PERCEPTION IS NOT ALWAYS REALITY

Or, WHY IS A T-ILLUSION?
by Larry Flammer

Nature of Science
Basic Processes
Realm and Limits

SYNOPSIS
Various visual illusions are used to engage and intrigue students, all raising the question "Why is this an illusion?" With interest piqued, students are engaged to answer this question about the T-illusion, proposing hypotheses to explain what makes it an illusion, then designing simple experiments to test those hypotheses. designing simple experiments to test those hypotheses. This is extended to a look at natural illusions, and how science effectively reveals their reality.

CONCEPTS
1. Illusions abound in nature, and science can effectively reveal them.
2. Scientific knowledge is uncertain, tentative and subject to revision.
3. Scientific explanations and interpretations can neither be proved nor disproved with certainty.

ASSESSABLE OBJECTIVES: Students will…
1. Solve a simple problem by correctly applying the process of science.
2. Recognize a number of illusions in nature
3. Recognize some natural illusions that have been explained using science

MATERIALS
Some samples of illusions, for overhead or PowerPoint (See list of web sites under Resources for more):

Mars face (mars.fx2.jpg)
Elephant legs (el.legs.jpg)
Horizontal lines (hori.lin.jpg)
Muller-Lyer illusion (mul.lyer.jpg)
Two-Tables illusion (lessons/tables.pdf)
Ouchi illusion (ouchi.jpg)
Top Hat illusion (top.hat.jpg)
T-illusion (t.ill.pdf)

2 pages for overhead, with 4 T-illusion hypotheses (t.ill.wx.pdf, and t.ill.yz.pdf)
For each team of 2-4:

Paper with a big T: a 10 cm horizontal line and a 15 cm vertical line (t.ill.T.pdf)
Paper with a 10 cm horizontal line and a *separate* 15 cm vertical line (for testing other ideas: (t.ill.2.pdf)
Opaque white card to cover the vertical line until exposed length appears equal to horizontal length
Ruler to measure exposed length for each observation

List of Examples of Scientific Explanations for Some Illusions (for overhead) (lessons/ill.expl.pdf)

TIME: 1-2 class periods

STUDENT HANDOUTS: See materials (1 set for each team of 2-4)

TEACHING STRATEGY
OVERVIEW

Open the course with engaging experiences, e.g., a number of illusions and discrepant events that raise questions e.g. "How?" and "Why?", questions which can be seen as problems to solve. Then we focus in on one of the illusions to see how a scientist might try to explain it. See some examples of contrived illusions and discrepant events in the list of Materials, and Resources and at:
http://www.indiana.edu/~ensiweb/lessons/unt.illu.html

Because of its apparent simplicity, the focus illusion we use is the **T-illusion**: when the two lines of a T are the same length, the vertical line appears longer. The question: what is it that makes the vertical line of this T *seem* longer than its horizontal line when they're actually the same length? We consider various possible explanations, e.g. the rotational orientation of the entire T, the relative positions of vertical and horizontal lines, whether the lines touch or not, the relative angles of the lines, whether they cross, where they cross, viewing angle, etc. Then assign to each group a different possible solution to explore, and figure out if it has any influence on the illusion. After giving a few clues as to how they might proceed, they go to work and reach some conclusion about their assigned solution.

Then, as a class, we compare and consider the conclusions from each team, and arrive at the most likely explanation (or explanations). In doing this, other questions are often raised, new ideas for checking possible explanations arise, and future work to clarify the problem may be suggested. Some students even take these on as individual projects.

Finally, either from assigned reading, past experience, or teacher-led discussion, students come to realize that they have been following a standard process for solving a problem with science, and they recognize (or discover) the technical terms and processes associated with each phase: problem recognized, hypotheses posed, predictions made, hypotheses tested and compared, conclusion reached, recycle and refine. Furthermore, they see how science can be used to understand how an illusion works.

We then go on to briefly explore a number of **natural illusions**, and how science has provided us with deeper understandings of those phenomena. Students begin to see that 1) many natural phenomena are not what they seem; we are surrounded with natural illusions, we are easily fooled: “Perception is not always reality!”; and 2) science is a powerful tool to help understand such phenomena without resorting to "magical", supernatural or other mystical explanations. See a list of some natural illusions, suitable for overhead or PowerPoint display, at: <http://www.indiana.edu/~ensiweb/lessons/nat.ill.pdf>.

PREPARATION
1. Provide copies of student materials, enough for every team in a class.
2. Prepare overheads or PowerPoint visuals of a number of optical illusions, and the list of Natural Illusions.
3. If you have any skills presenting sleight of hand “magic”, plan to do one or two of these. There are many magic gimmicks that you can find in magic shops. Look for those which are fairly easy to do, and are large enough for your class to see easily. Practice in front of a mirror until you can do a convincing performance. Just do each one once (for each class); never reveal their secrets.
4. Prepare for the Magic Hooey Stick lesson or the Great Volume Exchanger, if you plan to use one of these.

