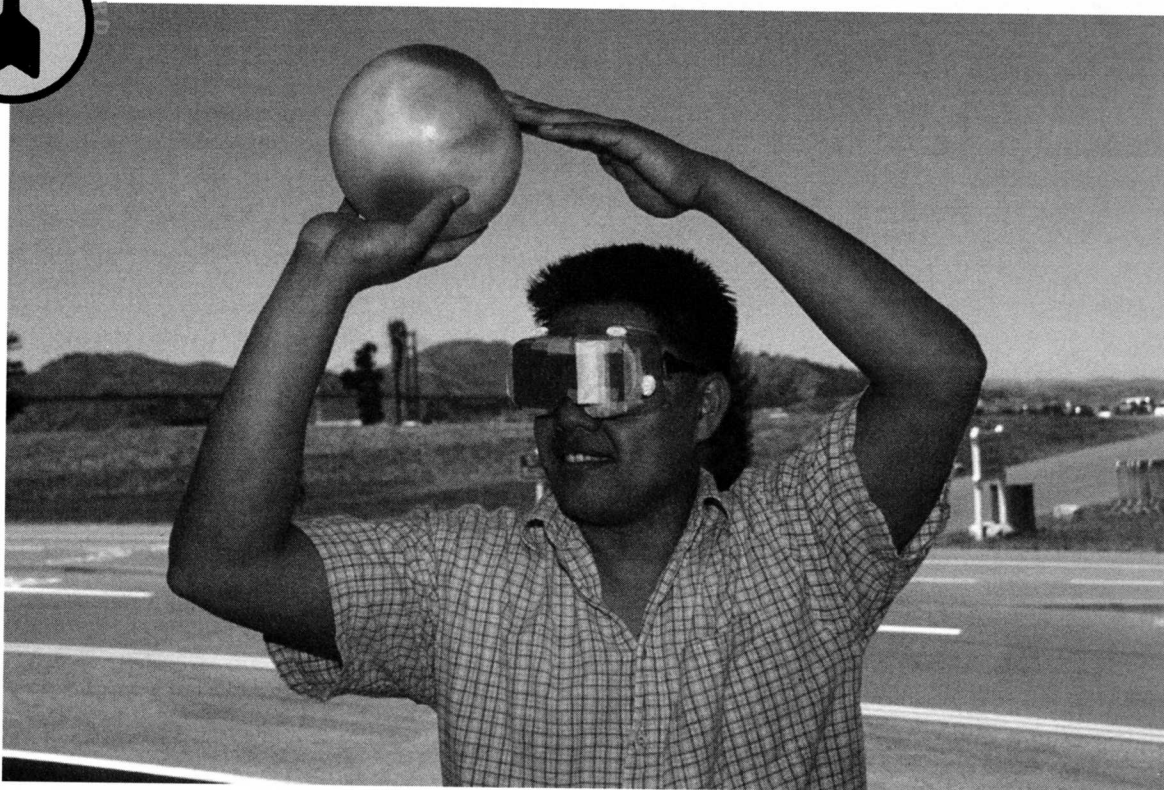


# Hoop Nightmares

Retrain your brain.

When you first try shooting a basket or throwing a ball at a target, you'll probably come pretty close, even if you might not consider yourself quite ready for the pros. But when you put on this special set of prism goggles and try to make the same shots, things get very interesting.



