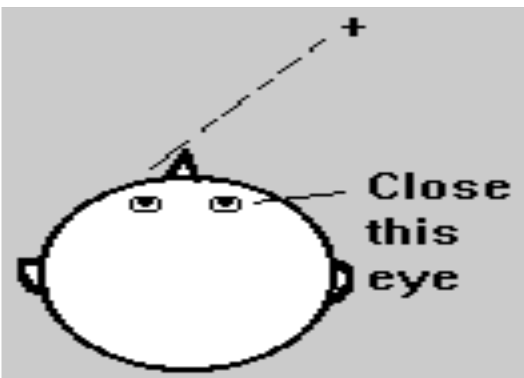
Honors Physiology
The Special Senses
Vision

Optical Illusions

#1:  The Blind Spot

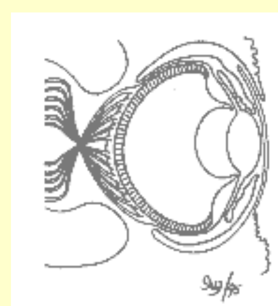
One of the most dramatic experiments to perform is the demonstration of the blind spot. The blind spot is the area on the retina without receptors that respond to light. Therefore an image that falls on this region will NOT be seen. It is in this region that the optic nerve exits the eye on its way to the brain. To find your blind spot, look at the image below. Close your right eye. Hold the image 20 inches away. With your left eye, look at the +.



Slowly bring the image (or move your head) closer while looking at the +. At a certain distance, the dot will disappear from sight...this is when the dot falls on the blind spot of your retina. Reverse the process. Close your left eye and look at the dot with your right eye. Move the image slowly closer to you and the + should disappear.

Did you know?

An octopus does not have a blind spot! The retina of the octopus is constructed more logically than the mammalian retina. The photoreceptors in the octopus retina are located in the inner portion of the eye and the cells that carry information to the brain are located in the outer portion of the retina. Therefore, the octopus optic nerve does not interrupt any space of retina.



Octopus Eye (Image courtesy of Biodidac)

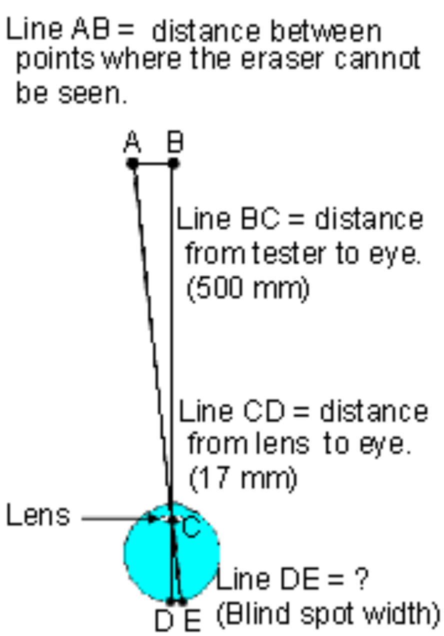
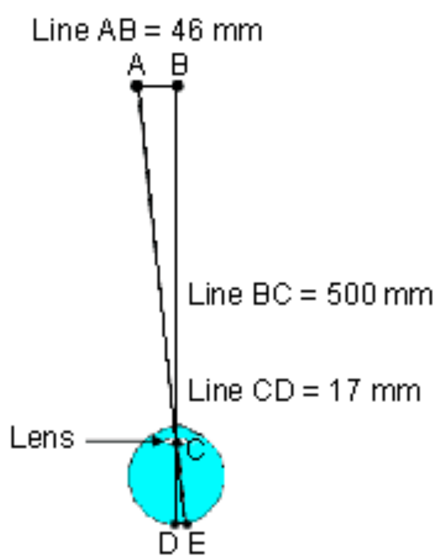
#2:  Measuring Your Blind Spot

The blind spot is caused when light falls on an area of the retina without photoreceptors. How big is this area on the retina? Here is one way to find out the horizontal diameter of the blind spot.

1. Make a tester by marking + on the far right side of a piece of notebook paper.
2. Stand with your back to a wall, with your head touching the wall.
3. Hold the tester 500 mm (0.5 m or 50 cm) in front of your eye. (It may help to have someone help you.)
4. Close your right eye and look at the + with your left eye.
5. Place a pencil eraser on the far left side of the tester.
6. Slowly move the pencil eraser to the right.
7. When the eraser disappears, mark this location on the tester. Call this point "A."
8. Continue moving the eraser to the right until it reappears. Mark this location on the tester. Call this point "B."
9. *Repeat the measurements until you are confident that they are accurate.*
10. Measure the distance between the spots where the eraser disappeared and reappeared.

