Week 5
Depth Perception Lab

SEEING DEPTH

When we look at the world, we see it in three dimensions (3D)—height, width, and depth. Even though the process of seeing depth is automatic, you don't need to think about it, seeing in depth is not so simple. That's because our brain creates the depth that we see. Our visual system has no direct way of seeing three dimensions because the images on our retinas are two-dimensional (in other words, flat).

One reason that we see depth is that our eyes are about 8-10 cm apart, and each eye views the world from a slightly different position. This slight difference between the images on each retina is used by our visual system to help create a three-dimensional (3D) perception of the world. The difference between the images seen by each eye is called binocular disparity. With 3D pictures, or stereograms, a slightly different image is shown to each eye, fooling the visual system into creating a perception of depth where there is none (because the stereograms are flat, 2 dimensional images).

STEREOGRAMS

You may already be familiar with **stereograms** that can be seen in 3D without glasses—3D posters and books are available everywhere. Recently, you have probably heard or seen people using them to view the 3D images from the Mars rovers. That type of stereogram is called an **autostereogram**, which can be seen by focusing your eyes behind the image. Some people find this easy to do, but others cannot see them very well or at all. In this demonstration, stereograms are made in a different way, by using two colors to draw the image and viewing the image with special glasses. This type of stereogram, called an **anaglyph**, is made up of red parts and blue (or sometimes green) parts. The glasses have a red filter in one eye and a blue filter in the other. The red filter passes the red parts of the image and blocks out the blue parts; the blue filter passes the blue parts of the image and blocks out the red parts. In this way, a different image can be shown to each eye.

MEASURING DEPTH PERCEPTION

Binocular disparity is a measure of the amount of difference between the images seen by each eye. If the difference between the two images is relatively small (the disparity is small), we perceive a single image in depth. This is called fusion and is what usually occurs in real life. As the amount of binocular disparity increases, so does our perception of depth. In other words, more disparity means more depth. But, if binocular disparity becomes too large, we can't fuse the images and we experience double vision, or **diplopia**.

In the real world, binocular disparity is determined by the position of objects relative to the point of fixation (the point you're looking at). There is an area in space, called the **horopter** that is defined by an imaginary circle that passes through each pupil and the point of fixation. From any point on the horopter, the image on each retina will be exactly the same—no disparity. Surrounding the fixation point and the horopter is another region called **Panum's fusional area**. We perceive other objects within Panum's fusional area as being fused (single vision) and standing out in depth relative to the point of fixation. We experience diplopia (double vision) for objects outside of Panum's fusional area. However, if an object is not too far outside, we can perceive it in depth, even though we cannot fuse its images, and we cannot judge the depth very accurately.

In this experiment, you will see how your perception of depth changes with binocular disparity. You will also find out how much disparity is needed for you to experience diplopia. This will give you a measure of Panum's fusional area.

OBJECTIVES

By completing this exercise, you will learn:

1. How the visual system uses the 2D (flat) images seen by the two eyes to construct a 3D image of the world.
2. The limits of our visual system in regard to seeing depth.
3. How vision scientists can measure our perceptions—psychophysical methods.
4. About using a magnitude estimation procedure to measure the size of a perception, in this case depth.
5. About collecting, analyzing, interpreting, and presenting scientific data.

GETTING STARTED

We will be using a computer program (to be passed out at the beginning of lab). In groups of 2 or 3, place the CD ROM into the tray. It should auto boot and bring you to a menu. Select the Experiment box. when this loads, look in the menu choices for the Depth Perception Experiment (on the right side of the list). Click on this link to begin.

Before beginning the actual Depth Perception experiment, click the **Info** button at the top of the screen. Read the **Background** information and **Instructions** for additional information you will need to complete the exercise.

INSTRUCTIONS

The following is a brief summary of the program instructions:

1. Before beginning the experiment for the first time select **Practice** to become familiar with the experimental procedure.
2. To complete a block of trials select **Experiment**, and select either the **Crossed** or **Uncrossed** Disparity condition.
3. Wear the red/blue 3-D glasses when viewing the stimuli. The *RED* lens goes over your *right* eye. *It is important that you do not reverse the glasses for this experiment, or the disparities will be reversed.*
4. After you finish each block of trials you will be taken the to the Results screen. After completing your first trial block select **Experiment** to begin the second block.
5. On the **Results** screen click the **Data Suggestions** button for suggestions on how to present your data.
6. At the completion of the lab exercise, you should be able to clearly explain each of the objectives listed at the top of this page.

