

Binocular Vision Concepts and Examples

Size is calibrated without switching into slide show mode. In slideshow mode, the images are a little bit larger and don't work quite as well.

Hold up your index finger on each hand (pointing up). Have the left index finger close to your face (like 10 inches) and the right index finger farther away (like 15 inches).

Look at the two fingers with one eye. Then close that eye and switch to the other eye. Notice the gap between the two fingers. Which eye sees the bigger gap?

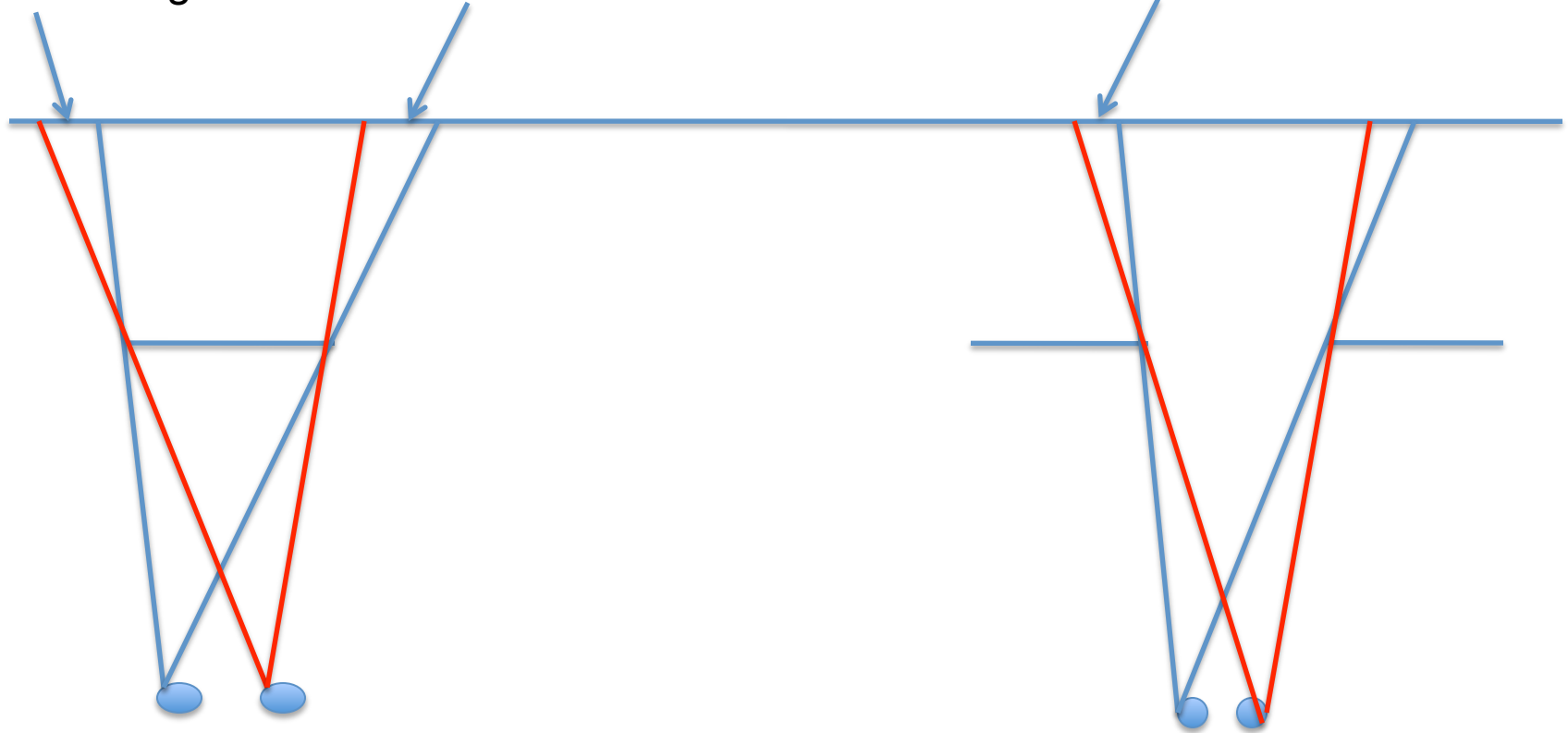
Now move the left index finger to the farther away position and the right index finger closer. Look at them with one eye, then the other. Which has the larger gap?

