Canadian Space Agency | Agence spatiale canadienne

Educational Product	
Teacher's Edition	Grades 9-12

Neurolab for Classrooms

Canadian Space Agency Educational Materials for STS-90 Neurolab

Canada

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DEAR EDUCATORS

Welcome to the STS-90 Mission Classroom Materials!

The Canadian Space Agency's primary educational goal is to interest Canada's young people in science, technology, space and space-related careers. This curriculum resource material is intended to provide teachers across Canada with an opportunity to present their students with enriching learning experiences based on the STS-90 Mission.

The activities are designed to be hands-on and fun for students of varying ability while providing an engaging and accurate glimpse into the science of the mission.

Although the materials fit most readily into a life-science curriculum, this resource is varied and accessible enough to be useful in other subjects, for example, in a physical education class where the relationship between the eyes and the muscles could be explored. As a further example, the students could research and report on Canada's space history or do creative writing dealing with gravity and microgravity as part of a language arts curriculum. And, a social science class could research the implications of human migration into space as a result of the experimental findings of STS-90.

Feel free to distribute and adapt the material as you see fit – it was written for you and your class.

As our front line representative, we at the Canadian Space Agency thank you for helping us prepare Canada's young people for the challenge of space in the next millennium.

Dave Williams in training

Canada in Space

Humans have gazed heavenwards since the dawn of time. They have wondered who or what is in the vast expanse of space. Without reliable information, they set about explaining the sun, the planets, the stars, and other heavenly bodies in terms they could understand, in the context of their own existence.

They imagined all sorts of creatures – animals and gods – as controlling the movements they perceived in the sky. Perhaps the sun was pulled by a charioteer and a mighty steed! Perhaps the Earth sat on the back of a giant tortoise!

Until the invention of the telescope, there were countless conflicting theories about the universe. New theories replaced old ones as the mysteries began to unfold one halting step at a time. Still, space lay like a vast, seemingly limitless expanse of wonder.

Only in the 1950s did it become feasible to send an object beyond the boundaries of the Earth. Canada's role in the evolving adventure of exploring the cosmos began with the establishment of the Churchill Rocket Range, Manitoba, where the first rockets were launched into the upper atmosphere. The chronology on p. 5 highlights Canada's continuing space efforts.

In 1989, the Canadian Space Agency was established to manage Canada's ongoing commitment to space exploration and research.

Dave Williams in training

A CHRONOLOGY

1957

The Churchill Rocket Range, Manitoba, was established to explore the upper atmosphere using rocket-launched payloads.

1959

Canada and NASA signed an agreement under which NASA would provide launching facilities for *Alouette*, Canada's first satellite.

1962

Canada became the third country ever to have a spacecraft in orbit – the *Alouette* satellite. This began a series of Canadian launches during the late 60s and throughout the 1970s.

1981

The Canadarm was first used operationally aboard the Shuttle *Columbia*.

1984

Marc Garneau became the first Canadian in space, as he flew aboard the Shuttle *Challenger*.

1992

Roberta Bondar flew in the first of the series of space shuttle flights dedicated to life sciences research. She became the first Canadian woman in space.

1992

Steve MacLean flew aboard the *Columbia* Mission STS-52 where further life sciences experiments were concluded.

1995

Chris Hadfield was the first Canadian to operate the Canadarm in space and the first and only Canadian to board the Russian Space Station *Mir*.

1996

Marc Garneau celebrated his second flight into space during the STS-77 Mission.

1996

Robert Thirsk participated in the slate of experiments conducted during the 17-day Life and Microgravity Science mission.

1997

Bjarni Tryggvason was Payload Specialist on the STS-85 Mission, focusing on tests using the Microgravity Vibration Isolation Mount (MIM) and various experiments to examine sensitivity to spacecraft vibrations.

1998

Dave Williams was the first Canadian Crew Medical Officer for a shuttle mission flight. He participated in the experiments on the nervous system conducted during the STS-90 Neurolab.

THE MISSION

The STS-90 mission, or Neurolab, was one of a series of NASA research missions dedicated to the study of life sciences. This mission was a very exciting quest that joined the two remaining frontiers of the 20th century, outer space and inner space - the flight of *Columbia* coupled with research into the workings of the human nervous system. The focus of Neurolab's research is the neurosciences.