To calculate the width of your blind spot on your retina, let's assume that 1) the back of your eye is flat and 2) the distance from the lens of your eye to the retina is 17 mm. We will ignore the distance from the cornea to the lens.

With the simple geometry of similar triangles, we can calculate the size of the blind spot because triangle ABC is similar to triangle CDE. So, the proportions of the lines will be similar. When I did this experiment, the measured distance between point A and point B was 46 mm. Inserting 46 mm into the equation, the blind spot on my retina has a diameter of 1.56 mm.

Set up	Example	Calculations
		$\frac{17}{500} = \frac{DE}{AB}$ - - - - - - - - - - - - - - $\frac{17}{500} = \frac{DE}{46}$; $DE = (46)\ \frac{17}{500}$; $DE = \frac{782}{500} = 1.56$

#3: Benham’s Disk

In 1894, toymaker Mr. C.E. Benham discovered that a spinning disk with a particular pattern of black and white marks could cause people to see colors. Mr. Benham called his disk an "Artificial Spectrum Top" and sold it through Newton and Company. Benham's Top (or Benham's Disk) has puzzled scientists for over 100 years.

Here is how to make your own Benham Top:

1. Get the printed card stock and a toothpick.
2. Cut out the circles carefully. It is important that the circle is as round as possible.
3. Poke a hole in the center of the circle with the toothpick.
4. Insert the toothpick into the hole. The toothpick should stick out about half an inch. Break or cut the toothpick in half.
5. Twist the toothpick to spin the spinner.
6. SPIN THE SPINNER! Try other disks.

Special Notes

1. The colors are seen best at slow speeds (between 3-5 rotations/second).
2. It is important that your spinner can spin at slow speeds. Therefore, make sure your spinner is centered properly. Make sure you place the toothpick in the center of the spinner.
3. Experiment!
   - Change the pattern. Make you own pattern using the blank disk. Use a black marker to draw a pattern or series of arcs on the white side of the disk.
   - Change the color of the disk. What happens if you use a blue disk?
   - Spin the spinner clockwise and counter-clockwise.

What colors do you see when you spin a Benham disk? List all of the colors that you see -
Red, Orange, Yellow, Green, Blue, Pink, Purple, or Brown

What's Happening? What Causes the Colors?

The retina of the eye is composed of two types of receptors sensitive to light: cones and rods. Cones are important for color vision and for seeing in bright light. There are three types of cones, each of which is most sensitive to a particular wavelength of light. Rods are important for seeing in low light.

It is possible that the colors seen in spinning Benham disks are the result of changes that occur in the retina and other parts of the visual system. For example, the spinning disks may activate neighboring areas of the retina differently. In other words, the black and white areas of the disk stimulate different parts of the retina. This alternating response may cause some type of interaction within the nervous system that generates colors.

Another theory is that different types of cones take different times to respond and that they stay activated for different amounts of time. Therefore, when you spin the disk, the white color activates all three types of cones, but then the black deactivates them. The activation/deactivation sequence causes an imbalance because the different types of cones take different times to respond and stay on for different times. This imbalance in information going to the brain results in colors.

Neither of these theories explains the colors of Benham's disk completely and the reason behind the illusion remains unsolved.