The next slide shows the difference between the “shape” of a solid surface in front of another plane, compared to the “shape” of a hole or window.

Visible to the left eye
but not the right

Visible to the right eye
but not the left

Visible to the right eye
but not the left

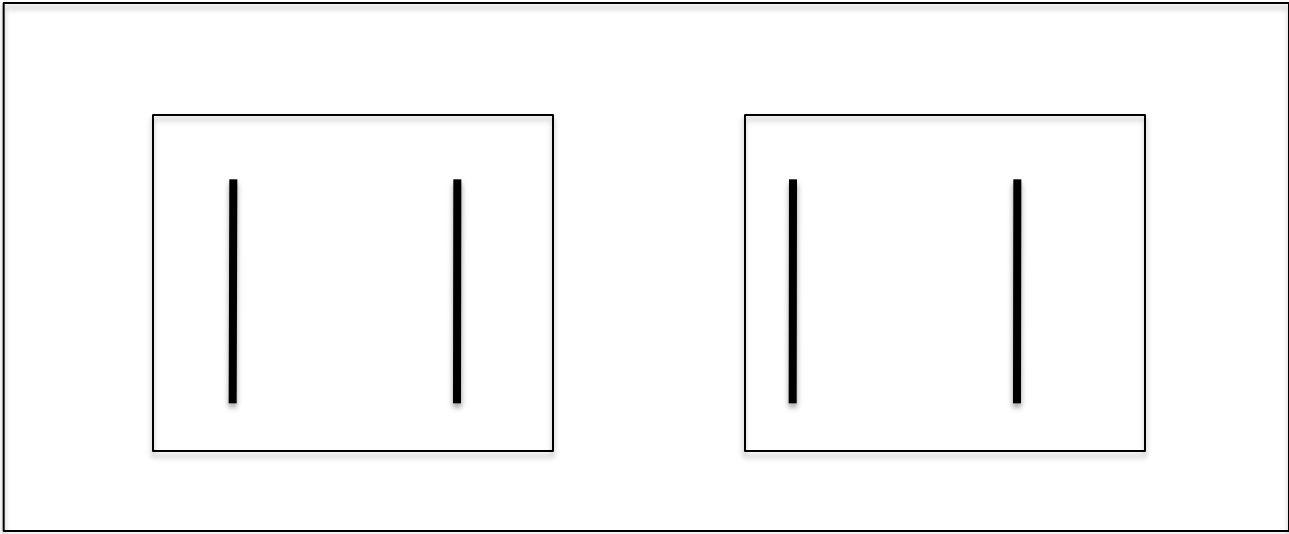


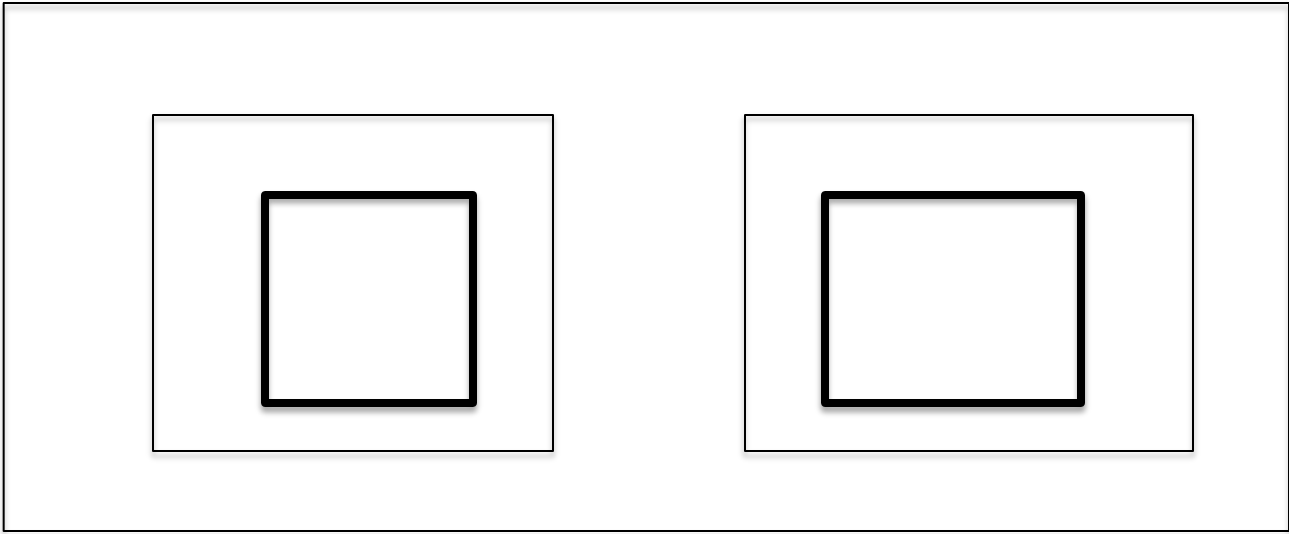
Solid "object in front

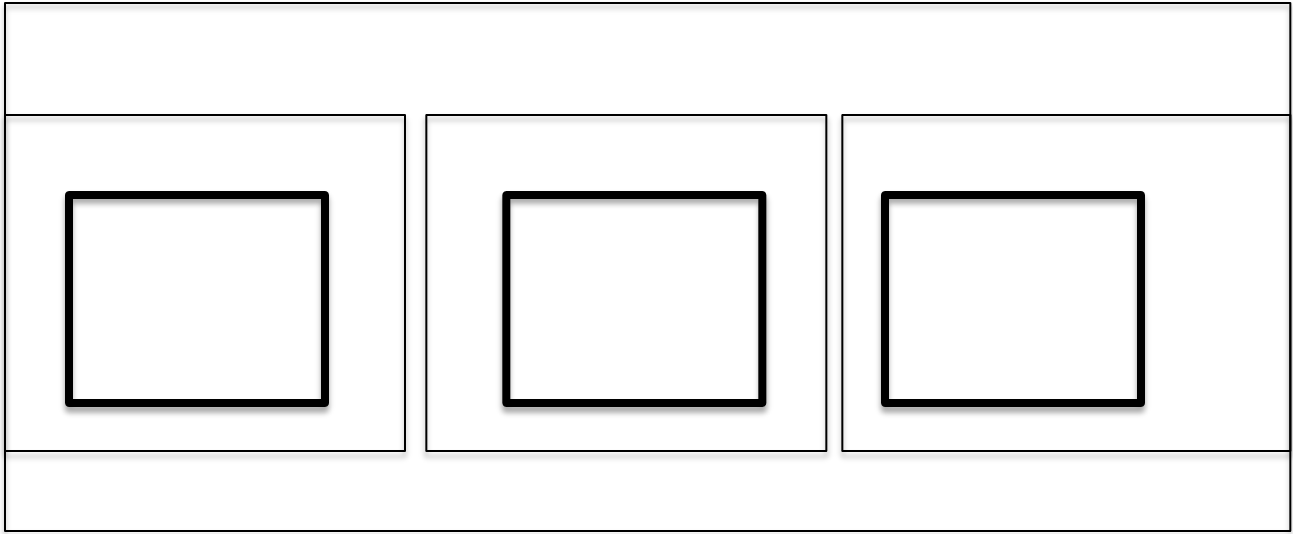
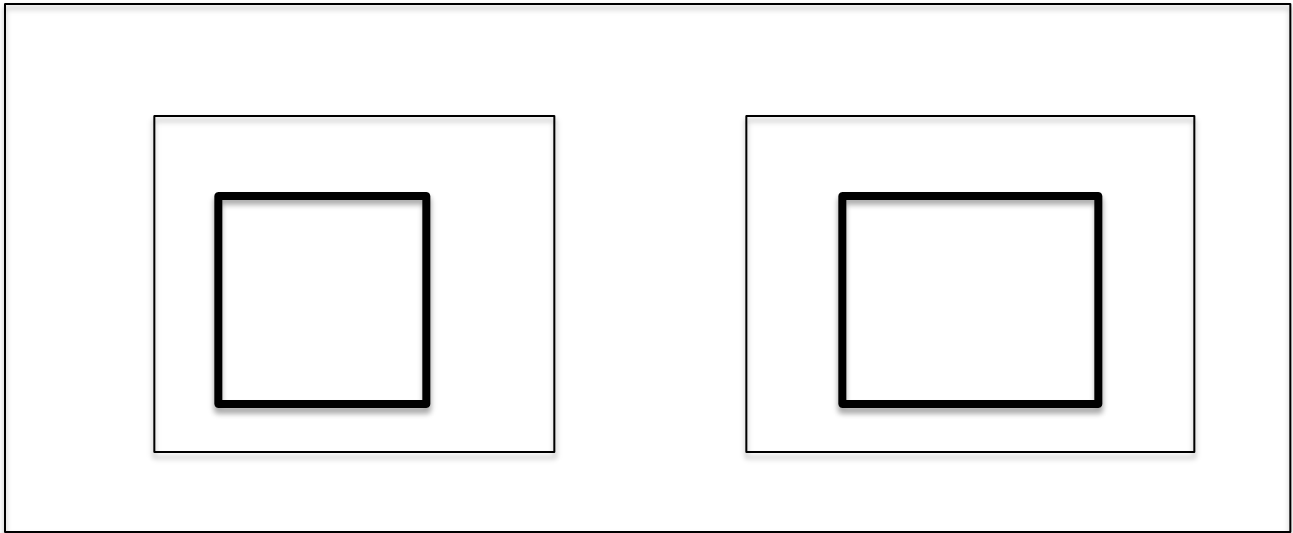
Hole or window in front