PROCEDURE

1. Engage your students with several visual illusions on your overhead or PowerPoint screen (see examples and various sources under **Materials**).
2. Do a little "magic", if you've practiced something.
3. End your series of examples with the T-illusion. You might use one of the common pictorial variations first, e.g., the top hat picture, and then show the simple T.
4. Pose the question “Why is this an illusion?” “What feature about this figure is responsible for the illusion?” Seek responses of possible elements which might contribute to the illusion, e.g., the rotational orientation of the entire T, the relative positions of vertical and horizontal lines,

whether the lines touch or not, the relative angles of the lines, the viewing angle, etc. Accept any reasonable ideas.

5. Take one of the suggestions and ask, “How could we test this idea, to see if it does indeed have any effect on the illusion?” For example, with the orientation suggestion, students might suggest that they could see if the effect was different with the same T in different positions.
6. For this or any similar suggestion, ask, “How would you tell *how effective* the illusion actually is?” “How could you *measure* this?”
7. If students have trouble with this, suggest that they start with a T diagram with a 10 cm horizontal line, and a 15 cm vertical line. Then have one person vary the vertical line length until the viewer thinks they are of equal length. This can be done by covering the lower end of the vertical line with an opaque card. Measure that line, subtract the horizontal length (10 cm) from the variable vertical line and divide that difference by 10. This will give you a percent difference, which should be greatest when the illusion is most effective. Doing this with the T in 4 different positions (for example) should provide some idea as to the effect of orientation on the illusion effect.
8. Ask students if they think that one viewing by one student (for all positions) would be sufficient. If they say, “Yes”, ask “Do you think that person would see exactly the same effects (same % differences for each position) if the series was repeated? Is there any subjective judgment involved?” If not sure, they may want to try this. They should consider how the could determine the “typical” judgment for each position.
9. From all of this, students should be able to design a simple experiment to test each possible solution, with 2-4 students on a team, and their results averaged for each position. This should tend to nullify individual subjective variations in their determinations.
10. Divide your class into groups of 2-4, and to each team, assign one of the suggested causes for the illusion to be tested. Provide each team with a set of materials (paper with a 10 cm horizontal line, and a 15 cm vertical line that can be positioned to the horizontal line appropriate for the solution being examined. For team(s) testing the T-orientation, give them the sheet with the intact T. For teams testing other hypotheses, give them the sheet with 2 separate lines; they are to cut the vertical line from the second sheet along the dashed line. In all cases, the opaque card is used to cover the lower end of the vertical line, moving it up until the viewer feels that its visible length equals the length of the horizontal line. Each team runs its trials, collects and compiles its data, and poses a conclusion about whether their suggested solution explains why it’s an illusion.
11. Each team reports its results to the class (on an overhead or whiteboard form created by the teacher), so that the results of all teams can be compared and evaluated.
12. Teacher leads class discussion in a brief review of just what was done, the conclusions reached by each team, and a comparative review of all the teams’ data. Does a single (or group of) solutions seem to be more influential in causing the illusion than others? How do these final conclusions bear on the original question “Why is this an illusion?” What is it about the more likely cause(s) that reflect the natural world and how we see it that might explain why our brain interprets vertical and horizontal lines differently?
13. What new questions are raised, and how might they be investigated? Some students may want to explore one or more of these on their own as a project, or for extra credit.
14. At some point, see if your students recognize the terms typically associated with the elements of this problem-solving activity, sometimes presented as the “Scientific Method”, terms e.g. the Problem, Hypothesis, Test, Prediction, Observations, Data (or Results), and Conclusion. Be sure they realize that not all science is done this way. Point out that much in science is done simply by making observations, gathering data (evidence?), and reaching conclusions, without any experimentation. Such sciences include forensic science, astronomy, geology, paleontology and meteorology. Our **Crime Scene** lesson would be excellent for your students to experience this.

