Parts of the Eye

Pupil, Iris, and Lens

We’ll start our discussion of vision with the parts of the eye that light strikes first and work our way in (Figure 1). An object, let’s say a chair, first strikes the cornea, which is a small transparent area in the outer covering of the eye. Light then passes through the pupil, which is a hole that is surrounded by the iris, the color in our eyes. The iris expand or contract in response to light as you probably already know, so that the iris is small and the pupil large in dim or dark light and vice-versa in bright light. In dim light it’s best to take in as much light as possible, whereas in bright light it’s best to take in less light so as not to damage fragile structures inside the eye. Interestingly, the pupil/iris combination also changes in response to psychological factors. One sign of activation of the sympathetic nervous system, which is a system important in arousal, fight, and flight, is dilated pupils. For example, sexual interest results in pupil dilation. (This piece of information may come in handy some time.) The light passes through the pupil to the lens, which, among other things, reverses the image so that an upside down image is what is actually displayed on the back of our eye. The pupil also changes in shape, becoming more rounded for vision close up and more flattened when we are focusing on something in the distance. The light waves that represent some object (e.g., a chair) then pass to the back of the eye to the retina where the signal is converted so that the brain can understand it. It is important to note that the pupil, iris, and lens have already manipulated the light waves that make up this image, and this constitutes the first of many ways in which our visual system actively works on the light/image, so that, what we actually “perceive” is very much an augmented version of the “real” visual stimulus.

Figure 1. Parts of the Eye

Retina

The retina plays a very important role in that it consists of unique types of cells that are referred to as sensory receptors. All of our sensory systems include receptors in one form or another, and, in each case, they play the role of converting some external physical signal (e.g., light waves, sound waves, or pressure) to a neural signal that the brain can understand. In fact, the visual parts of the brain do not directly respond to light waves at all, rather they respond to the a neural signal the results from the retina’s response to light waves. As you can see in figure 2, the retina consists of three layers of cells. The cells are set up in an odd fashion, in that the light passes through the layers to get to the retina, then the neural signal passes back out the layers and
then all of the cells converge together to go out through the optic nerve. This area where the nerves pass through the back of the eye is called the optic disc. In this area there are no cells, so light falling on this area cannot be processed. This is why the optic disc is also referred to as the blind spot. When we look directly at an object, the light waves that make up the object fall on the fovea. This small area in the middle of the retina is where, in many ways, the most important visual processing on the retina takes place.

![Figure 2. Layers of the Retina](image)

**Rods and Cones**

There are two types of receptor cells that make up the retina, rods and cones. These cells got their names because of their shapes. There are also basic functional differences between rods and cones. First of all, there are many more rods than cones, although cones do the bulk of the work in every day light. The cones are more responsible for acute (detailed) vision, and are also responsive to colors, whereas rods mostly only respond in black and white. Rods do the bulk of work in dim and dark light and this is one reason why, in dark light, we see much less color and detail. While cones are mostly located on the fovea, rods are located in all parts of the eye besides the fovea. Although cones have better acuity, in that they respond to details much better, rods are said to be more sensitive, in that it takes less light for the rods to respond.

The difference between rods and cones in acuity vs. sensitivity is largely due to the way the retina is “wired” as opposed to the physical structure of the rods or cones themselves (see figure 3). As the message passes from the receptors through the other layers of cells back into the brain, there is much less convergence for cones, meaning that individual cones synapse on fewer cells than do the rods. This retains and focuses the signals for the cones, so they are better able to respond to detail, much as a computer screen with higher resolution (more pixels) shows more detail (see figure 4). On the other hand, since several rods converge onto a few cells in the next layer a signal anywhere on the retina is more likely to get passed on to any given subsequent cell in the neural pathway. Therefore, the rods are more sensitive to the fact that a signal has
occurred, they just aren’t quite sure where it came from (see figure 5, requires a shockwave plug in).

Figure 3. Convergence of Rods vs Cones on Subsequent Cells

Figure 4. Effect of Differential Rod-Cone Convergence on Visual Acuity