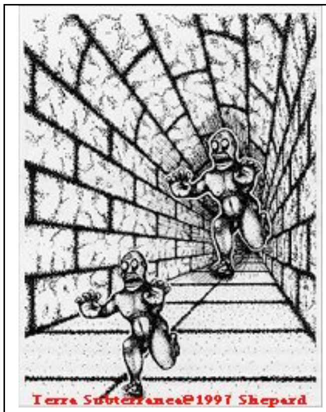
Lecture 24 – Illusions, Masking, Motion Perception

LAB 7 COMMENTS

IllusionWorks web site

Many of the illusions demonstrated that what we see is not simply the retinal image. Much of what we see depends on how the visual system interprets and processes the retinal images. Shadows, size constancy, prior knowledge and other factors play an important role in visual perception.



Size constancy illusions demonstrate how significantly our visual system modifies the raw data of the retinal image. The moon illusion (Schwartz Fig. 10-8) is an example of a **size constancy** illusion. You should be able to explain the size constancy illusion shown in the figure to the left, which was copied from the Illusion Works web site. (http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/index.html)

MASKING

In the study of visual perception, **masking** refers to the phenomenon in which the presence of one image (the mask) reduces visibility of another image (the target). The mask may be present at the same time as the target (simultaneous masking), and its presence reduces sensitivity of the visual system, making the target more difficult to see. Schwartz mentions the example of the **crowding phenomenon** in amblyopic patients. An amblyope has more difficulty reading a letter if it is surrounded by other letters, while an isolated letter can be read more easily.

In some experiments, the mask is presented just before the target, making the target slightly more difficult to see. This is referred to as **forward masking** and **paracontrast** is one example of this. In paracontrast, the mask appears just before the target, and slightly to one side. The target will be slightly more difficult to see because of the masking effect.

In some cases, a mask presented afterwards can make a target harder to see. This is referred to as **backward masking** and **metacontrast** is one type of backward masking. In metacontrast the target is presented first, and then the mask appears slightly to the side. Even though it is presented after the target, the subsequent mask affects visibility of the target. How is this possible? Refer to Schwartz for the answer.

Other examples of masking are **after-effects**, which cause visual adaptation, such the light-bulb figure on the IllusionWorks web site or the **motion after-effect**. If the visual system adapts to a certain stimulus by looking at it for a while, its sensitivity to that stimulus declines, while the opposite perception is enhanced.

Another example is the **waterfall illusion**. After staring at a waterfall for a while, then looking at scenery, the scenery appears to move upward.

Q. Can you explain the waterfall illusion?

MOTION PERCEPTION

Motion perception web site

The *motion perception web site* *(http://www.lifesci.sussex.ac.uk/home/George_Mather/Motion/), created by George Mather* (University of Sussex, England) provides a nice, though somewhat complicated summary of motion perception. In the introduction, he pointed out that motion perception depends on our ability to detect changes in retinal illumination over both space and time.

Motion obviously causes a spatial change in the retinal image. This means that the image moves to a different location in the retina (spatial change). In addition, retinal sites receiving the image will have a change in intensity over time (temporal change). The visual system must not only detect changes in location, but it must also interpret a change in illumination over time, at specific retinal locations. In the lizard illustration, rightward movement was associated with

- increasing brightness on the right side of an edge
- decreasing brightness on the left side of the edge.

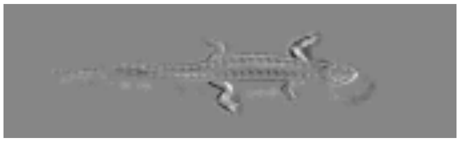


Figure 1. Example of a lizard in motion from George Mather's motion perception web site.