The 17-day international mission directed its attention to the effects of weightlessness on the nervous system, the most complex and least understood parts of the human body. Made up of the brain, spinal cord, nerves and sensory organs, these systems face major challenges during space flight. They are involved in the regulation of blood pressure, co-ordination of movement and sleep regulation – all of which are affected on a space shuttle mission.

During the flight of Neurolab, astronauts conducted life science experiments in the shuttle *Columbia's* Spacelab module, a fully equipped international space laboratory. The co-ordinated efforts of thousands of scientists, engineers and astronauts from across Canada, the United States, Europe and Japan were involved in the success of this mission.

THE SCIENCE

Two of the 26 Neurolab experiments, chosen by NASA from about 170 proposals, involved Canadian Investigators. One of these experiments, *Visuo-Motor Co-ordination Facility (VCF)*, involved a study of changes in movement during weightlessness that affect such things as pointing to and grasping objects. This project may provide insights into muscular performance on Earth with implications for recovery after injuries. The Canadian co-investigator for this experiment, Dr. Barry Fowler, is a scientist at York University in Toronto.

The other Canada experiment, the *Role of Visual Cues in Spatial Orientation (Visual Cues)*, studied the process by which astronauts orient themselves in microgravity. It examined how they switch from reliance on their inner ear balance organs (which they use on Earth) to using strictly visual cues. The investigation looked at the use of "fake gravity" by putting pressure on the bottom of the feet to see if it could override the visual cues, and how long it would take to re-adapt on return to the Earth. These results may have a bearing on motion sickness both on Earth and in space. The Canadian co-investigator for this experiment, Dr. Ian Howard, is a scientist at the Human Performance Laboratory of the Center for Research and Space Technology (CRESTech) in Toronto.

"Neurolab seeks to explore the remaining two frontiers of the 20th century: space and the human nervous system. The mission provides us with a unique opportunity to capture the imagination of students to further understand human physiology and how humans relate to the world in which we live."

Dr. Dave Williams

THE IMPORTANCE OF NEUROLAB

Neurolab focused on basic research in neuroscience, providing a unique opportunity to study neurological diseases and disorders in a microgravity environment and to investigate potential treatments and therapies. While the mission's main aim was to expand our understanding of how the nervous system develops and functions in space, this knowledge may have direct applications to its development and function on Earth.

Aptly called "the last frontier of human biology", neuroscience research holds infinite possibilities for greater understanding of how the nervous system works and for treating and preventing nervous system ailments.

With all of the data collected over the years on how astronauts adapt to microgravity, researchers are beginning to understand the basics of space physiology, and the experience has posed as many questions as it has answered.
For example:

- How do we learn to function so quickly without gravity, given that all our basic movements (walking, catching, etc.) were learned in the presence of gravity?
- How do the gravity-sensitive parts of the body like the inner ear, cardio-vascular system and muscles learn to cope without gravity?
- Why are sleep and biological rhythms changed in space?
- Must gravity be present at the point in life when basic skills such as walking are usually learned?

These questions were explored on the mission by taking measurements on the crew and research animals before, during and after the flight. The experiments on the crew included blood presssure, eye-hand co-ordination, inner ear research with emphasis on balance, and the problems associated with sleep.

The absence of gravity is a unique research environment with some fascinating possibilities for advancing the treatment of disease.

- For the over half million North Americans with orthostatic intolerance (e.g. dizziness from standing too quickly), Neurolab research may help define the disorder, bringing therapeutic intervention closer;
- Neurolab research using head-mounted Virtual Reality displays studied the effects of disease and trauma on the inner ear which senses balance and motion. This condition affects over 90 million North Americans. The results may suggest the possibility of visual prosthetics as a treatment approach;
- Insomniacs may be aided by advances in understanding of how the "sleep hormone", melatonin, functions, as well as by the development of novel portable equipment for home-based sleep studies;
- New knowledge of neuronal plasticity, the way nerve cells "re-wire" to compensate for disease or injury, may aid in many areas of nervous system therapy;
- The role of gravity in the development of the mammalian nervous system was studied, offering insights into how genetics and the environment interact during this crucial process;
- An on board aquatic system may shed light on various forms of motion sickness and disorientation.

