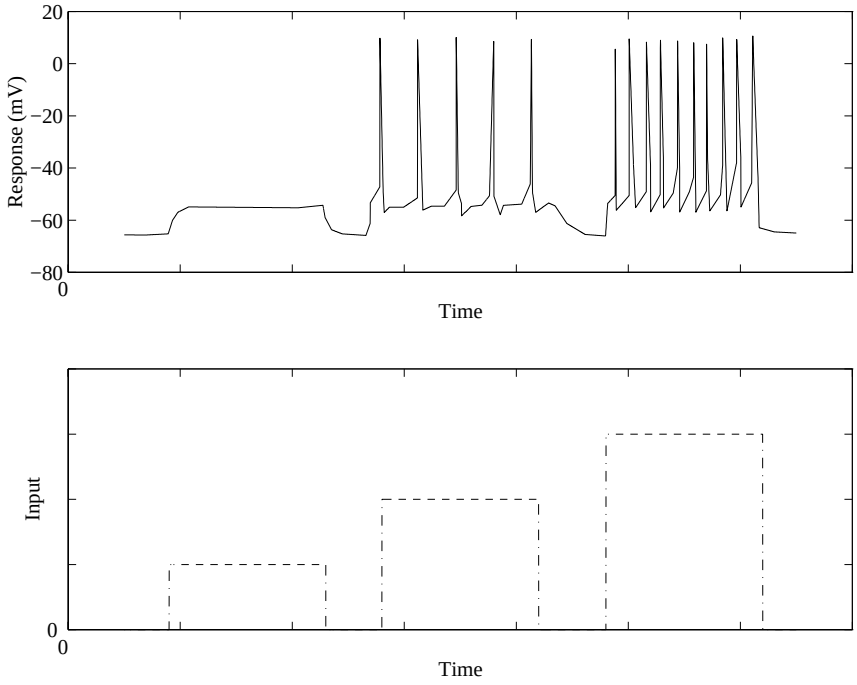
Thinking about Thinking



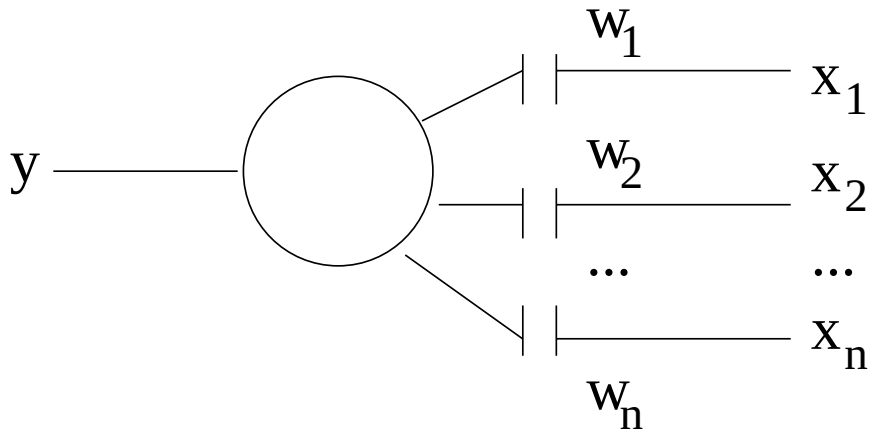
Biological Neuron



Response

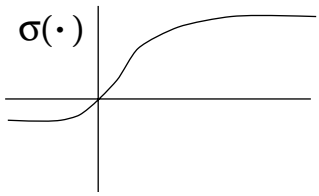


Mathematical Neuron



- Activation

  $y = \sigma(\mathbf{w} \cdot \mathbf{x})$, where $\sigma(\cdot)$ looks like



- Learning

$$\dot{\mathbf{w}} = ?$$

- Learning Rule Requirements:
  - *Simplicity*
  - *Locality*
  - *Selectivity*

Selectivity

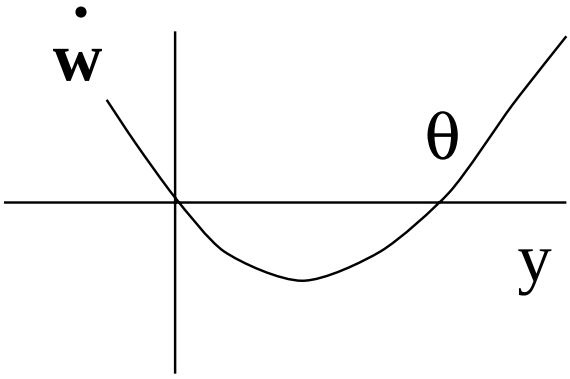
- A neuron is *selective* if it responds to some subset of the inputs
- Examples:
  - Visual cortical cells responding to bars of light of a particular orientation
  - Audio cortical cells responding to frequency bands
  - Some higher level visual cells responding to faces
- Selectivity is almost always partially determined by genetics and developed further after birth
- It is dramatically affected by the environment: ie. visual deprivation in a critical period can destroy orientation selectivity