The slide after this is a caricature of the finger situation. Look at the two images with binocular fusion. That is, look at them with both eyes until there is clear depth. Which line stands out in front?

How is that like the two index finger examples?







Binocular Stereo Concepts

Binocular fusion --- Two images seen as one.

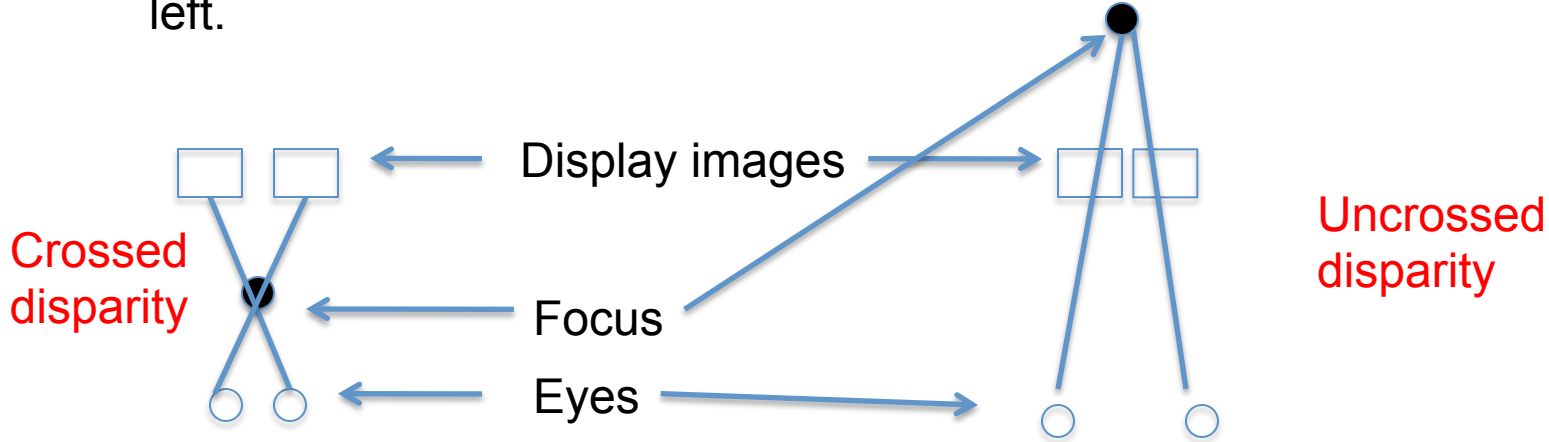
Binocular disparity -- Difference between two almost identical images. Like the example of your two fingers, and the previous slide.

Stereopsis --- Experience of depth in binocular pair. Roughly, the condition for seeing depth is that the two images be nearly alike, but with disparity. Apparently, the binocular system can detect that the two images are enough alike to put them together in binocular fusion, but different enough that there is disparity. If the two images are identical, there should be singleness of vision (fusion) without depth.