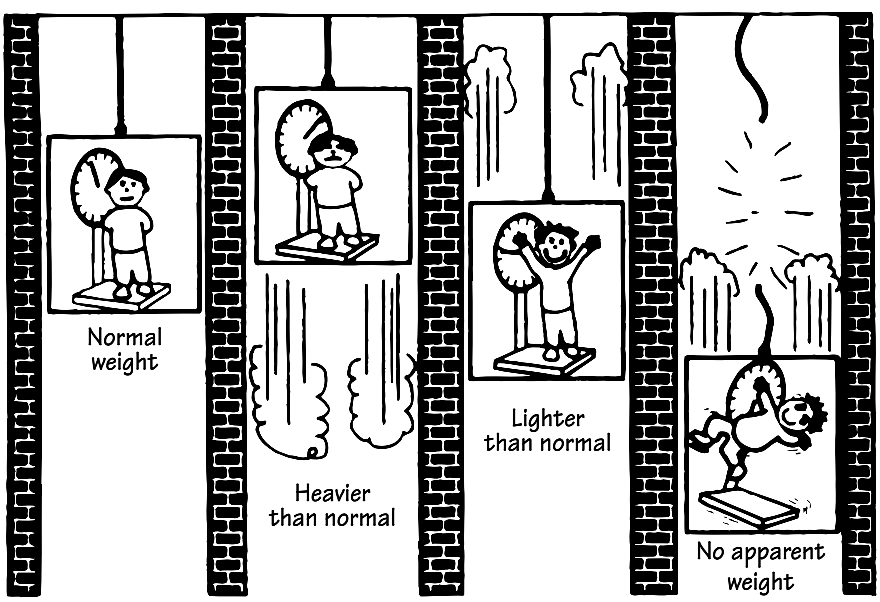
THE IMPORTANCE OF NEUROLAB

Gravity and Microgravity

Gravity is a force that causes an action on a body, usually as a downward pull. It is the force associated with mass and can act without contact. *Resistive forces* counter gravitational pull so that the two together result in a net force of zero.

Microgravity is an environment where the effects of gravity are very small. The extent to which gravity seems to disappear – the quality of microgravity that is achieved – is the extent to which the resistive forces are eliminated.

Gravity and resistive forces affect the human body externally. On Earth, gravity acts uniformly on all parts of the body, but resistive forces act only on contacting surfaces such as the ground and a person's feet. The total force on the human body is zero because the body reacts to distribute the force evenly throughout even though the resistive force acts only on the feet. In a microgravity environment, the resistive forces are very small and therefore, there is no internal force distribution.



Acceleration and Weight
The person in the stationary elevator car experiences normal weight. In the car immediately to the right, apparent weight increases slightly because of the upward acceleration. Apparent weight decreases slightly in the next car because of the downward acceleration. No weight is measured in the last car on the right because of free fall.

NASA Microgravity – A Teacher's Guide with Activities in Science, Mathematics and Technology, EG-1997-08-110-HQ, Education Standards Grades 5-8

CANADIAN ASTRONAUT DAFYDD (DAVE) RHYS WILLIAMS, M.D.

Dr. Dave Williams was the Crew Medical Officer on the STS-90 Mission. He was born in Saskatoon, Sackatchewan on May 16, 1954, and as a young child moved to the rural community of Beaconsfield, near Montréal, Quebec. Among his pastimes were horse-back riding, fishing and canoeing.

Dave remembers trading space cards with his friends during the time of the Mercury and Gemini programs and thinking of becoming an astronaut, although he didn't consider it a real possibility at the time. He was more interested in becoming an aquanaut and living in an underwater environment. By the age of 13, he had completed all the children's swimming and life-saving classes and an adult SCUBA diving course. While an undergraduate in university, he earned his tuition as a lifeguard swimming instructor and examiner, a skiing instructor and a NAUI (National Association of Underwater Instructors) SCUBA instructor.