#4: Depth Perception 1

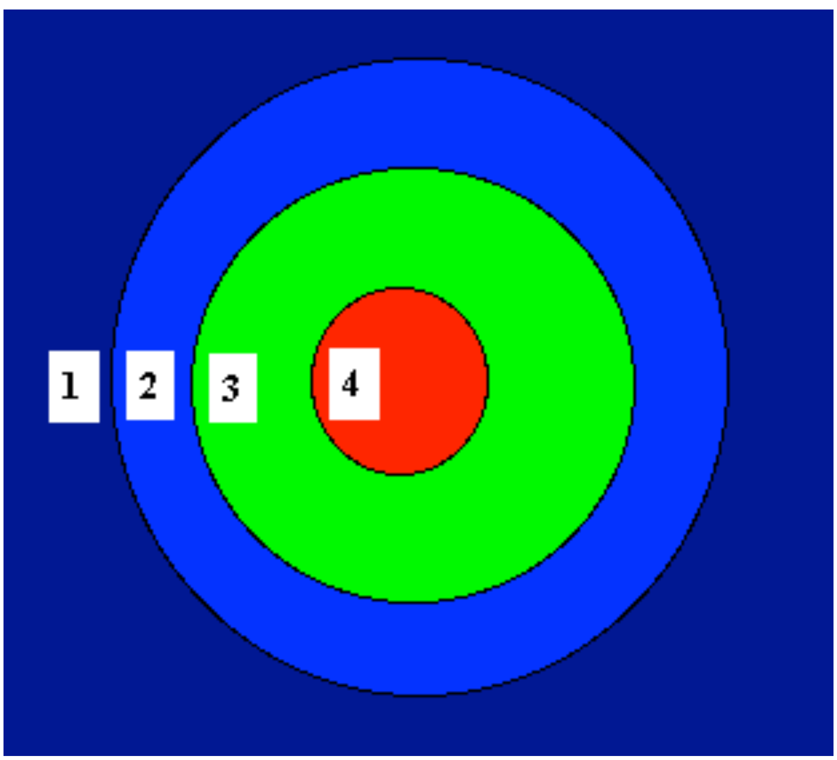
Materials: 2 Pencils

Two eyes are better than one, especially when it comes to depth perception. Depth perception is the ability to judge objects that are nearer or farther than others. To demonstrate the difference of using one vs. two eyes to judge depth hold the two pencils, one in each hand. Hold them horizontally facing each other at arms-length from your body. With one eye closed, focus on the space between the two pencils and try to touch the end of the pencils together. Slowly repeat this several times. Now try with two eyes: it should be much easier. This is because each eye looks at the image from a different angle.

#5: Depth Perception 2

Materials: Paper for target, pens (two colors)

Get a piece of paper and draw a target similar to the one on the right. The actual dimensions of the circles are not too important and you don't have to color the circles. Place the target on the ground about five feet in front of you. Have a friend stand near the target. Have your friend hold out a colored pen with the tip pointing down. Close one eye. Tell your friend to move forward or backward or side to side until you think the pen would hit the center of the target if it was dropped. Tell your friend to drop the pen when you think the pen is over the target center. The pen should leave a spot where it hit the target. Try it 10 times with one eye closed and add up the "score" for the 10 drops. Now try it with both eyes opened (get a different color pen when you use 2 eyes to see the difference on the target).



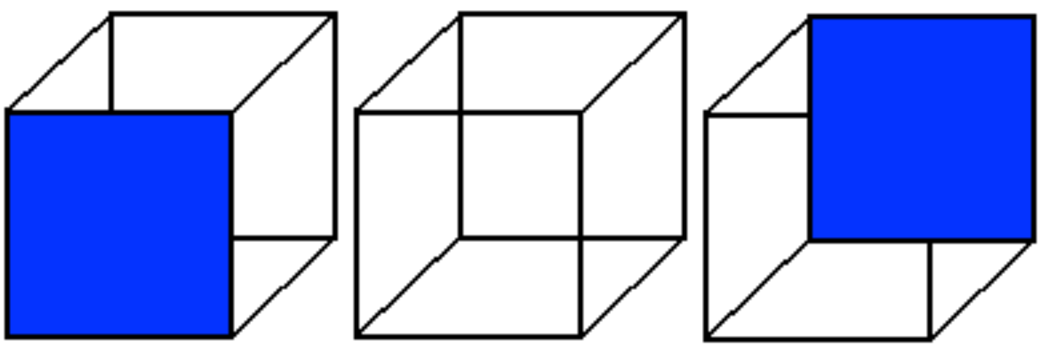
#6: 3-D Vision

Here's another way to demonstrate how different images are projected on to each eye. Look at an object in the distance (20-30 feet away), such as a clock on the wall. Close one eye, hold up your arm and line up your finger with the object. Now without moving your finger or your head, close the opened eye and open the closed eye. The object in the distance will appear to jump to the side...your finger will no longer be lined up. This shows that different images fall on each eye.

#7: Visual Illusions

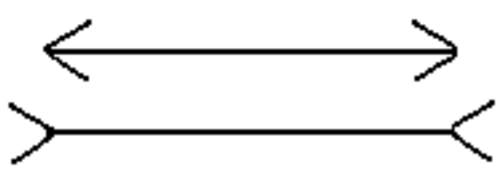
1. The Magic Cube

   Look at the center cube. Which side is the front? Is the front as shown on the cube on the right side or is the front as shown on the cube on the left side or is there no front at all?



