

Our Sense of Sight: Part 2. Perceiving motion, form, and depth

Visual Puzzles

Featuring a “Class Experiment” and “Try Your Own Experiment”

Teacher Guide

WHAT STUDENTS WILL DO

- TEST their depth perception using one eye and then two
- CALCULATE the class averages for the test perception tests
- DISCUSS the functions of depth perception
- DEFINE binocular vision
- IDENTIFY monocular cues for depth
- DESIGN and CONDUCT further experiments on visual perception, for example:
 - TEST people’s ability to interpret visual illusions
 - CONSTRUCT and test new visual illusions
 - DEVISE a “minimum difference test” for visual attention

SETTING UP THE LAB

Supplies

For the Introductory Activity

Two pencils or pens for each student

For the Class Experiment

For each group of four (or other number) students:

Measuring tools (cloth tape or meter sticks)

Plastic cups, beakers or other sturdy containers

Small objects such as clothespins, small legos, paper clips

For “Try Your Own Experiment!”

Visual illusion figures, found at the end of this Teacher Guide

Paper and markers or pens

Rulers

Other Preparations

- For the Class Experiment and Do Your Own Experiment, students can **write results** on a plain sheet of paper.
- **Construct a chart** on the board where data can be entered for class discussion.
- **Decide the size of the student groups**; three is a convenient number for these experiments—a Subject, a Tester, and a Recorder. Depending on materials available, four or five students can comprise a group.
- **For “Try Your Own Experiment!”**, prepare materials in the Supply list and put them out on an “Explore” table.
- **Modify activities for exceptional students:**
 - Make sure a student who has low vision is seated in a well-lighted area
 - Provide other activities for blind students: some may be interested in teaching the class how to read Braille or in explaining how they navigate without sight. They may be able to explain modifications they have for their computers or other equipment.

INTRODUCTORY ACTIVITIES

Give students initial information

Introduce **Visual Perception** to the class according to your teaching practices; e.g., with reading, lecture, and discussion before lab work: the **Teacher Resource** accompanying this unit gives background information on perception. In addition to information on the cells and pathways of the system, for the experiments on depth perception, students will need to know the concepts of monocular and binocular vision, monocular cues for depth and distance, and retinal disparity.

For the investigations in the “Try Your Own Experiment” section, discuss how our brains integrate current visual information with past experience and how our attention is progressively directed from a whole scene to its parts. Use some of the references in the Teacher Resource section to introduce students to visual illusions so they will be able to use those you make available to them from the Teacher Guide for devising tests.

Introduce lab activities with a demonstration

When students enter the classroom on lab day, introduce the activities with an “eye-catching” **short activity**:

Have each student hold a pencil or pen in each hand at arms length in front of the face. Ask everyone to touch the tips (e.g., erasers of pencils) together while closing one eye (pencils can be held horizontally—end to end, or vertically—one above the other.) Next have them open both eyes and repeat the activity.

Use the activity to open a short discussion of the importance of binocular vision and depth perception.

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CLASS EXPERIMENT

The sections below match those in the Student Guide. The comments guide teachers in preparing and teaching the labs.

LAB QUESTION

After demonstrating the concept of depth perception with the pencils, briefly review various aspects of visual perception, and help students to write the following **Lab Question** or one that matches it closely:

Can a person judge distance more accurately when looking with one eye or with two?

PLANS AND PREDICTIONS

Encourage students to add their own knowledge and experiences in order to make predictions after you have provided background information. Ask if it is easy to misjudge how far away something is, and if this changes under different circumstances.

PROCEDURE

1. **Introduce safety precautions:**

Follow all standard lab safety guidelines for preparing and teaching the activity; e.g., take precautions to avoid germ spread; wash hands; dispose of chemicals properly; use equipment properly.

2. **Establish** the number of students in each group

3. **Explain** the steps in the Class Experiment. These are listed in the Student Guide, under **Procedure**.

4. When students test monocular vs. binocular cues at a distance (step 9 under Procedures), have everyone measure the same distance, about 8 to 10 feet, so calculations can be made from similar data.

5. Remind students to **clean up** the lab when they finish.

DATA AND OBSERVATIONS

See that students are recording observations on paper.

Have the data recorders from each group list their results in a prepared chart on the board.

When all results are written, have students **calculate** the class average for the number of successful drops with one eye and then with two eyes, for each of the distances tested.

ANALYSIS: THINK ABOUT IT!

The following questions can encourage thinking about the activity; add your own questions. (See also the specific questions in the Analysis section of the Student Guide.)