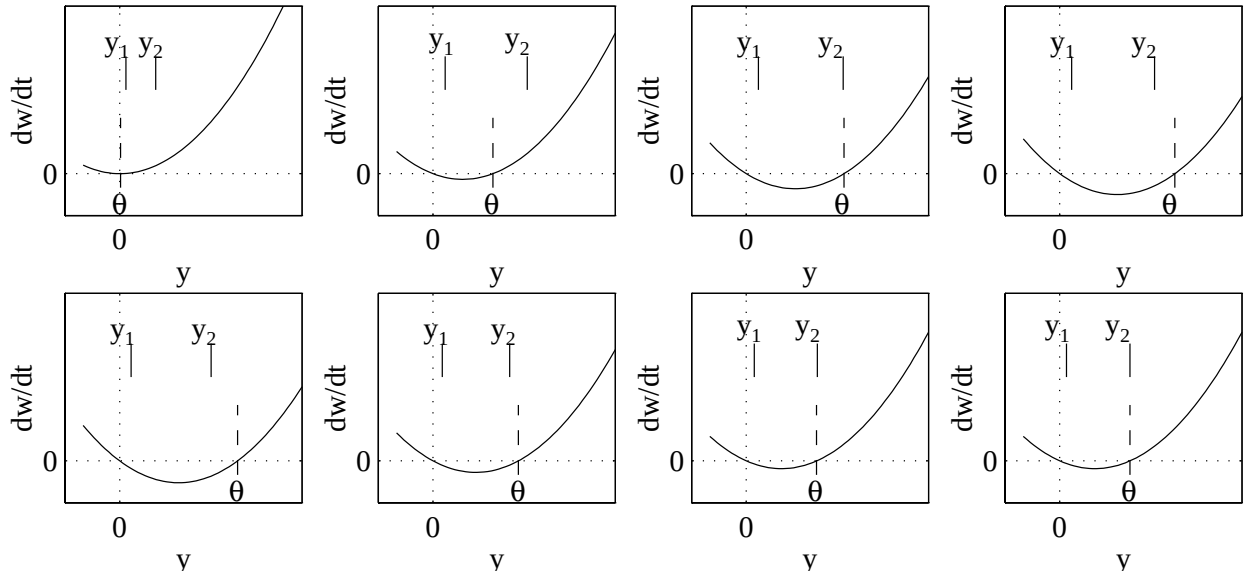
BCM Learning Rule

$$y = \mathbf{w} \cdot \mathbf{x}$$

$$\dot{\mathbf{w}} = y(y - \theta)\mathbf{x}$$

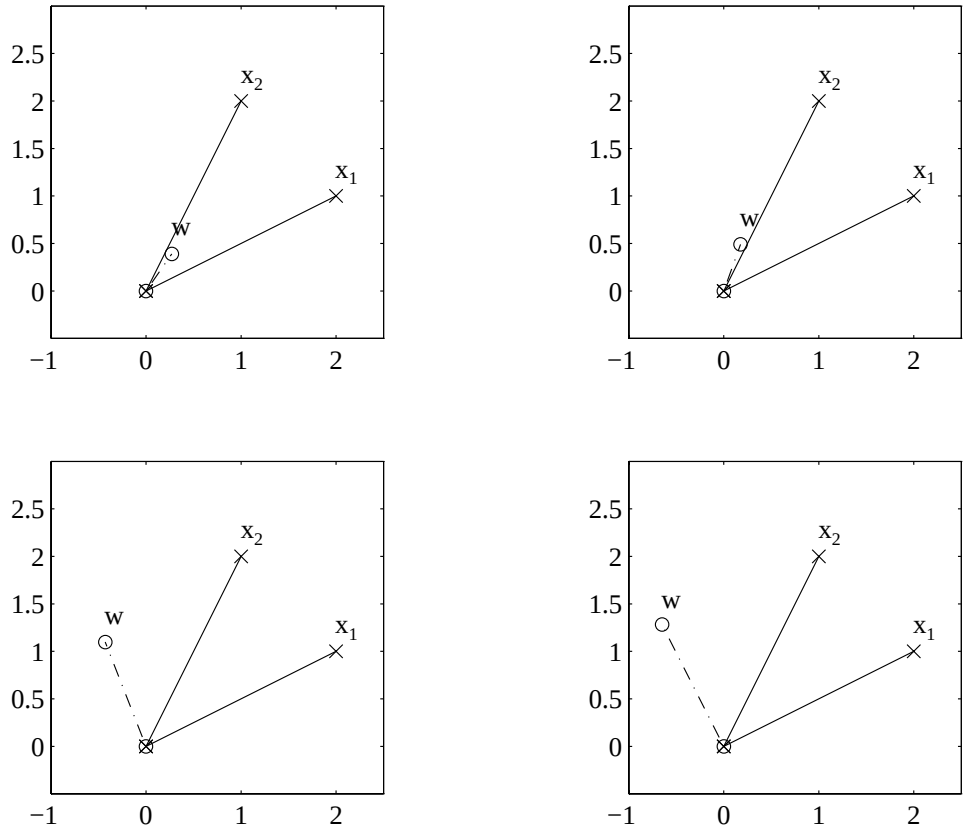
$$\theta \sim E[y^2]$$



