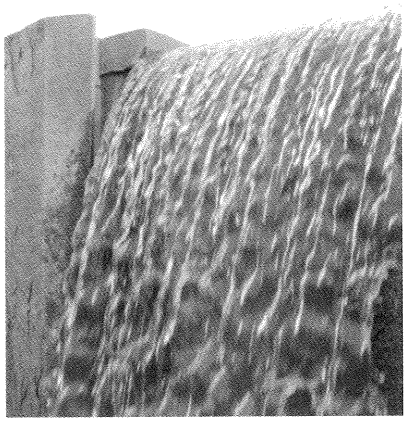


The *waterfall effect.*

Motion in the eye

by Hugh McDonald

How do we see motion?

This might seem an unusual question. After all, shouldn't seeing something that's moving be the same as seeing something that's standing still? But seeing motion is actually a very special aspect of your visual system, one with important physiological and evolutionary implications.

You don't rely solely on vision to perceive motion, of course—hearing plays an important role, too—but the primary human pathway for perception of motion is visual. The visual system runs on light: Light from the sun or another source bounces from objects into your eye and is focused by the eye's lens onto the *retina,* a membrane at the back of your eyeball that contains millions of light-sensitive cells. The light stimulates some of these cells to fire, and their combined messages are sent to your brain, which creates your visual perception of the world.

So what's so special about seeing things move? Moving objects grab your attention more than almost any other kind of visual stimulus. Like most animals, you've been "hard-wired" by eons of evolution to be especially sensitive to motion. Efficiently detecting a moving object has often meant being able to capture a meal—or avoid becoming one. The evolutionary argument is that animals detecting motion capably were more likely to survive, and the visual adaptations that made seeing motion easier were therefore more likely to be passed on to future generations. This ultimately led to a world populated with animals that were pretty good at seeing motion—like us.

Notice, for example, that you can detect motion virtually *anywhere* in your visual field—unlike fine details, which can only be perceived by looking directly at an object. In fact, while you may be unaware of stationary objects in your visual periphery, they often seem to jump into existence when they move. (See Try This! at left.) In addition, most animals reflexively turn their heads in the direction of motion perceived out of the corner of the eye.

Your nervous system is even adapted to differentiate among different kinds of motion. Specialized cells in your eye and brain react to motion in specific directions. By measuring the visual system's response to lines moving in different directions, researchers have determined that some cells respond only if the lines move in one direction, and other cells respond only to motion in other directions.

Moving objects also present special challenges for the visual system. The image of a moving

Try This!

Motion makes things visible

Fix your eyes on a point in front of you. Now hold an object (something colorful works well) in your outstretched hand and slowly move it to one side, keeping the object as steady as possible. Stop as soon as you can't see the object anymore, and remember to keep staring straight ahead. Now find out what happens when you move the object up and down.

What's Going On?

Even though you couldn't see the object a moment earlier, it should be visible as soon as it's in motion—demonstrating that you can detect motion at the edge of your peripheral vision.

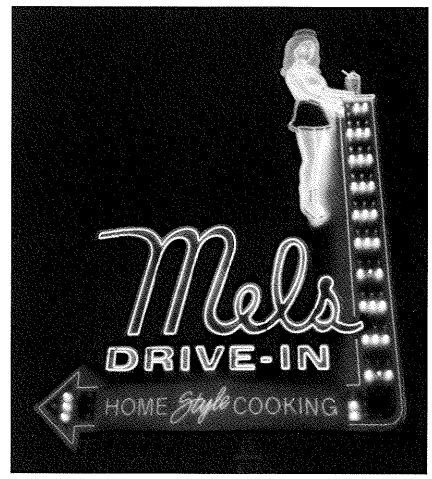
object focused on a stationary retina (when your head and eyes are still) may be identical to the image of a stationary object seen as your head or eyes move. So how does your brain know whether it's the object or your eyes that are moving? Your brain tells these movements apart by analyzing several different kinds of additional information. For example, your nervous system takes the position and motion of your head and eyes into account when it interprets an apparently moving stimulus. Your brain also relies on *vestibular* information to interpret motion: Data from the balance-sensing organs in your inner ear are used to determine where the movement originates. (And under some circumstances, inconsistencies between visual and vestibular information can cause motion sickness; see "That Queasy Feeling" on page 22.)

Along with your sensitivity to motion, though, you're also susceptible to illusions involving motion. We've all experienced these. For example, there's the *waterfall effect,* in which seeing something move in one direction can cause the subsequent illusion of motion in the opposite direction. The name of this illusion comes from a common situation in which it occurs: After keeping your eyes fixed on one point in a waterfall for thirty seconds or so and then looking at a blank wall or rock face, the wall may momentarily appear to crawl upward. As you watch the water, the cells that detect its downward motion adapt and stop responding, and upward-motion detectors then override them for a second or two—so you briefly perceive motion in the direction opposite to that which you first saw.

You may also see motion where there is none. For example, lights on a theater marquee and on some signs can look as if they're moving. That's a special case of the *phi phenomenon,* in which two lights blinking alternately at a certain rate are perceived as one light moving from place to place.

Perceiving motion in a movie is another example of seeing motion where there isn't any: Moving images in film or television are really a series of rapidly flashing still images, but your visual system "holds on" to each image for a fraction of a second (a phenomenon called *persistence of vision*) and combines them to produce the illusion of smooth motion.

The world around us is breathtaking in its complexity, but our visual systems have been shaped by evolution to allow us to perceive the amazing variety of stimuli surrounding us. Seeing provides us with beauty as well as allowing us to detect stimuli important to our survival, and our ability to see and understand motion is an especially fascinating—and challenging—aspect of our ability to navigate our visual world. ➤



The *phi phenomenon.*

Perception Exhibits at the Exploratorium

Vision scientists have found motion to be a particularly rewarding avenue of study, which is why motion perception is a key aspect of the Exploratorium's new *Seeing* collection. The collection showcases contemporary and classic exhibits on vision, many focusing on how we see movement. For example, Silage Beach (by Artist-in-Residence Mowry Baden) puts visitors into a moving environment to generate the strong illusion of physical motion. Depth Spinner gives viewers a taste of the waterfall effect, while Motion Detection and Disappearing Act show how motion can make invisible objects visible. The *Seeing* collection officially opens to the public on June 29, 2002.