After you have finished reading the lab handout and the lecture reading packet, you should be familiar with the way in which the visual system creates our perception of a three-dimensional (3D) world. You should also be familiar with the terms **disparity, diplopia, and Panum's fusional area.** For a review of these terms and other concepts go to the Depth Perception experiment and click the Info button. Before beginning an experiment it is important to understand the question(s) you are trying to answer and what the most likely answers are.

In this experiment you will be measuring how the perception of depth changes with changes in the disparity of an image. You will also obtain a measure of the limits of depth perception (in other words, the size of Panum's fusional area). Beyond these limits the visual system cannot create a good perception of depth and you see double (diplopia). You will be comparing both crossed (in front) and uncrossed (behind) disparities— in some people, Panum's fusional area is asymmetrical (not the same size in both directions).

COLLECTING DATA

Before beginning the experiment complete a block of practice trials. Some people do not see the depth in these stimuli immediately—you may need to view them for a few seconds before you see anything. View them from directly in front of the monitor.

To complete your data collection you must complete **two** blocks of 30 trials each in both the Crossed and Uncrossed Disparity conditions. Your viewing distance should be about 60 cm (24 in). *Sitting at the correct viewing distance is especially important in this experiment.* If you change your viewing distance during the experiment, the disparities of the binocular images will change.

It doesn't matter in what order you complete the two conditions, unless you will be summarizing the results for several observers—then you should try to have different observers complete the conditions in different orders (that way you'll know if the order had an effect).

In your lab notebook, be sure to describe the experimental procedure that you used. Be sure to include a description of the stimuli and how you responded to the stimuli. The general rule is to describe the procedure in enough detail so that someone who is unfamiliar with the procedure could do the exact same experiment just from reading your description.

ANALYZING YOUR DATA

When you have finished the data collection, the program will present a summary of your results. This summary includes a graph that plots your estimates of the perceived depth of the stimuli versus the actual disparity of the stimuli, for both the crossed and uncrossed disparity conditions.

(The disparity, or difference between the left and right eyes' views, is measured in pixels—the tiny dots that make up the picture on the computer monitor.) The points at which you reported diplopia (seeing double) are also marked on the graph. The area between these points is an estimate of your Panum's fusional area. Click on the **Data Suggestions** button for a more detailed explanation of this graph.

If your data appear to be “backwards,” as compared to the sample data (click the Data Suggestions button to see the sample data), it probably indicates that you were wearing the glasses backwards. If that happens you do not need to do the experiment over—just reverse your data. The crossed disparity condition would actually be uncrossed, and vice versa.

Prepare a graph similar to the one presented by the program that shows both disparity conditions (or print the Results screen). Remember that you’re trying to show (1) how your perception of depth changed with changes in disparity, and (2) the limits of Panum’s fusion area.

INTERPRETING YOUR DATA

The final step is to make sense out of your results. The numbers and graphs by themselves don’t mean anything until you interpret them.

Explain your results.

1. How did your perception of depth change with the disparity of the stimulus? In other words, did the stimuli appear to have more or less depth as disparity increased?

2. What does that tell you about the way disparity information is used by the visual system to create a perception of depth? Was the outcome what you expected? If it wasn’t, why do you think it turned out the way it did?

3. What happened to your perception of depth beyond the limits of Panum’s fusional area? Did the change in depth continue in the same direction, or did it reverse?

4. In some people, Panum’s fusional area is asymmetrical—it is wider in one direction than the other (for crossed versus uncrossed disparity). Was your Panum’s fusional area symmetrical or asymmetrical?

5. For some people, the stimuli in this experiment might not be beyond Panum’s fusional area. These people would be able to fuse all the stimuli without ever seeing double. If this was true for you, what do you think that means?

6. Good research often generates as many new questions as it answers. Are there any new questions that the results of this experiment suggest to you?

ADDITIONAL INVESTIGATIONS

1. Change your viewing distance to 30 cm (12 in) (half the viewing distance), or 120 cm (48 in) (double the viewing distance). What happens to the disparity of the dots when you change the viewing distance?
2. How would you expect your measure of Panum’s fusional area to change? Does it change as expected?