15. Now that your students have dealt with an intriguing problem scientifically, ask, "Why have we been doing this lesson?" Hopefully, all will recognize that we've been "doing science" or "seeing how science works to solve problems." Point out there's one more reason: "We are surrounded by *Natural Illusions*." Ask if they can think of any. If not, mention a few, e.g., "The Earth seems flat," The Sun seems to move across the sky while we stand still," and "Species seem to be the same, generation after generation." Start listing the natural illusions offered by your students, adding a few especially interesting ones they might miss (see under **Overview** the links to some examples).
16. Select several of those listed illusions, and ask your students if they know anything about how we came to understand how they work, what the reality is behind the illusion. Add the names of scientists and/or techniques they used to explain those phenomena. If your students have access to the internet, have them research some of these and share with the class. Try to have them do this in a visual way, showing examples (pictures, or actual objects) representing those phenomena. See list of some examples of **scientific explanations of illusions** at http://www.indiana.edu/~ensiweb/lessons/ill.expl.pdf. You may need to step in and do a few yourself, as an example of what you're looking for.
17. Ask questions: "What's science good for?" "How has it helped us?" "What good is it for us to understand the reality behind natural illusions?" You may want to have your students search the Internet for ways these discoveries have helped us. Engage the students in dialogue over those questions; encourage everyone to participate. Before discussion stops, ask, "What have you learned?" Get them to summarize their experiences and knowledge gained in this lesson.

ASSESSMENT

1. Recognize or describe examples of illusions in nature
2. Given a particular illusion, state the essential problem "Why is it an illusion?", propose one or more hypotheses, simple experiments to test one of them, predictions of expected results if hypothesis is correct, and if it's incorrect.
3. Recognize or report some of the productive functions and values of science in our society.

EXTENSIONS &VARIATIONS

1. If any of your students can write computer programs, they may want to try developing a program which can move elements of the T to different positions, and then rotate the combined figure to different orientations, and enable the viewer to change the length of the vertical line of the T until it *appears* the same as the "horizontal" line, then instantly calculate the % difference between their actual lengths and display the results. Such a program could be used by your classes in the future for doing this lesson more quickly and efficiently.
2. Try this lesson using some other fairly simple optical illusion. An interactive version of the Muller-Lyer Illusion can be found at: <http://www.michaelbach.de/ot/sze_muelue/index.html>. This one enables the user to estimate and measure, as done with the T-illusion. From this, a percent error can be calculated as described in the T-illusion lesson.
3. From time to time, during your course, bring out a new illusion, partly to get attention and engage, and partly to remind students about how we are surrounded with illusions, and how science can expose their underlying reality. Try to select illusions (both contrived and natural) that relate in some way with the current topic.
4. Visit magic shops, read books on magic (see our **Magic Hooey Stick** lesson for references). Look for commercial "magic" demonstrations that could illustrate particular concepts in your course. For example, any game of chance can be related to genetics and laws of probability (dice, cards). Try to get demos that are fairly large, so they can be seen easily throughout your class. Practice presenting the trick before a mirror and/or any handy critic, until you can do an effective job (fumbling is ok, but

at least be able to do it without revealing the trick. Don't repeat any trick to the same audience. Don't ever reveal the secret of the trick. Let your students hypothesize about this.

5. Later in your Nature of Science unit, be sure to do the "**Magic Hooey Stick**" or "**The Great Volume Exchanger**" lesson on this site. The amazing effect in each case is easily done, and can also be used to help your students to realize that science is limited to the realm of *natural phenomena*: that science cannot explain truly supernatural phenomena (as such). It's important for them to realize that the reason for this is that supernatural explanations cannot be disproved; a basic requirement for any scientific premise is that it be possible to disprove. The ENSI lesson "**Sunsets, Souls & Senses**" also does a great job emphasizing this point. If you don't use any of these lessons here, do try to include them later in your course in some appropriate context. Don't overdo these activities; be selective. Just doing Procedure step 1 should be sufficient. You can always insert a new one at various points in your course, to remind them of illusions-and-science connection, or just to get their attention!. A very handy one is our "**False Assumptions**" lesson, which also makes a nice "sponge" activity at various points in your course.

RESOURCES: Web sites with illusions:
Excellent interactive/moving illusions (including the Muller-Lyer, Mars face, and many others)
http://www.michaelbach.de/ot/

Face on Mars: (excellent disc. and pics)
http://www.msss.com/education/facepage/face.html
http://www.msss.com/mars_images/moc/extended_may2001/face/
http://www.space.com/scienceastronomy/solarsystem/mars_face_010525-1.html

Kitaoka illusions (seem to move)
http://www.ritsumei.ac.jp/~akitaoka/index-e.html
http://www.ritsumei.ac.jp/~akitaoka/saishin2e.html

MC Escher Illusions:
http://www.geocities.com/SoHo/Museum/3828/optical.html

http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/index.html
http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/hall_of_illusions.html
Ouchi Illusion:
http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/ouchi_illusion.html

http://www.optillusions.com/
http://www.grand-illusions.com/

ATTRIBUTION
Created as an extension and practical application of the engaging benefits of using illusions in the classroom, by Larry Flammer, 2004. Inspired by ENSI fellow, Walter Wogee, and his use of magic in the classroom.