At McGill University, Dr. Williams earned his B.Sc. in Biology, his M.S. in Physiology and his M.D. and Master of Surgery degrees. He completed a Family Practice residency from the University of Ottawa and an Emergency Medicine residency from the University of Toronto, as well as a Fellowship in Emergency Medicine from the Royal College of Physicians and Surgeons of Canada. He is an assistant professor of medicine at the University of Toronto.

His wife, Cathy, is a commercial pilot and flying instructor. It was during a presentation describing Canada's astronaut program that Marc Garneau made at the flying club where she taught that she nudged her husband and said: "You should be doing this." Nine years later, Dr. Williams' interests and abilities had taken him in just that direction.

The Canadian Space Agency (CSA) selected him for astronaut training and then appointed him manager of the Missions and Space Medicine group within the Astronaut Office. In 1994, he served as a crew member and Crew Medical Officer on a seven-day space mission simulation and was Principal Investigator of a study to evaluate the initial training and retention of resuscitation skills of non-medical astronauts. A member of the 1995 NASA astronaut class, he worked on technical issues for the Payloads/Habitability Branch of the Astronaut Office at Johnson Space Center. Dr. Williams is now head of NASA's Space and Life Sciences Directorate.

STS-90 MISSION CREW

Left to right: Payload Specialist: James (Jim) Pawelczyk; Mission Specialist: Richard (Rick) M. Linneham; pilot: Scott D. Altman; Mission Specialist: Kathryn (Kay) P. Hire; Commander: Richard A. Searfoss; Mission Specialist: Dafydd (Dave) Rhys Williams; Payload Specialist: Jay C. Buckey Jr.

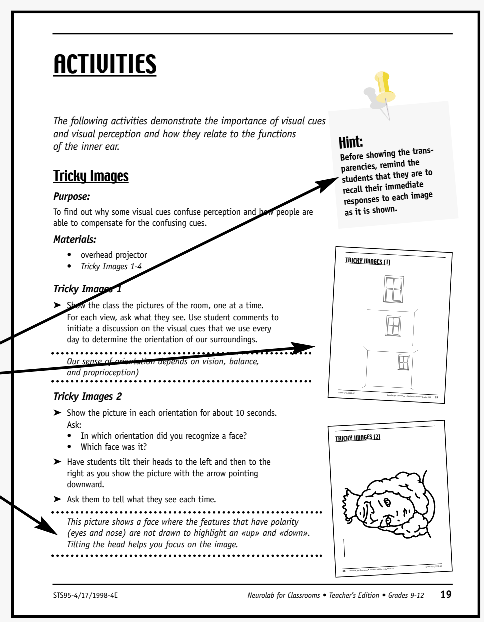
Neurolab for Classroom

The teacher's edition includes a number of special features that make this resource easy to use.

➤ Highlighted information to clarify specific concepts.

➤ Cross-reference to corresponding student pages on the teacher pages for each activity.

➤ Hints for implementation and safety notes.



ACTIVITIES

The following activities demonstrate the importance of visual cues and visual perception and how they relate to the functions of the inner ear.

Tricky Images

Purpose:

To find out why some visual cues confuse perception and how people are able to compensate for the confusing cues.

Materials:

- overhead projector
- *Tricky Images 1-4*

Tricky Images 1

➤ Show the class the pictures of the room, one at a time. For each view, ask what they see. Use student comments to initiate a discussion on the visual cues that we use every day to determine the orientation of our surroundings.

Our sense of orientation depends on vision, balance, and proprioception)

Tricky Images 2

➤ Show the picture in each orientation for about 10 seconds. Ask:
- In which orientation did you recognize a face?
- Which face was it?

➤ Have students tilt their heads to the left and then to the right as you show the picture with the arrow pointing downward.

➤ Ask them to tell what they see each time.

This picture shows a face where the features that have polarity (eyes and nose) are not drawn to highlight an «up» and «down». Tilting the head helps you focus on the image.

Hint: Before showing the transparencies, remind the students that they are to recall their immediate responses to each image as it is shown.