Binocular rivalry -- when two images are too different from one another, they cannot be combined. What happens is very interesting to many researchers. The two eyes feel like they are looking at one thing, but what is seen is one of the other of the two images, with fading from one to the other.

Crossed disparity --- If you look at two images so that your left eye sees the right hand image and right eye sees the left image, that is looking with your eyes crossed, which means that your two eyes are focused on a spot in front of the display.

Uncrossed disparity --- This is achieved by focusing beyond the image plane. The right eye sees the right hand image and the left eye sees the left.



The next image slide, like the first binocular image slide, is meant to show you again how easy it is to make stereo displays with depth.

Compare the top pair with the bottom pair. See if you can get depth in each one. What is out front in each case? Is this consistent with the slide of the vertical lines?

a a

a a

a a

a a

The next slides made mincemeat of the ideas that seemed obvious based on research with images like the ones you've seen so far.

Bela Julesz, an engineer in radio astronomy, worked at Bell Labs in the 1950's, in a situation where he knew some vision researchers. He was accustomed to working with background noise, trying to find signals in that noise. He proposed to try some of his concepts in research on vision.

Specifically, he invented the random dot display. This is an image in which (for black and white) whether or not a given pixel, or clump of pixels, is black or white is determined randomly. The random choice is made for every pixel. The result looks like one of the squares in the next slide.

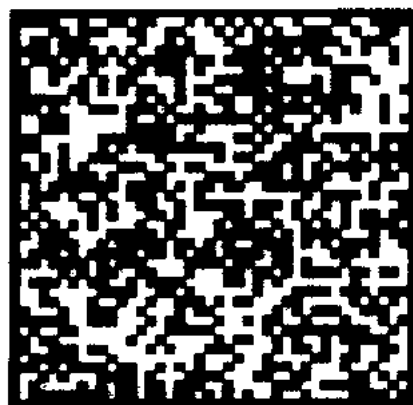
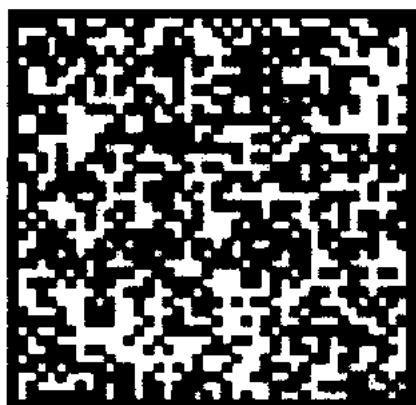
What Julesz did next was to select a shaped area, like a square, and create a second random dot image by moving a square group of pixels to the left or right by a few pixels. That would cover a few pixels of the first random dot image, as well as leaving a gap. The gap is filled in by new random texture. The second display looks just like the first. It is hard to look at them and see differences. For sure, there is no actual shaped area in either slide.

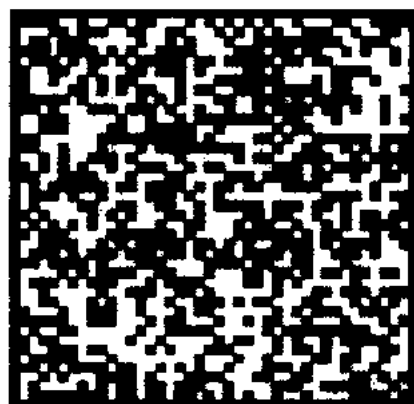
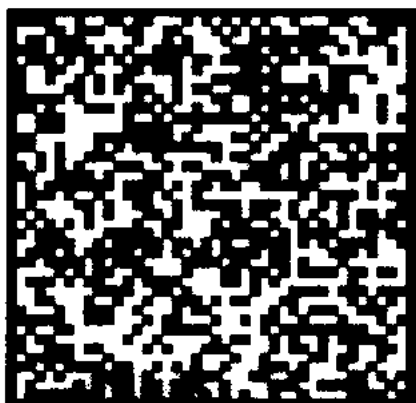
The next slide is a Julesz random dot pair like his very first one, as just described. Notice that you see no shapes in either display.