The visual system, therefore must also interpret spatial information in terms of a contrast gradient; that is, is the retinal illumination *increasing* or *decreasing* in a particular retinal location. Quoting from the web site:

> *This representation [Shown in Figure 1, above] effectively isolates those parts of the image that contain movement. However, to code the direction of movement, we need to combine this temporal change information with information about spatial change-intensity edges. Referring back to the two movie frames above, we can see that the increases of intensity over time came from image regions that contain spatial edges that are bright on the left and dark on the right (e.g. the snout). Decreases over time were associated with edges of opposite contrast polarity. These space-time pairings signify motion from left to right. A reversal of polarity either in the temporal signal or in the spatial signal would signify motion in the opposite direction.*

This was nicely illustrated on the four-stroke apparent motion page. The animation consists of six frames showing a motorcycle moving forward in Frames 1, 2 and 3. After a transition slide (Frame 4), Frames 5, 6, and 7 play. They are the same as Frames 1, 2 and 3, respectively, but the black and white parts of the image have been reversed (Fig. 2 below). Since the black/white contrast at all edges is reversed, this should reverse the direction of motion. But the negative images are drawn to move backward. As a result, although the image actually moves backwards spatially from Frame 3 to 5, the reversed contrast gradient makes it appears to move forwards. The motorcycle therefore appears to be continuously moving forward.

Figure 2. Contrast and motion reversal.

Motion contributes significantly to our perception of depth, as illustrated by the **kinetic depth effect** and **biological motion***.* Scientific evidence indicates that biological motion is processed by specialized neurons in the brain (Schwartz p. 219).

SCHWARTZ CHAPTER 9 REVIEW

Motion perception is based on the principles of temporal vision. To perceive motion, the stimulus must show a **spatiotemporal** change in the retinal image.

- A change in retinal illumination over time for one particular location in the retina
- A spatial shift of the image to a different retinal location

For example, when looking at a baseball flying across space, its image passes over one retinal location creating a quick change in retinal illumination there (temporal change). Then its image appears on an adjacent retinal location (spatial change). The same applies for every other moving object that we see.

For foveal vision, under best visibility conditions, the minimum speed for motion perception is an angular movement of about *1-3 arc minutes per second.* This can vary greatly depending on test conditions.

Stroboscopic motion or illusory movement

It is possible to create the illusion of movement by sequentially flashing the image of an object in two adjacent retinal locations. This fulfills the requirements for motion perception listed above. This is referred of as **stroboscopic motion**, or the **phi phenomenon**.

This is illustrated by Schwartz Figure 9-1. One light is flashed, and shortly after, another adjacent light is flashed. If the second image is flashed about 60-200 msec after the first, it will produce an illusion of movement. This principle is used to create apparent motion in illuminated signs or neon lights. It is also the basis for motion pictures, television and computer generated images. An image is shifted spatially to an adjacent retinal location with these temporal parameters.

A nice demonstration of the stroboscopic motion may be found at the “Joy of Visual Perception” web site. See: *http://www.yorku.ca/eye/balls.htm*

Motion after effects

If a person stares at a moving grating, the visual system adapts to that motion. If you suddenly stop the grating, the stationary stripes will appear to drift in the opposite direction. This illustrates the principles of masking and adaptation that you read about in Schwartz Chapter 8. This is another example of a **motion after effect,** and you saw a dramatic demonstration of this at the IllusionWorks web site. Another example is the waterfall illusion, mentioned above.

Interestingly, motion after effects are *binocularly transferred*. If you view the adapting target with one eye, you can see the after effect in the other eye! This is evidence for specialized motion detectors within the visual cortex, or higher centers in the brain. You should verify this my redoing the motion after effect demonstration at IllusionWorks with one eye, and see if the effect is visible to the other eye.

Magnocellular pathway

Studies have shown that certain areas within the visual cortex and higher centers specialize in motion analysis. These receive primary input from the **magnocellular pathways**, which are the neuronal tracts that are important for temporal vision and motion perception. The magnocellular pathways begin with ganglion cells that receive input mainly from cones in the peripheral retina. The pathway is distinct from another pathway that mainly processes foveal information—the **parvocellular pathway**. The magno and parvocellular pathways travel in parallel from the retina, through the LGN, to the visual cortex. From there, it appears that visual information is processed by an area in the parietal lobe known as the **middle temporal area (MT)**. It is also sometimes referred to as area **V5**. The pathway from the primary visual cortex (V1) to V5 is known as the parietal pathway, and it is important for motion perception.