TRICKY IMAGES (1)

TRICKY IMAGES (2)

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THE VISUO-MOTOR CO-ORDINATION FACILITY (VCF) EXPERIMENT

Introduction

The *Visuo-motor Co-ordination Facility (VCF)* experiment was designed to study astronauts' poor co-ordination in space to find out how the human body reacts when gravity suddenly is reduced. It involved the study of changes in movement during weightlessness that affect such things as grasping objects and pointing. From this research, pilot and passenger safety aboard planes and shuttles may be improved and astronauts may learn how to train to become "space co-ordinated".

Normal activity on Earth such as walking, standing, sitting and working with the hands requires the brain to interpret and integrate information from all the body's senses (touch, hearing, sight, etc.). Once the brain processes this information, it gives feedback to the body on how limbs are positioned, how the entire body is oriented (up or down, right or left), and which muscles should be moved to re-orient the body.

In space, the inner ears, muscles, joints and skin cannot rely on gravity as a constant indicator of position and orientation. In order to produce correct responses, the brain must rearrange the relationships among the signals from these sensory systems when it processes the information. This rearrangement requires a period of adaptation. Before the body adapts, the astronauts can get the illusion that the body or their environment is moving when both are stationary. When they return to Earth, they may experience these problems again, since their body must readjust to the sensation of gravity. The length of recovery time is related to the duration of the mission.

Neurolab studies are important not only for the health and welfare of crew members, but also hold promise for developing novel, safe, and effective techniques that would have widespread applications on Earth. Microgravity provides a unique model for studies of this nature. Neurolab research may provide answers about:

- insomnia, a sleep disorder that is most widespread amongst shift workers and the elderly;
- balance or inner ear disorders that affect many people, causing dizziness and disorientation;
- how injury and disease affect people with low blood pressure or heart irregularities.

This experiment may also provide insights into muscular performance on Earth with implications for aiding recovery after injuries.

THE VISUO-MOTOR CO-ORDINATION FACILITY (VCF) EXPERIMENT

Underwater training at NASA

Vocabulary

Adapt – to become adjusted to an environmental condition.

Environment – the circumstances, objects, or physical conditions surrounding an organism.

g – the force of gravity at sea level on Earth.

Gravity – a force that pulls bodies towards one another. The force of gravity is related to the mass of the bodies.

Microgravity – an environment in which gravitational force approaches zero.

Proprioception – a physical sense of one's body or the position of one's limbs.

Reaction time – the interval between the onset of a stimulus and the beginning of an overt response.

Weight – a measure of the downward force that gravity exerts on an object.

Weightlessness – the absence of the sensation of weight.

SETTING A CONTEXT

Class Discussion

- Ask students to describe their experiences on roller coasters and/or their experiences on "virtual roller coasters."

When you are in free fall things appear to have no weight because they are falling at the same rate as you are.

OR

- Pose a scenario such as the one below.
- Have students tell what they think would happen.

You are the only pilot aboard the world's highest roller coaster zooming over a tall bend. As you reach the peak, your passengers' arms flail upwards in a brief moment of weightlessness. Quickly reaching for your control panel, you aim too high and hit the wrong button.

Simulate Weightlessness

- Have students hold a small, heavy object in their hands and note its weight. Then, ask them to jump off a chair and note the weight again. (While they are falling they should feel less weight in their hands than when they are standing on the ground.) They could also try jogging with the object or jumping on a trampoline. What difference did they feel?
- Ask students to think about what it might be like to perform a specific task at that moment when they are experiencing weightlessness and relate it to what the astronauts must do every day.

ACTIVITIES

These activities help students understand the adaptations that astronauts must undergo in their mocrogravity environment.