## Materials

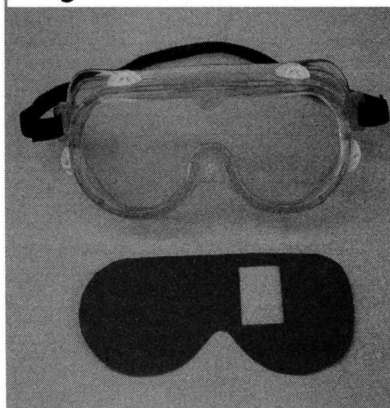
- plastic safety goggles with a flat face plate (available at hardware and home improvement stores or from scientific supply companies)
- dark-colored poster board, approximately 4 in  $\times$  8 in (10 cm  $\times$  20 cm), large enough to cover the face plate of your goggles
- pencil
- scissors
- masking tape
- plastic or glass prism, about 2 in (5 or 6 cm) long, with faces about 1 in (2 or 3 cm) wide; angles should be 45/45/90 or 30/60/90 (You can obtain prisms from Edmund Scientific Co., 800-728-6999, [www.edsci.com](http://www.edsci.com), e.g., #30318-00, science museum stores, science supply companies, and some novelty or magic stores; long plastic prisms can be cut to shorter lengths with a band saw or hacksaw.)
- a hoop or a target to throw the ball at (A Nerf hoop is ideal, but you can improvise a hoop from a coat hanger or use a cardboard box on a chair or table.)
- a ball that can be thrown indoors without breaking things (A Nerf ball is ideal.)

## ASSEMBLY

**1** Lay the safety goggles face down on the poster board, trace the outline of the goggles on the poster board, and cut out the outline to create a poster-board mask.

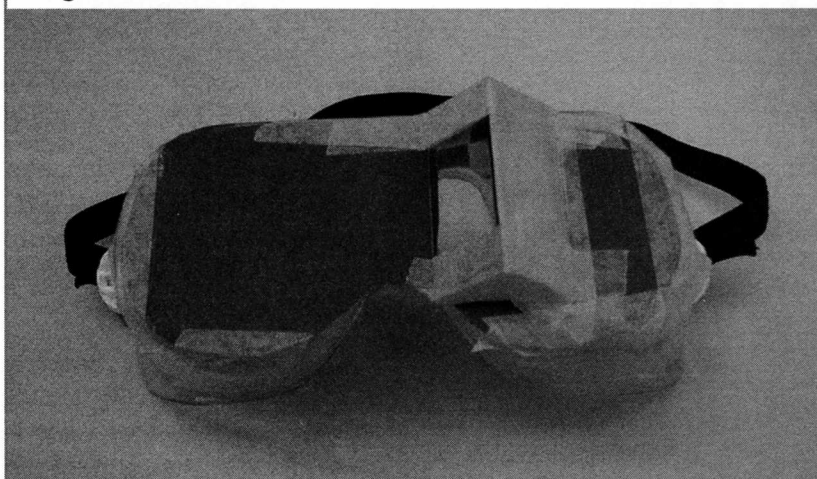
**2** Cut a rectangular opening in the mask just to one side of the middle of the goggles, as shown in figure 1. You will be taping the prism over this hole, so its size will depend on the size of the prism you have. A general guideline is to make the width of the opening half as wide as the widest face on the prism.

**Figure 1**



*Goggles and mask*

**Figure 2**



*Goggles with mask and prism in place*

**3** Tape the prism in place over the hole on the poster-board mask. The edge of the prism nearest the middle of the mask should just overlap the edge of the hole, as shown in figure 2. Put the largest face of the prism over the hole. If you're using a 30/60/90 prism, the next largest face should be facing the center of the mask. If you're using a 45/45/90 prism, one of the equal-size faces should be facing the center of the mask (you can try other orientations later to see the difference, if you want to).

**4** Tape the entire mask, with the prism attached, to the front of the goggles. When you put the goggles on, the prism will be in front of your left eye.

**5** Cover the face of the prism that will be farthest from your nose with masking tape, as shown in figure 2, so that only the face of the prism slanting toward the middle of the goggles will receive light.

**6** Set up a hoop or set up another target.

## To Do and Notice

Stand about 9 or 10 feet (3 m) from the hoop or target. (The farther you are from the target, the more obvious the effect will be.) Put the goggles on, and make sure that you can see the hoop or target through the goggles. (You will only see it with one eye, because there is only one prism.) **NOTE:** Make sure that your throwing hand is positioned so that you cannot see it or the ball through the goggles.