- What features of our eyes and brains allow us to perceive depth and the solidity of objects?
- How do your results compare with those of other groups?
- Can you explain the differences you see among the observations? (For scores with monocular vision: differences in how well people are able to use monocular cues, “lucky guesses;” for scores with binocular vision: some people may have vision problems that interfere in a general way—astigmatism, myopia; even “normal” people vary in their acuity and visual processing—this is presumably a result of genes that may give people more or fewer cone cells in the fovea, or determine how well the axons from one place to another are “wired up,” for example.)
- Do you have any direct evidence from your experiment to show that such a thing as retinal disparity exists and results in stereoscopic vision? (There is no direct evidence from these activities; this would require investigation, with special instruments, of images falling on the retina, and recordings from cells in the cortex to show that some cells receive input from both retinas.)
- Discuss what the results mean in terms of the concepts learned in the Background lecture and discussion on visual perception.

CONCLUSIONS

Students should:

- State how the Lab Question was answered in their experiments.
- List three things (or a number you choose) they think are important about today's experiment. Focus students by asking such questions as: How is depth perception important to us? What do our brains do with sensory (particularly visual) information? Can you investigate some questions on your own? Do scientists know everything there is to know about visual perception?
- List ways to improve this experiment or further things to test.

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TRY YOUR OWN EXPERIMENT!

LAB QUESTION

After the students have completed the Class Experiment, refresh their memories about visual perception in general, so they will be ready for experiments beyond depth perception. Remind them that the phrase “**visual perception**” refers to more than just depth perception: it is a broad term that refers to how we interpret the meaning of what we see.

When we use our depth perception, we interpret some objects as being closer than others, and we comprehend that, for example, a globe is a solid sphere, not a flat circle. In interpreting other visual information, we use our **past experience**. As explained in the Teacher Resource for this unit, when we see a friend at some distance, we recognize the person and know that this is a normal human, even though the image on the retina is much smaller than that of a person standing right next to us. We are using cues from the rest of the scene—we notice that the trees and buildings also appear small, and realize from experience that this means that the person is some distance away, and is not a miniature human!

Because we use cues like this, pictures that mix up the cues can fool us. Parts of the brain that associate memories with what we are currently seeing are responsible for visual perception, and these “higher brain centers” are frequently tricked by **visual illusions**.

Ask questions to encourage thinking about how our eyes and brains can be tricked. Have any of them used the Magic Eye books (see the Reference List at the end of this unit)? Have any been to illusion halls at a science center or museum? How have they been fooled?

After this review, indicate the lab bench where additional materials are available for “Try Your Own Experiment” and let students explore the items. Then **brainstorm** with them for ideas such as how visual illusions trick us, or how to extend the depth perception study.

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| <p>See that each group defines a Lab Question, as they did for the Class Experiment.</p> |
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PLANS AND PREDICTIONS

SUGGESTIONS FOR EXPERIMENTS

(Add your own ideas to this list. The Student Guide also suggests some of these experiments but does not contain all details given here.)

- Make the visual illusions at the end of this unit (or others you may find—see the Reference list) available to students who want to work with illusions. They should **devise tests** for classmates to see how they score. For example, students can test people for their ability to see if two objects are the same size in a visual illusion. For the **control** experiment, show the subjects two identical circles. To change a **variable**, add a series of small circles around one of the original circles, and a series of large circles around the other original circle, and repeat the test. (One of the visual illusions at the end of this unit shows these figures.) Be sure students **formulate a lab question and prediction**, and that they **measure responses** and **calculate results**.
- **Construct** your own visual illusions, for example, a picture with opposite cues for size and distance. Test your classmates.
- To investigate visual attention, **devise a “minimum difference test”** to see how different one or one group of objects in a set must be from the others, in order for people to notice it readily. As suggested in the Student Guide, students can draw a field of identical smiley faces, with one that is different, and work to see how differently they must draw it to get virtually instant recognition of this one face in the field. Again, they should make **predictions** about which drawings will fool people and which they will quickly recognize.
- In a variation on this minimum difference test, students can use a copy of a famous picture (Mona Lisa) or of a well-known person (one of the U. S. Presidents). Make careful alterations to one picture; for example, thicken the eyebrows or change the hairstyle, then present the original and the altered copy both **upside down** to the Subject. How much alteration is necessary for people to immediately discern the change?
- **Extend the depth perception study** to find out if there is a distance limit to the idea that two eyes are better than one. Students may need to go outside to finish this experiment. Theoretically, monocular cues take over from stereoscopic vision at distances beginning at about 100 feet, but ability to drop a small object into a small container will probably fade before that.

HOW CAN YOU DESIGN A GOOD EXPERIMENT?

The following section is reproduced from the Student Guide.

In designing experiments to answer questions like these, keep in mind what a **successful investigator** must do:

- Ask a **very specific question**: not, for example, “Can I fool someone with a visual illusion?,” but rather, “With this visual illusion on relative sizes of objects, what percentage of subjects will give the wrong answer?” It’s good to have the general question in mind, but ask a narrow question for each experiment.
- Be sure you understand the **control condition** for your experiment, and then **change only one thing, or variable**, in the experiment.
- For example, if you plan to test people for their ability to see if two objects are the same size in a visual illusion, for the **control** experiment show the subjects two identical circles. To change a **variable**, add a series of small circles around one of the original circles, and a series of large circles around the other original circle, and repeat the test. Do not let your Subject know you are using the same original circles!
- Follow this same plan with other kinds of visual illusions: in this way you will make your activity a real **experiment**, with a **prediction** and a **test** for the prediction. Then **analyze**—think about—your results and make **conclusions**.