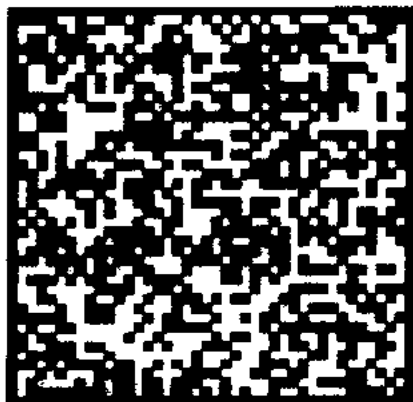
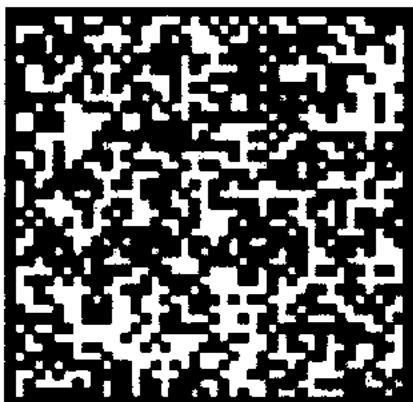
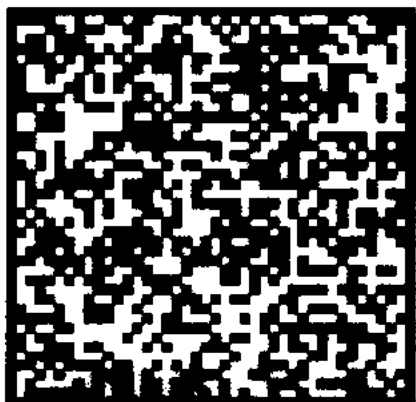
Now look at them as a binocular image to see if something emerges in depth.

The slide after that should be the opposite.

The set with 3 slides should give you both at once. The middle slide should combine with the left of right image, and the right image at once, so that you'll see two different depth effects.







THEORY – defining disparity.

I have said what disparity is, but that was not precise. Finding out what counts turns out to be a research problem, especially after Julesz.

Before Julesz, it was assumed that each eye checks on what patterns it sees, then the two eyes compare. If the same shape appears in each eye, then the system tries to match them up. If they match, but occur at different places, that difference functions as disparity that gives the depth.

In the Julesz random dot displays, there is NO image on either side. The square is defined as the difference between the two whole images. Because there is no image on either side, the matching cannot be done by first finding a pattern in each eye.

What is being matched between the two images so that the difference can be detected? This turns out to be a challenging research problem and made binocular vision interesting to many researchers.

The next two slides should illustrate rivalry, as the two images are not similar enough to fuse.

Look at each pair long enough to see them fade back and forth. It takes me 10 – 15 seconds for fades to occur.



A diagram consisting of a large outer rectangle containing two smaller, side-by-side rectangles. The left rectangle is labeled 'A' and the right rectangle is labeled 'B'. Both labels are in a bold, black, sans-serif font.

A

B



Disparity in the next two slides can be manipulated by moving one cross piece a little bit towards or away from the end. If you look at the cross-piece that goes from lower left to upper right, you see that it does not cut the other cross piece exactly in half. The part above and to the left is a little longer in one image than the other.

This difference reflects disparity between the two images. You can duplicate one of these images and move that cross piece up and down to observe what happens as the disparity changes.

As long as there is a difference, you should see one cross-piece floating out in front of the other.

Principles

In order to get stereopsis for experiments, there must be a method to present separate images to each eye. There are numerous ways to do this.

Keep in mind that even those these methods look different from one another, they all do the SAME thing – present one image to one eye and a different image to the other eye.

The following slides list examples.

Stereoscope

A laboratory device used to show one image to one eye, and a different image to the other eye.

There are two major kinds, the stereoscope with lenses (like the stereopticon and Viewmaster) and the mirror stereoscope.

You can find images and descriptions easily with Google.

ViewMaster

The child's toy, the Viewmaster, presents a separate disparate image to each eye. It is the same as the technical device that shows a separate image to each eye called the stereoscope.

Anaglyphs

Anaglyphs are images created in two colors, like red and cyan. That's the comic book image. Those are the two similar but disparate images. One eye is selected for one image, and the other eye for the other by wearing glasses with colored filters. A cyan filter lets the cyan pass, but blocks the red. That makes the red image look dark. The opposite happens with the red filter. It makes the cyan look dark. Then the two eyes each see a dark image, but they are different.