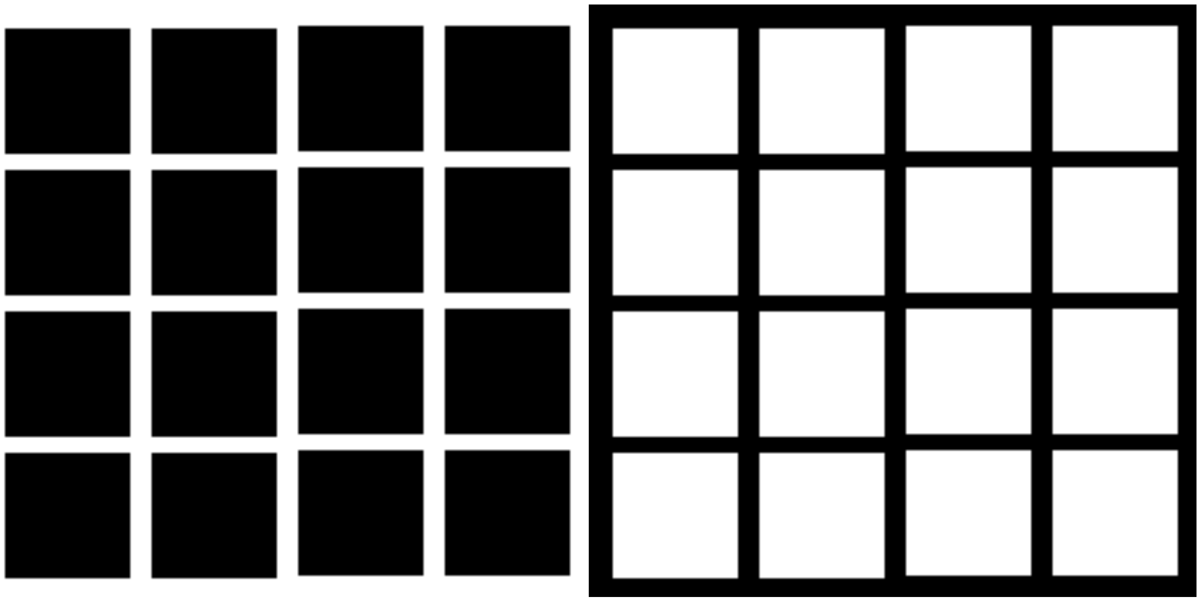
2. Which of the lines shown below is longer?

   Muller-Lyer Illusion



   Measure them. What is the length of the top line? The bottom?

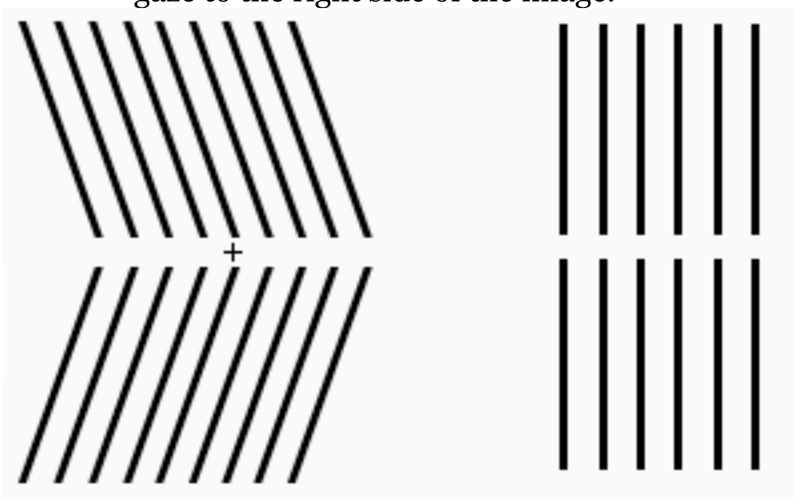
3. Stare at the middle of picture with black squares 15-30 seconds. Are those really dots that appear at the corners of the squares? What happens if you focus on a dot? Now look at the middle of the picture with the white squares. Do you see dots again? What color are they?