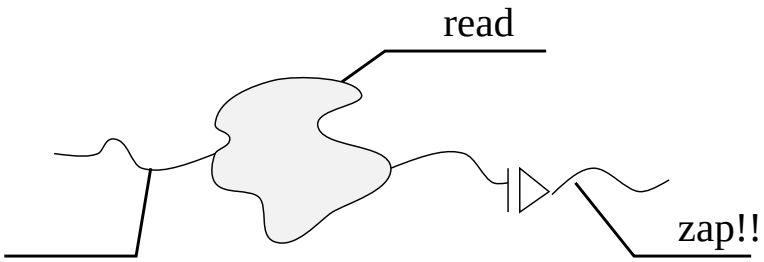


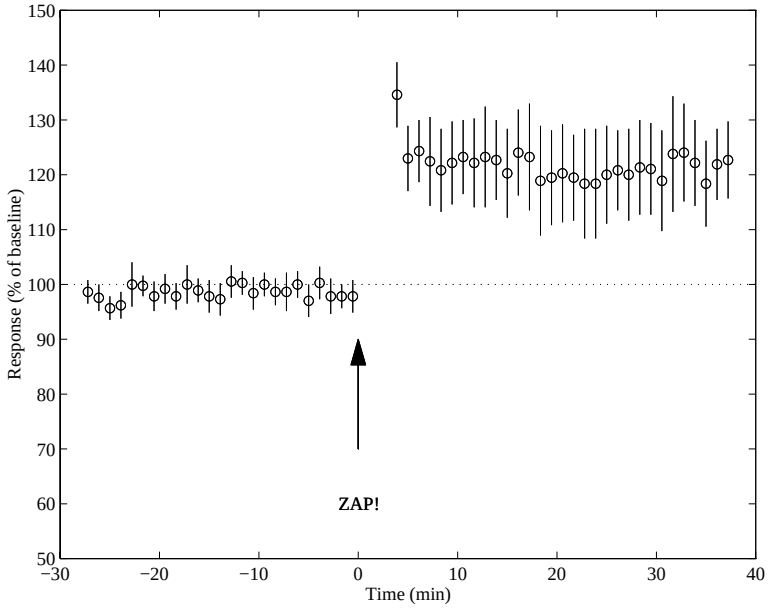
Another Way to Look At It

- Weight moves until it is *orthogonal* to some input patterns
- Weight seeks out *important* directions in a complicated space

