Lecture Four: Sensation and Signal Detection Theory

The abstract: This lecture will have three (or four) parts

1) We will discuss the general problem of using the senses to understand the world.
2) We will trace the visual pathway from eye to brain.
3) We will consider the most basic sorts of perceptual decisions in the context of Signal Detection Theory and we will discuss some of the broader applications of the theory.
4) We might get on to color vision….but history suggests that I may get side tracked long before that.

The outline:

POINT 1: THE BIG QUESTIONS: How do we see? How hard can that be to understand?

A three-part answer

Sensation - Getting data in to the system from the world
Attention - Selecting some of the data
Perception - Interpreting the data

POINT 2: From eye to brain

A lot of terms

Eye

(fill in the blanks →)
Aqueous Humor
Pupil
Lens
Vitreous Humor
Retina

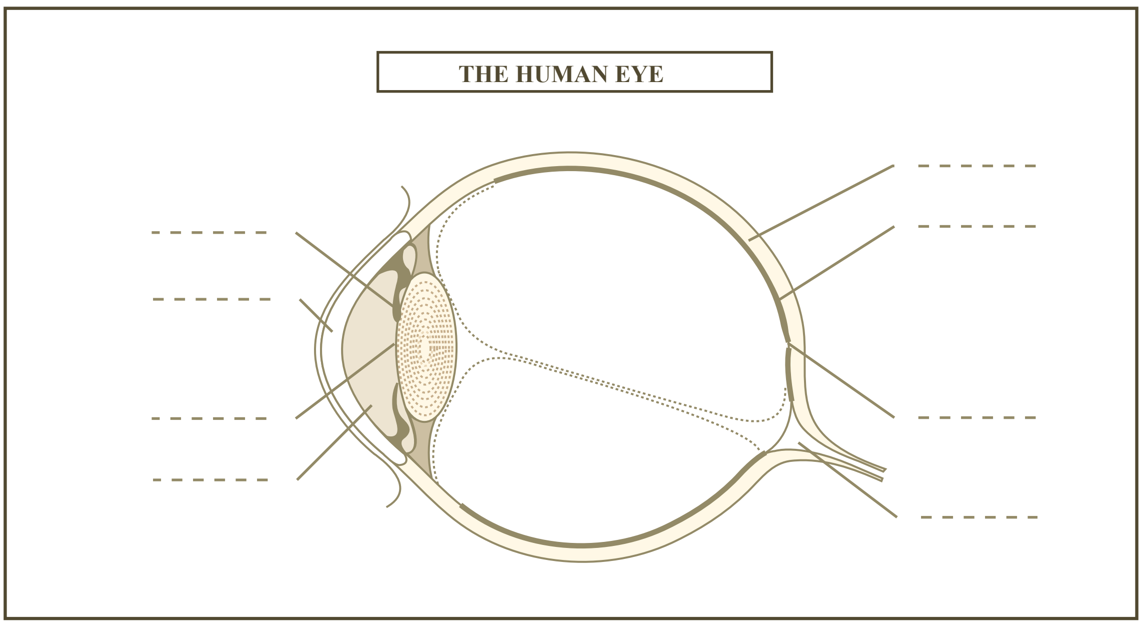

Figure by MIT OCW.

Retina
from the <u>back</u>
Pigment epithelium
receptors
rods
cones
horizontal cells
bipolar cells
amacrine cells
ganglion cells