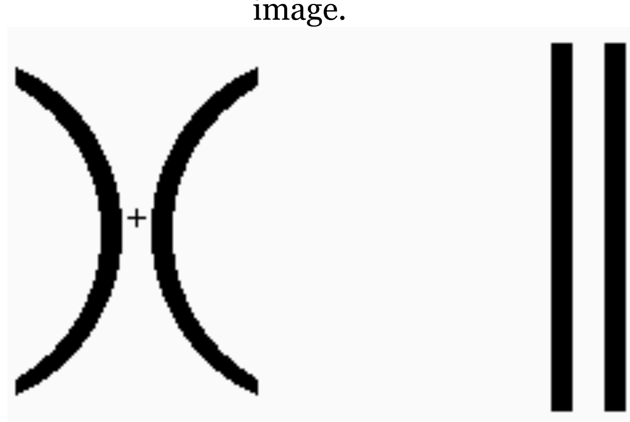
4. Do you see a vase or a face in the figure below? This type of picture was first illustrated by psychologist Edgar Rubin in 1915. Notice that it is very difficult to see both the faces and the vase at the same time.

5. After Images

Stare at the + for about 15 seconds, then shift your gaze to the right side of the image.



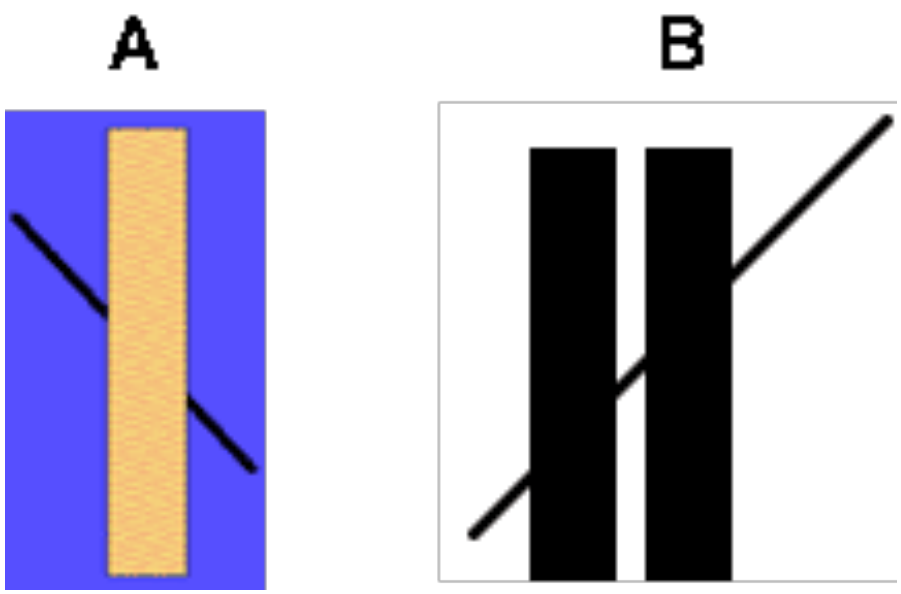
Stare at the + for about 15 seconds, then shift your gaze to the right side of the image.



Do the lines on the right side of the image look straight? Are they really straight?