Grasping Experiment

Purpose:

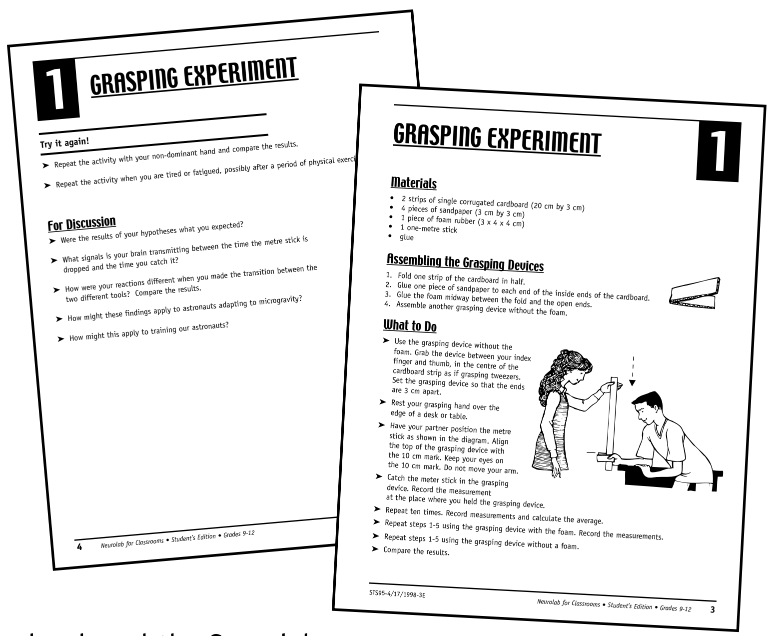
To stimulate the difficulty that astronauts experience when grasping objects in microgravity.
To measure reaction time under different conditions and the time it takes to re-adapt to their original environment.

In this activity, students are not measuring reaction time directly but the distance the metre stick falls which is related to reaction time.

Materials:

For each group:

- *Grasping Experiment, Student 1*
- two grasping devices – one with foam and one without foam
- 1 metre stick



1 GRASPING EXPERIMENT

Try it again!

➤ Repeat the activity with your non-dominant hand and compare the results.

➤ Repeat the activity when you are tired or fatigued, possibly after a period of physical exerci

For Discussion

➤ Were the results of your hypotheses what you expected?

➤ What signals is your brain transmitting between the time the metre stick is dropped and the time you catch it?

➤ How were your reactions different when you made the transition between the two different tools? Compare the results.

➤ How might these findings apply to astronauts adapting to microgravity?

➤ How might this apply to training our astronauts?

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GRASPING EXPERIMENT 1

Materials

- 2 strips of single corrugated cardboard (20 cm by 3 cm)
- 4 pieces of sandpaper (3 cm by 3 cm)
- 1 piece of foam rubber (3 x 4 x 4 cm)
- 1 one-metre stick
- glue

Assembling the Grasping Devices

1. Fold one strip of the cardboard in half.
2. Glue one piece of sandpaper to each end of the inside ends of the cardboard.
3. Glue the foam midway between the fold and the open ends.
4. Assemble another grasping device without the foam.

What to Do

➤ Use the grasping device without the foam. Grab the device between your index finger and thumb, in the centre of the cardboard strip as if grasping tweezers. Set the grasping device so that the ends are 3 cm apart.

➤ Rest your grasping hand over the edge of a desk or table.

➤ Have your partner position the metre stick as shown in the diagram. Align the top of the grasping device with the 10 cm mark. Keep your eyes on the 10 cm mark. Do not move your arm.

➤ Catch the meter stick in the grasping device. Record the measurement at the place where you held the grasping device.

➤ Repeat ten times. Record measurements and calculate the average.

➤ Repeat steps 1-5 using the grasping device with the foam. Record the measurements.

➤ Repeat steps 1-5 using the grasping device without a foam.

➤ Compare the results.

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➤ Have students read the directions on the *Grasping Experiment* student sheet, and answer any questions together.

➤ As a group, develop a hypothesis for each trial.

➤ Invite groups to present the results of their trials.

➤ Ask students to relate these results to the difficulties astronauts have performing daily tasks aboard the Spacelab.

Extensions:

➤ Use this activity as a full lab exercise. Have students write a hypothesis for each trial, describe the method, write up observations and conclusions, and propose an explanation for the results.

➤ Have students plot their results on a graph.

➤ Develop a database of the class results.

➤ Have students explore the Canadian Space Agency Web site for information about the STS-90 Mission. The CSA web site is found at: http://www.space.gc.ca.