Try to make a basket or hit the target with the ball. Notice how close you get. Have your partner retrieve the ball for you if possible—it's hard to do with the goggles on.

Keep trying until you make a basket or hit the target three times in a row. How many tries does it take you?

Take the goggles off and try again. Keep trying until you score three times in a row. How many tries does it take you?

## What's Going On?

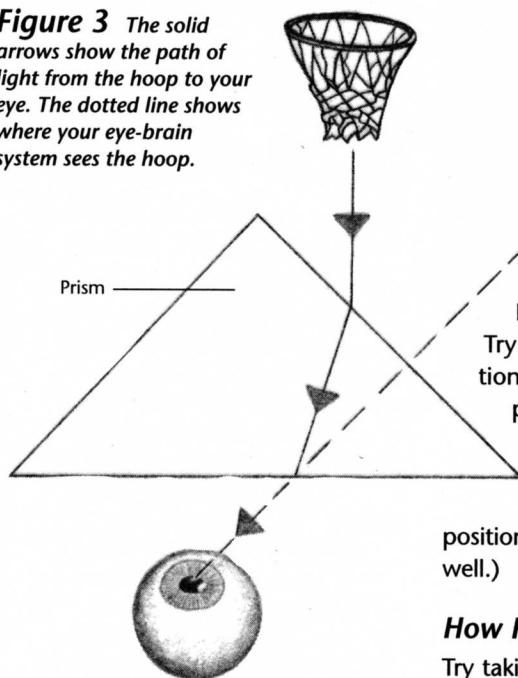
When you first put on the goggles, the ball doesn't go where your eye says it should. Because of the way it *refracts*, or bends, light, the prism makes objects in front of you appear to be to your right (see figure 3). Your brain, however, soon adapts to the distortion and adjusts your visual perception. You begin to aim farther left and get closer to hitting the target or hoop.

When you remove the goggles, your visual system remembers the prism distortion, and it functions as if the goggles were still in place. It may take a few trials for your visual system to “unlearn” the adjustments it made and return to normal.

Your experience with the goggles shows that your brain and perceptual systems are dynamic: They continually respond and adapt to your experiences, whether or not you’re thinking about them.

How does the prism distort your view of the world? Light travels from the hoop (or target) to your eye along the path shown by the arrows in figure 3. As it passes through the prism, it is bent twice—once when it enters the prism and again when it leaves. Your eye-brain system tries to follow this light back to its origin in order to locate the hoop, but it doesn’t have the ability to recognize that the light was bent. It follows the light back along a straight line defined by the ray of light that enters your eye, and so the hoop appears to be somewhere on this line.

**Figure 3** The solid arrows show the path of light from the hoop to your eye. The dotted line shows where your eye-brain system sees the hoop.



## So What?

You forced your visual system to adapt when you put on the goggles. But it doesn’t take an artificial and extreme action like looking through a prism to bring this ability to adapt into play.

On a daily basis your brain is challenged to relearn skills and change the way it processes information—all it takes is driving someone else’s car, taking a new route to the grocery store, or putting your toothbrush in a new location.

If we did not have the ability to adapt to changes in the world (or to changes in our perception of the world), life would be much harder.

*Shaking hands while wearing prism goggles can be difficult.*

## Going Further

### Playing with Prisms

Experiment with your goggles. Try different orientations or locations of the prism or use different prisms. You can even try using two prisms, one for each eye. (It may be difficult, however, to get two prisms positioned so that you can see things well.)

### How Fast Do People Adapt?

Try taking quantitative data for different people using the prism goggles to

find the range of the learning and unlearning times.

### Old Habits Die Hard

Is there something in your house that you use a lot and that has been in the same location for a long time? Change its location, and notice how long you reflexively keep trying the old location first. How long does it take for you to completely change?

## Credits

This snack is based on the Exploratorium exhibit of the same name.