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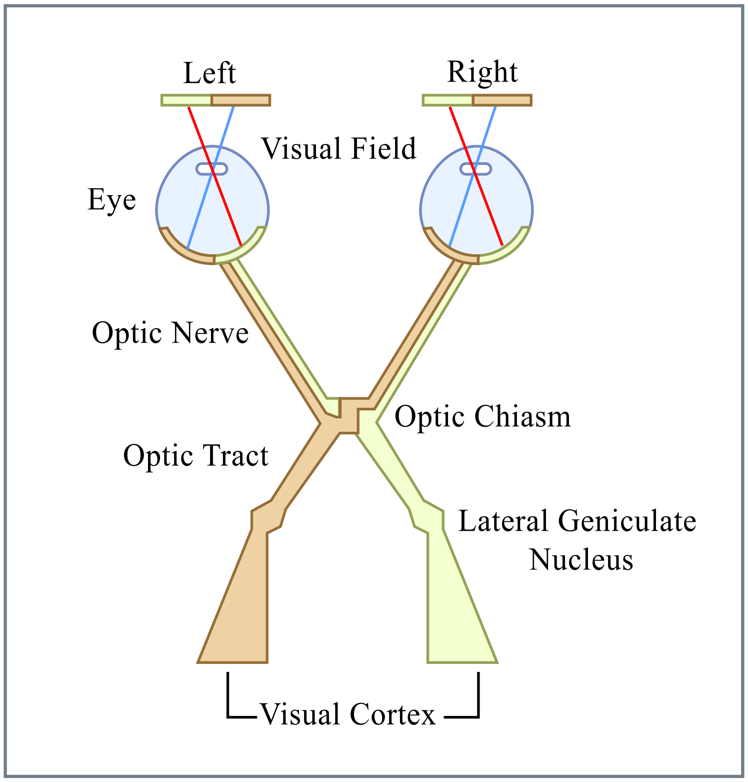
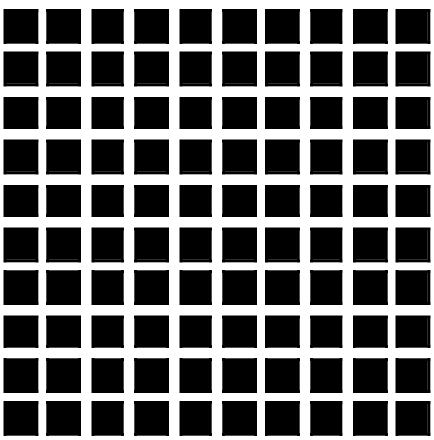


To the brain
- optic nerve
- optic chiasm
- lateral geniculate nucleus of the thalamus
- primary visual cortex
- extrastriate cortex

Brain region schematic removed for copyright reasons.

Figure by MIT OCW.



This is the Hermann (or Hering) grid….why is it interesting?

There is an endless amount of fascinating material to discuss here. I am a vision researcher so we might get stuck here forever…

And we are ignoring the other senses…which is heartbreaking.

Ah….well

POINT THREE: Signal Detection Theory

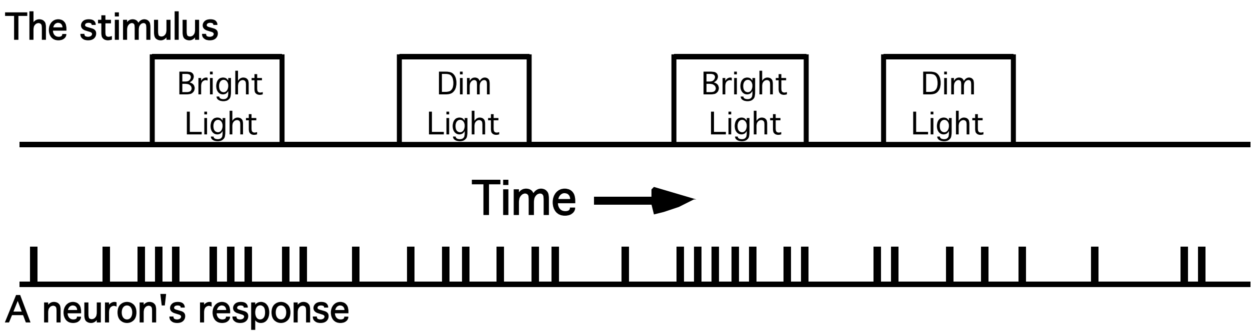
Just about the simplest possible perceptual question: Did you see that spot of light in the dark?

What is an absolute threshold?

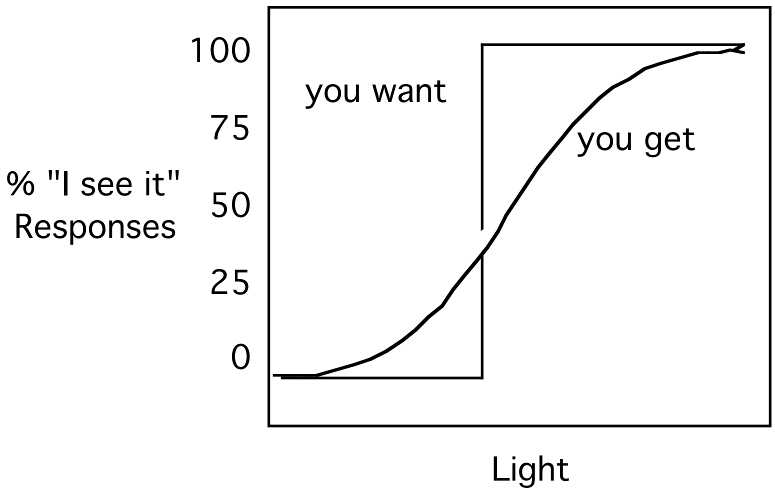
How sensitive are you to light?
Two *tour de force* papers
Hecht, S., Shlaer, S., & Pirenne, M. H. (1942). Energy, quanta, and vision. *J. General Physiology, 25*, 819-840.

