Patterns of neural firing …

- Each “tick” seen in the figures below represent an action potential being generated in a neuron
- The brain assigns different “meaning” to different patterns or rates of firing

Stimulation Causes
FAST firing
(excitation)

Stimulation Causes
SLOW firing
(inhibition)

Time
Visual System:

The Stimulus

The “physical” properties of the visual stimulus

- **electromagnetic energy**
  - Measured in “photons”
  - **portion of electromagnetic spectrum** between 400 nm and 700 nm
  - nm is a nanometer (1 billionth of a meter)
A Little Light Physics

Visible Spectrum...

The Electromagnetic Spectrum

The visible spectrum
A Little Light Physics (cont’d)

- Light can be absorbed, diffracted, reflected, transmitted, or refracted
A Little Light Physics (cont’d)

• **Absorbed**: Energy (e.g., light) that is taken up, and is not transmitted at all

A Little Light Physics (cont’d)

• **Diffracted**: Bent, or having waves that are spread out, (e.g., waves of sound or light, as they pass through a narrow aperture)
A Little Light Physics (cont’d)

• **Reflected:** Energy that is redirected when it strikes a surface, usually back to its point of origin

A Little Light Physics (cont’d)

• **Transmitted:** Energy that is passed on through a surface (when it is neither reflected nor absorbed by the surface)
A Little Light Physics (cont’d)

• **Refracted**: Energy that is altered as it passes into another medium, (e.g., light entering water from the air)

The “psychological” properties of the visual stimulus as related to the “physical” properties

<table>
<thead>
<tr>
<th>Physical</th>
<th>Psychological</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>Hue</td>
</tr>
<tr>
<td>Amplitude</td>
<td>Brightness</td>
</tr>
<tr>
<td>Purity</td>
<td>Saturation</td>
</tr>
</tbody>
</table>

9/4/2008
In this discussion…

• Much of our time will be spent describing perceptual systems and how they interact with one another and the environment

• Species-specificity
  – e.g., there are some tacit assumptions at work in research on human perception
  – In the case of the visual system, for example, different species are sensitive to different ranges of wavelengths (within a broader, but still constrained, range of the electromagnetic spectrum)
  – Humans are sensitive to a specific range (350 or 400 nm to 700nm)

Biologically Relevant Perturbations of Environment

• Consider the “human sensitive” range of the electro-magnetic (EM) spectrum…

• This narrow band is called “visible light” (wavelengths b/t 350 and 700 nanometers…where nm = 9 decimal places, e.g., .000000350m)
Is it really “visible?”

- It’s not the case that it’s “visible, therefore we see it” but “we see it, therefore we call it ‘visible’”
- e.g., this labeling is very species-specific; for bees, “visible light” is a different band, shifted to include ultraviolet (UV) wavelengths

Why so constrained?

- Theoretically, all that would be required for Radar to be included in a species’ “visible light” is their having a perceptual system that would interact with those wavelengths
- But there’s a good reason most eyes on the planet only interact with wavelengths b/t UV and Infra-red…
These wavelengths are of a size most likely to interact with creature-sized objects!

- **Gamma rays:**
  - wavelengths so short (12+ decimal places), they pass through most matter

- **Radio waves:**
  - wavelengths so long (10 meters) they pass around biological objects (though not always mountains)

Species-specific perception not just in the “eye of the beholder”

- Certain bats echolocate with chirps at +/-50 kHz
- Prey moth hears ONLY that range (there is only one sound in the moth’s environment)
  - When auditory system registers that sound, triggers motor response
  - Wings beat out of sync, produces erratic flight, hard for bat to pursue
- Since humans hear only up to 20 kHz, this whole life/death exchange is not part of our perceptual reality
And so on…

- e.g., odorless gas (nitrogen)
  - Has a chemical structure, but not one that interacts with human perceptual system
  - It does interact with worm’s system (e.g., provides important “biologically relevant” information

Different “visible” light?

Fig. 5.4: A dog photographed in the infrared part of the spectrum. This is what a snake might see. The ‘hot’ bits will be the bits not covered in fur, e.g. the eyes and mouth. Note that this dog has a cold nose, a sure sign of good health.
What makes a good eye?

• Rabbits have eyes spaced so far apart that they almost have 360 degree vision (what's the compromise?)

• Marine animals also have eyes far apart on the sides of their heads
  - e.g. whales have a huge blindspot right in front, so they can't see a boat coming straight at them; whalers take advantage of this fact and always approach a whale dead-on so that it can't see them

• Hawks and other birds have amazing visual acuity (as much as 8 times that of humans)
Primate Reality

- Primates differ from many other animals in various ways, including important perceptual differences.
- Includes emphasis on vision over other senses (as evolved from nocturnal terrestrials to diurnal tree dwellers).
- As humans, we share much of the perceptual reality of nonhuman primates, with some species-specific differences.

Visual System:

Anatomy of the Eye
Visual Pathways: Quick overview of the route

- Outputs of the retina pass through the optic nerve, cross and split at the optic chiasm, through the optic tract to the LGN
- From there, they pass to V1, or primary visual cortex, and then on to "higher-level" brain areas

Get oriented by looking at the visual pathways from below…
...and from the side

The Human Eye
The structures of the eye and corresponding functions

- **Outer eye structures**
  - *sclera*
    - “white” of the eye - blocks light
  - *cornea*
    - transparent
    - focuses light-static
  - *anterior chamber*
    - filled with aqueous humor
  - *extraocular muscles*
middle eye...

- **iris**
  - ringed muscle - controls amount of light entering the eye

- **pupil**
  - opening in the iris

- **lens**
  - focuses light – active
    * “accommodation”

- **posterior chamber**
  - filled with vitreous humor
inner eye...

- **retina**
  - **photoreceptors**
    - react to light
  - **communication cells**
    - allows for cells in the retina to “talk” to each other
- **fovea**
  - highest concentration of photoreceptors
- **optic nerve**
  - bundle of ganglion cell axons
- **optic disk**
  - blind spot - where optic nerve exits