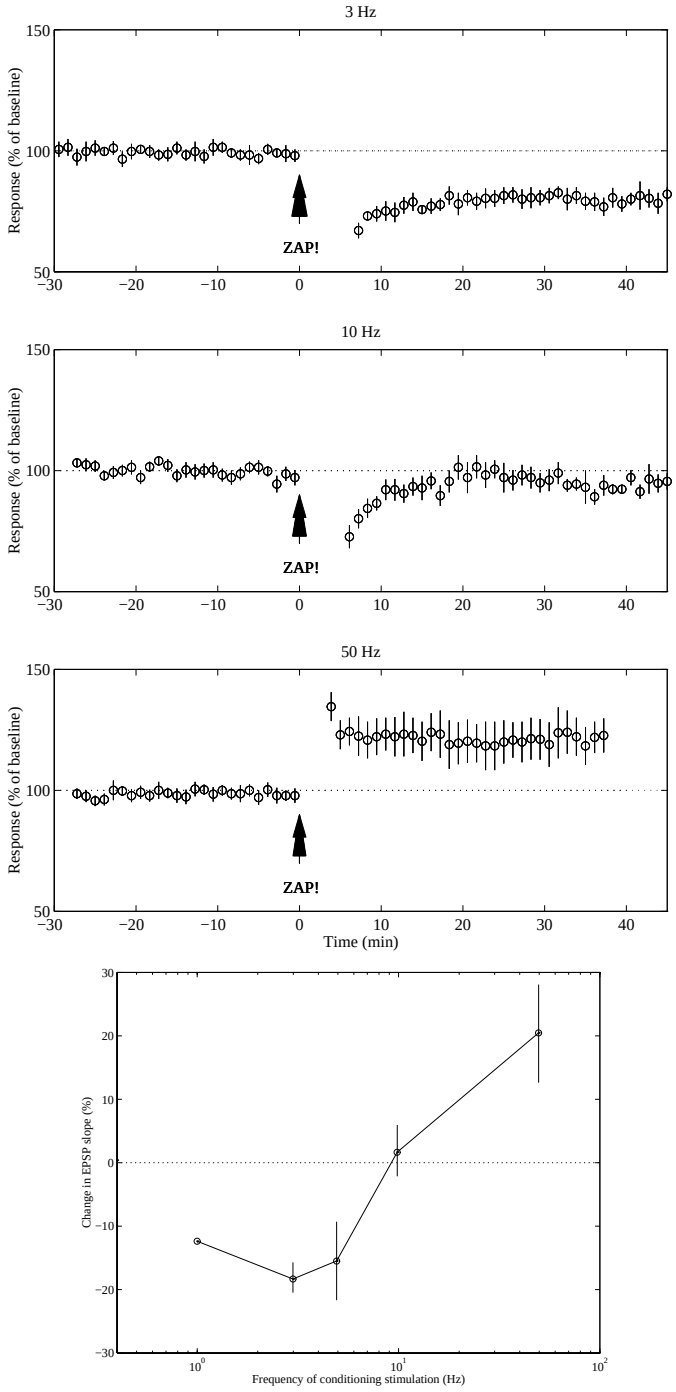


Measuring Learning



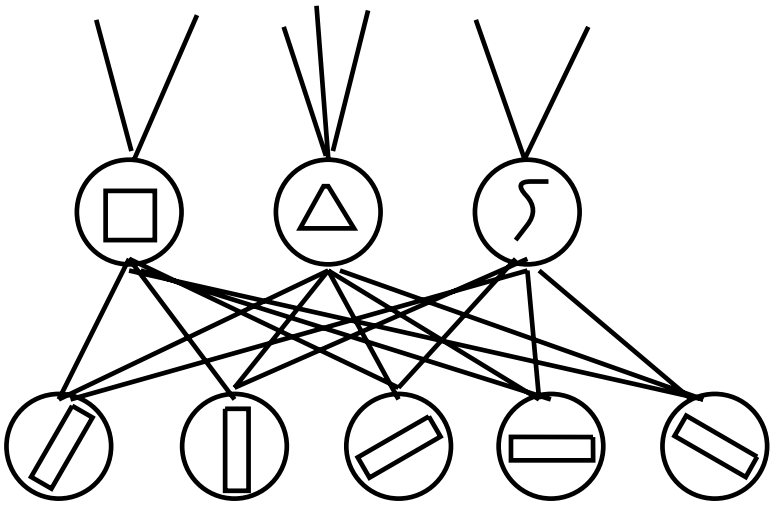


Measuring Learning

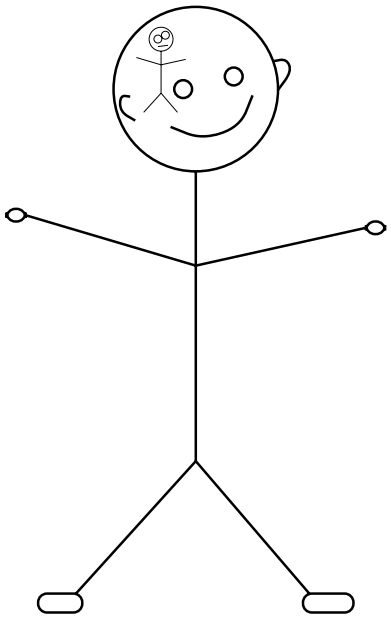


Layers of Processing

- Layers selective to simple things project to more complex layers



Conclusions



- Selectivity is important for processing complicated environments
- Selectivity can be *learned* from the environment using some simple rules
- Other than integrated current, what information is carried by neural signal?
- Is there a link between these low level selectivity processes and higher level functioning?
- What differences are there with networks of neurons?