Sakitt, B. (1972). Counting every quantum. *J. Physiology (London), 223*(1), 131-150.

What would a neuron say?



Did you see it? Let's do the experiment



A couple of Signal Detection Theory websites
http://www.cns.nyu.edu/~david/sdt/sdt.html

http://wise.cgu.edu/sdt/overview.html
Has a cute applet to make ROCs make sense

More terminology

2AFC = 2-alternative forced-choice

Hits
True Negatives
Misses
False alarms

criterion
d'

ROC (Receiver operating characteristic) curves

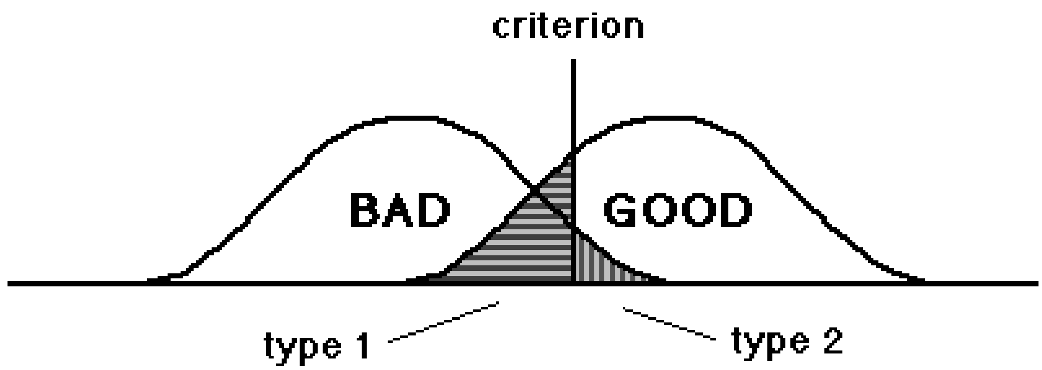
The ubiquity of SDT problems

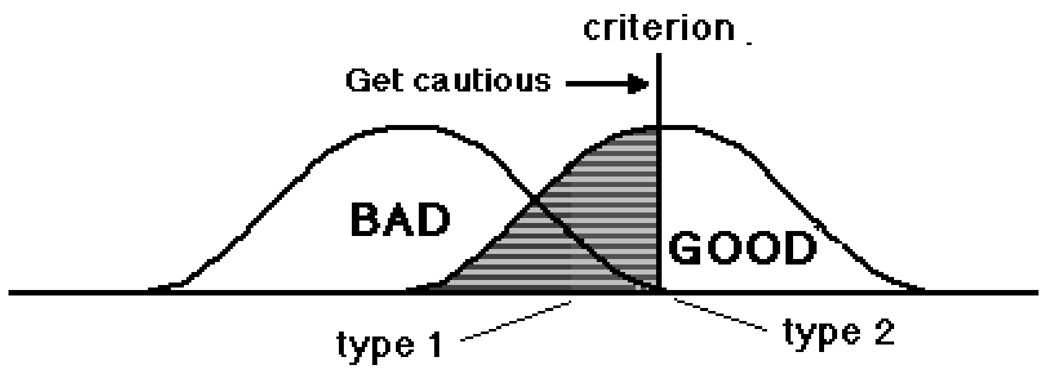
From detection to discrimination

What is Weber's law?

IF we have time: SDT and prejudicial behavior

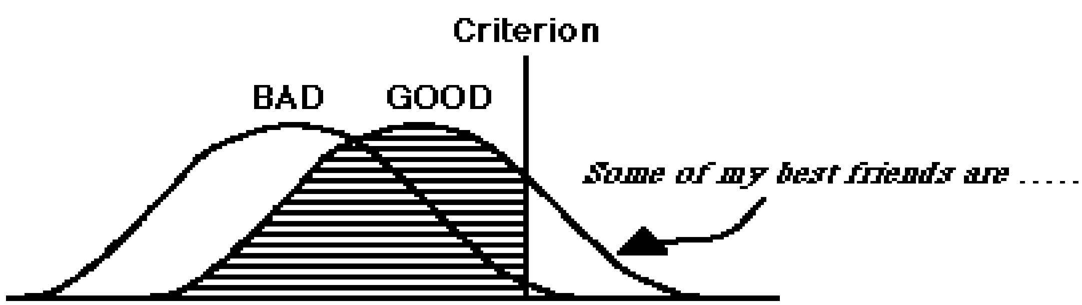
YOUR GROUP





ABOVE MAY BE YOUR GROUP OR ANOTHER

Get ignorant (That makes the distrbutions wider so they overlap more)



Now look at the consequences.