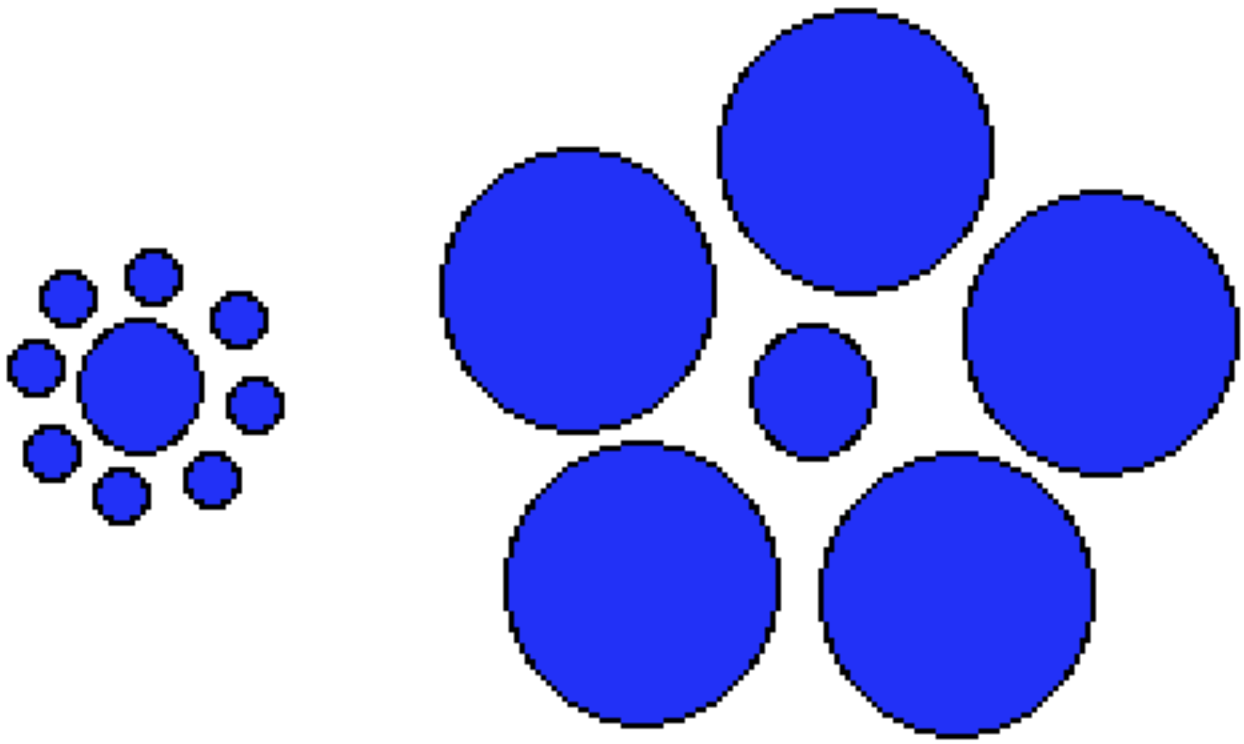
7. The Poggendorff Illusion was created by Johann Poggendorff in 1860. Are the lines behind the rectangles straight or not? It looks as if it does not go straight across, but does it?

Poggendorff Illusion



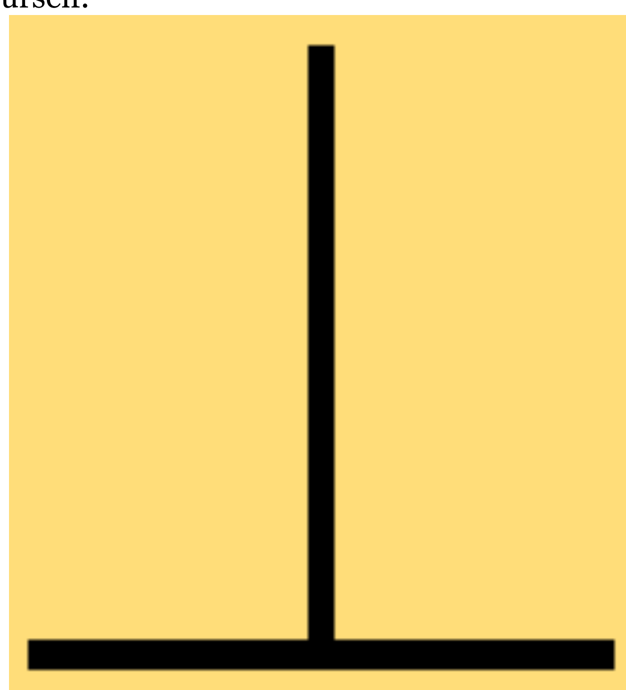
8. Hmmm...is the center circle on the right the same size as the center circle on the left?

Titchener Illusion



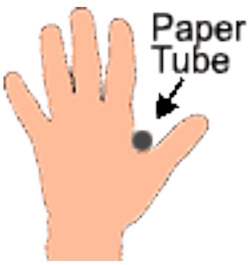
This illusion shows that our brains judge size by comparing objects to things in the surroundings.

11. To tee or not to tee...that is the question. This inverted "T" has two lines....are they the same length? Measure them yourself.



#8:  X-Ray Vision

 Materials: Notebook paper, ruler



Do you have "X-Ray Vision?" You may be able to see through your own hand with this simple illusion. Roll up a piece of notebook paper into a tube. The diameter of the tube should be about 0.5 inch. Hold up your left hand in front of you. Hold the tube right next to the bottom of your left "pointer" finger in between you thumb (see figure below).

Look through the tube with your RIGHT eye AND keep your left eye open too. What you should see is a hole in your left hand!! Why?