Magnocellular neurons in the retina (nerve fiber layer) are the ones that are most susceptible to glaucomatous damage, so vision tests that emphasize magnocellular functions such as high speed flicker, temporal sensitivity or motion, may be used to test for glaucoma. We'll study the magno and parvo parallel pathways later in the semester.

Random dot kinematograms

Motion perception has been studied by using sine wave gratings that drift across a stimulus window at different rates of speed. This is a relatively simple form of motion, since it involves a change in retinal illumination at one location, or a shift of a single image from on location to another. This is referred to as **first-order motion**.

A more complex kind of motion has been studied using **random dot kinematograms**. These are illustrated in Schwartz Fig. 9-3 and 9-4. The stimuli contain many tiny dots that are moving in random directions, except for a subset, which moves in a common direction. These dots, which are moving together, are said to have **motion coherence**. To test another aspect of motion perception, the percentage of dots with motion coherence is gradually increased until the subject notices the subset moving in a common direction. This is the person's **motion coherence threshold**.

In order to perceive motion coherence, the visual system must integrate the perceived motion of many dots in multiple locations into a perception of common motion. This is more complex than first-order motion and is referred to as **global motion perception** or **second-order motion**. The introduction to the motion perception web site also illustrates and explains this nicely.

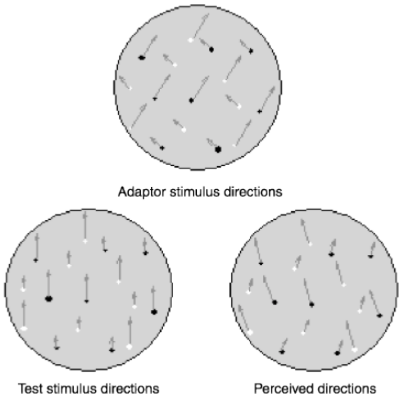


Figure 3. Examples of random dot kinematograms, from the Journal of Vision web site. (http://www.journalofvision.org/6/12/10/article.aspx)

Random dot kinematograms can also be used to used to measure the **minimum displacement threshold**, or minimum movement of dot that a person can detect, or the **maximum displacement threshold**, which is the maximum displacement that gives rise to a perception of motion (Schwartz Fig. 9-4).

OTHER TOPICS IN MOTION PERCEPTION

Schwartz mentions research that has shown a difference in motion perception for photopic versus scotopic conditions. "Psychophysical studies show that objects appear to move slower (about 25% slower) under scotopic (rod), compared to photopic (cone) vision. (Schwartz p. 220)

We normally measure visual acuity with a stationary chart, but visual acuity may be different for a moving target, depending on how fast it is moving. For objects moving slowly enough that the eye's smooth pursuit mechanism can maintain foveal fixation, **dynamic visual acuity** is about the same as static visual acuity. But for faster movement, visual acuity declines because the eyes are not able to maintain steady foveal fixation. This is illustrated in Schwartz Fig. 9-6. The testing and visual training of dynamic visual acuity is important in a sports vision, a topic you'll study in another course.

If you quickly shift fixation from one object to another, your eyes perform an eye movement known as a **saccade**. If you take a video picture and quickly shift your view from one object to another, the entire scene moves. When your eyes perform a saccade, the visual scene sweeps across the retinas, but you don't perceive movement in the scene. Amazingly, the visual scene remains stable. This is because, during the brief time of the saccade, your visual system automatically suppresses the visual input from the retinas. This is referred to as **saccadic suppression.** This stabilizes our visual perception in spite of frequent rapid movement of our eyes.

Depth Perception (Schwartz Chapter 10) – Read and study Chapter 10 on your own.