Color Vision? Well, if we get there, I will have to make another handout!

Questions to answer from Chapter Five:

P171 Can you describe **Weber's Law** and **Fechner's law**. Can you say a word about why they are of any interest?

P173 **Signal detection theory** will get discussed in lecture. It tends to confuse people. But, especially for the mathematically inclined, it is an interesting and important piece of the study of the senses.

P177 Can you describe the *transduction* of auditory stimuli from pressure waves in the air to a neural signal? You will want to be able to say something about the **ossicles, cochlea, basilar membrane, & hair cells.**

P184 The structure of the eye will get covered in lecture and I won't repeat the terminology here.

P184 What does **brightness contrast** tell you about the way we see the world?

P189 What does **lateral inhibition** do for us?

P190 Color vision….oy, color vision. People ask more questions and get more confused about color vision than about any other topic in the course. So, here are the important points

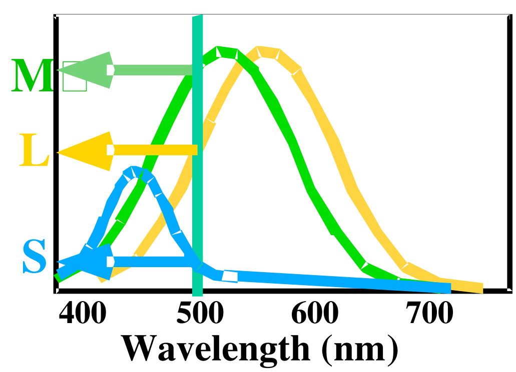
1) Light is the portion of the EM spectrum containing wavelengths between about 400 and 700 nanometers (nm). Sunlight includes all of these wavelengths.

2) Physical objects differ in the percentages of different wavelengths reflected from their surfaces.

3) You have three types of cone photoreceptors. Each is broadly sensitive to a wide range of wavelengths. However, they differ in their sensitivities as shown in this picture.

4) This means that a single wavelength at a single intensity will produce three different responses: from the long- (L), medium- (M), and short-wavelength sensitive cones (S).

5) In fact, any combination of wavelengths, no matter how complicated, will produce three responses; one each from the L, M, & S cones. This is the heart of **Trichromatic theory (=Young-Helmholtz theory –** p192).



6) SO if two very different physical stimuli produce the same three responses, they will appear identical. They are **metamers.**

7) In determining the **hue** (p190) of a surface or a light, it is the ratio of the L, M, & S cone responses that is important. Specifically, the L/M ratio tells you how red or green a surface appears and the (L+M)/S ratio tells you how yellow (L+M) or blue it is. This is the heart of **opponent process theory** (194). Trichromacy is step one. Opponent processes are step 2.

8) Color mixing confuses the pants off people but it is not that complicated. It is just about determining what stimulus reaches the eye.

9) In **additive color mixture**, two or more lights are combined so that the *union* of the two sets of wavelengths reach the eye. So if light one is the set {400 & 500 nm} and light two is the set {600 & 650 nm}, light one plus light two will be the set {400, 500, 600, 650}.

10) In **subtractive color mixture**, filters remove light and you see the *intersection* of the filter properties. Paint, for example, is a filter. It sucks up one set of wavelengths and reflects back the remaining subset. Suppose you start with sunlight containing wavelengths from 400 to 700 nm. Now, let's pass that light through filter one. Let's suppose it pass wavelengths between 500 and 600 nm. Let's pass that remaining light through filter two, suppose it only passes light between 400 and 550nm. The resulting subtraction will leave you with light between 500 and 550 nm – the only wavelengths passed by both filters.

Hope that helps…..

P197 and you should be able to define the term "**receptive field".**

Something to write about, #4: Kitaoka's Snakes

Akiyoshi Kitaoka makes some of the best visual illusions in the world. You will find his snakes on the course web page in the KITAOKA'S SNAKES file. You can also visit his web page. It has all sorts of gorgeous things on it.
http://www.ritsumei.ac.jp/~akitaoka/index-e.html

His explanation is posted in the same file on our webpage

You can also check
http://psych.upenn.edu/backuslab/vss/vss2004/backus2004.html

But no one *really* understands this effect.
If write about this, play with it. What makes it move? What makes it stop?
Do you have a theory?