Therefore a different image is selected for each eye.

Polaroid glasses -- movies

Polarizing material selects light that is traveling in parallel rays. If light that is all mixed up in polarity goes through a polarizing filter, then all the light that gets through is lined up parallel. If a second polaroid filter is placed so the polarized light goes through it, the second filter can be turned to an angle that will block the light. If a movie is projected in polarized light, one image can be projected with the light tilted one way and the other image can be projected with light tilted in the opposite direction. Viewers are given polaroid glasses (they look clear, or a little like sunglasses). One side has polaroid material oriented to block one of the images – and pass one. The other side is the opposite. Thus, the polaroid material selects a separate image for each eye.

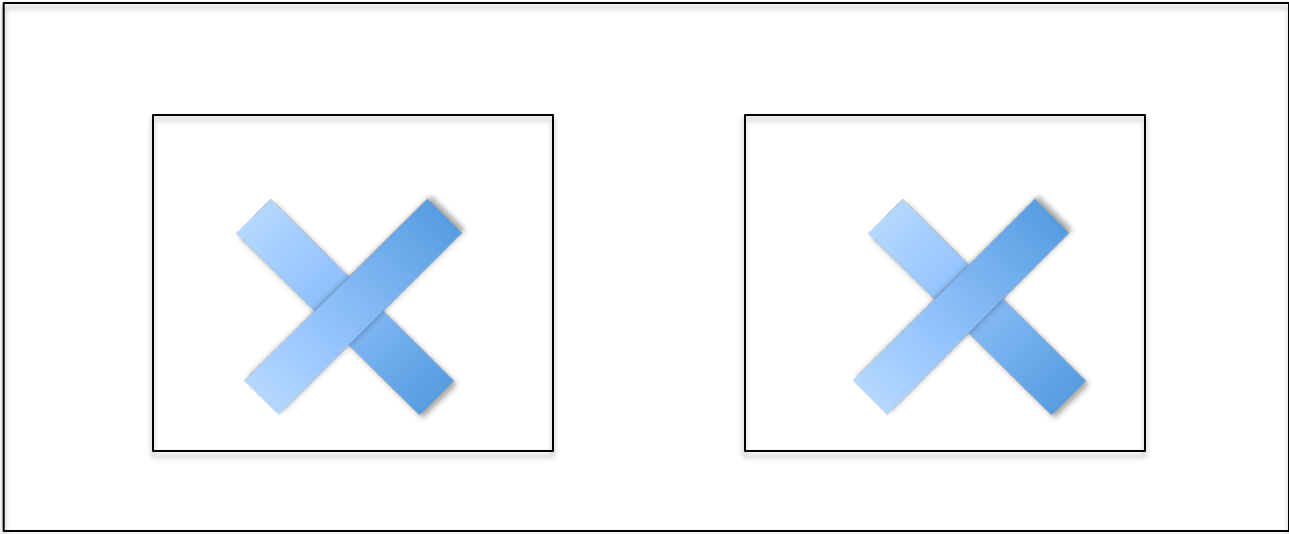
Stereopticon

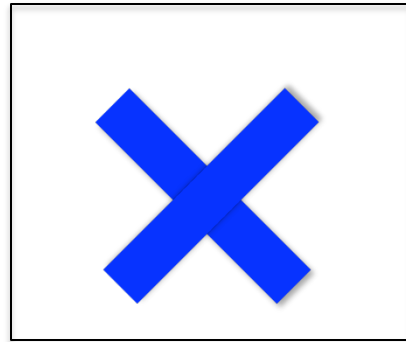
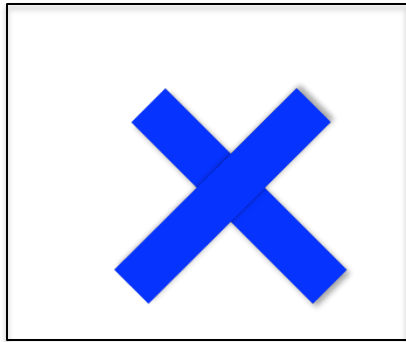
The Victorian name for the home entertainment version of a stereoscope.