For example, **create a test** to see how different one object in a group of identical objects must be for people to identify it quickly. For example, draw a page of identical smiley faces in rows. Make one smiley face a little different—make the smile a bit less curved. How long does it take someone to point to the different one? To **change a variable**, make a frowning face in a sea of smiley faces. Can you think of another kind of variable to change? If all the objects are a dull color, are the results different from what you get if all are brightly colored? Do certain colors make identification harder?

- Researchers try to **change only one variable** in a new experiment after they do a control experiment. Sometimes this is difficult, but at least they must be aware of other variables and think about what effects they might have.
- **Keep good records** of everything you do.

PROCEDURE

- **Introduce safety precautions**: Follow all standard lab safety guidelines for preparing and teaching the activity; e.g., take precautions to avoid germ spread; wash hands; dispose of chemicals properly; use equipment properly.
- If time is limited, restrict the number of materials you put out for experimenting.

- Before students begin their experiments, have each group write a simple plan that includes a **question, a prediction, a list of steps** they will take to answer the question, and data sheets and graphs (if needed).
- The list of steps in the experiments should include comments on the control system and on the variable being tested.
- **Approve** each group's experiment before they begin.
- Remind students to keep **good records**.
- Students should **clean up** the lab when they finish.

DATA AND OBSERVATIONS

- Make supplies available to students.
- Suggest that students create any data sheets and graphs they need.

ANALYSIS: THINK ABOUT IT!

The following questions can encourage thinking about the activity; add your own ideas. (See also the specific questions in the Analysis section of the Student Guide.)

- Have each group present its findings in a quick oral presentation (two to three minutes).
- How do your data help answer your lab question?
- What was the control experiment or condition for your experiment? What did you change or add as your variable?
- Did you make sure to change only one variable? Were there variables you could not control?

CONCLUSIONS

(See also the questions in the Student Guide.)

Ask students how certain they are of their conclusions. Would they need more evidence to make their conclusions more secure?

Each group should write a final conclusion, making sure it addresses their Lab Question.

MORE VISUAL PERCEPTION ACTIVITIES

Find out more about visual perception and puzzles by searching the World Wide Web or your library. Can you find out how “3-D” movies are made? What is “motion blindness?”

Here are some good Web sites to visit for visual perception information:

<http://www.vision3D.com> at the Optometrists’ Network, this site shows you the Magic Eye book type of illusion. Go to Magic Eye 3D.

<http://www.worldofescher.com/gallery> M.C. Escher’s famous drawings

<http://www.illusionworks.com/index.html>

<http://www.sandlotscience.com> lots of illusions

<http://faculty.washington.edu/chudler/chvision.html>

<http://www.hhmi.org/senses>
see: The Strange Symptoms of Blindness to Motion

<http://www.visionscience.com>
click on Motion Integration, then on Stereograms

<http://www.sciam.com/explorations/0492melzak.html#sidebar> Scientific American article on “phantom seeing and hearing,” similar to phantom limb experiences

ILLUSIONS

The following illusions are from Neuroscience for Kids,
<http://faculty.washington.edu/chudler/chvision.html>

1. Is the center circle on the right the same size as the center circle on the left? It appears that the circle that is surrounded by the small circles is larger than the circle that is surrounded by the larger circles. Measure the diameters of the two center circles to see.
2. This inverted "T" has two lines: are they the same length--- is the vertical line longer than the horizontal line? Measure them yourself.

3. Which arc comes from the circle with the largest diameter?

It probably looks as though arc C is part of the largest circle. However, all the arcs are actually from the SAME circle. Look at the same figure again, with the right and left sides of the larger 2 arcs blocked off. All arcs come from circles of identical size.

4. Which of the lines shown below is longer?

Measure them—measure only the horizontal lines, not the place where the arrowheads end. You may be surprised to find out that they are the same length. This is called the Muller-Lyer illusion. We see the lines as different because we have been "taught" to use specific shapes and angles to tell us about size.

5. This is the famous Poggendorff Illusion (created by Johann Poggendorff in 1860). Is the line behind the rectangle straight or not? It looks like it does not go straight across, but check by placing a straight-edge on the line.

6. Do you see a vase or a face in the figure below? This type of figure was first illustrated by Edgar Rubin (a psychologist) in 1915. Notice that it is very difficult to see both the faces and the vase at the same time. This may happen because we tend to focus our attention on only one part of the image...either the faces or the vase.