Magic Eye Pictures

Julesz' postdoctoral student, Christopher Tyler, invented magic eye pictures. They are based on the Wallpaper Effect. Wall paper is made of vertical patterns repeated horizontally. Each vertical strip is the same, but there is often a little deviation from one to another. If a person can look at the wallpaper with crossed or uncrossed fusion (focused short or beyond), then different parts of the wallpaper are on each eye. If the two images are similar enough, there will be fusion. If different enough, there will be disparity that can be detected as depth.

Tyler showed that a column made of repetitions of one of the Julesz slides alternated with vertical columns of the other, looked like one big random dot pattern. But if a person can get the wallpaper effect, the image or images defined by disparity rises up in depth.



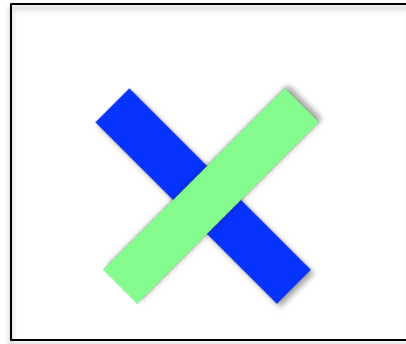
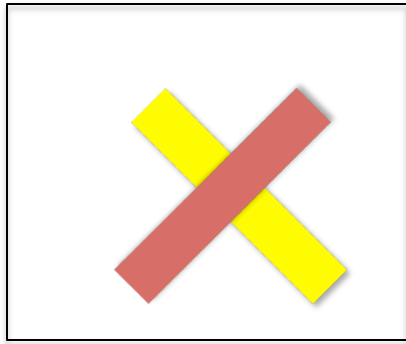


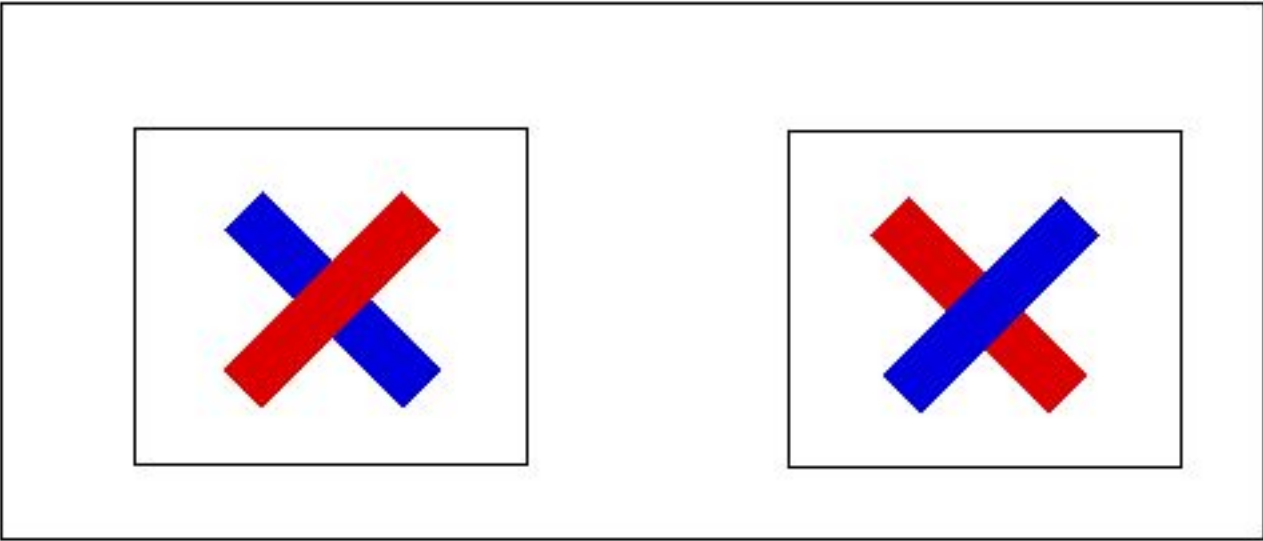
What do you think will happen in the next slide? There are cross-pieces, but all are different colors.

What happens?

Is there depth?

Give it time to be sure.





Exercise based on this lab ---

Think of some ways that binocular displays can be varied. What questions are posed?

What are some questions that you could ask that could be answered by creating test pairs to look at binocularly?