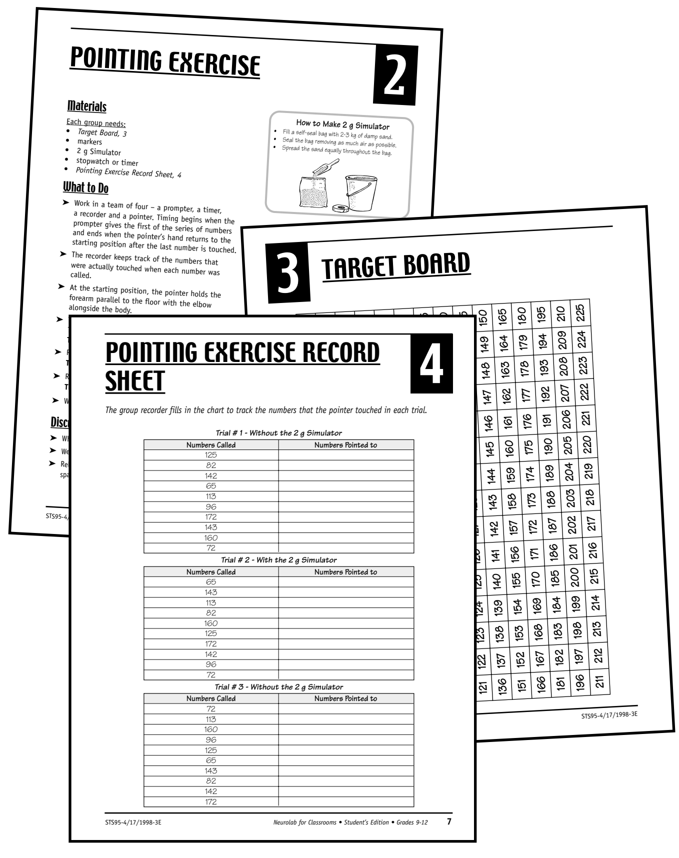
ACTIVITIES

Pointing Exercise

Purpose:

To observe how their ability to point at a familiar object is compromised in a simulated 2 g environment (double gravity) and how their pointing ability adapts back from a 2 g environment to a 1 g environment (normal gravity).

Materials:



For each team or group:

- *Pointing Exercise, Student 2*
- *Pointing Exercise Target Board, Student 3*
- *Pointing Exercise Record Sheet, Student 4*
- 1 marker
- 2 g simulator
- stopwatch or timer

➤ Form groups of 3 or 5 students. Within each group, select a student to read out the numbers. Pair the other students – one points to the target board and the other acts as the recorder.

➤ Read the directions together and answer questions they may have.

➤ Encourage students to point as quickly as possible as this is a timed event.

Extensions:

➤ Have the students develop a hypothesis and write up the experiment as a lab report.

➤ Have students graph the results of the three trials. They might graph accuracy vs. time, possibly all on the same graph.

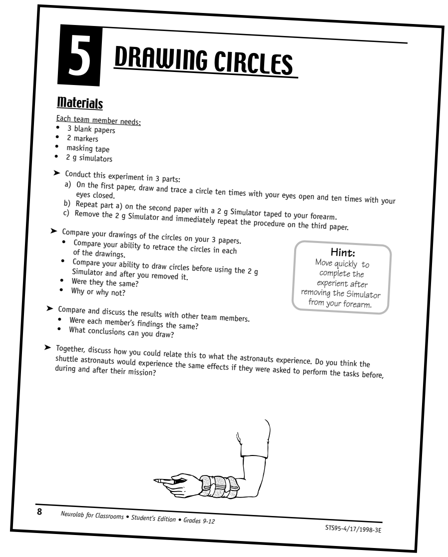
Commercial wrist or ankle weights can be used for the mass apparatus (2 g Simulator).

ACTIVITIES

Drawing Circles

Purpose:

To find out whether students can naturally readjust their movements when extra resistance is applied to their writing arm and/or visual cues are eliminated.


5 DRAWING CIRCLES

Materials

Each team member needs:
- 3 blank papers
- 2 markers
- masking tape
- 2 g simulators

➤ Conduct this experiment in 3 parts:
a) On the first paper, draw and trace a circle ten times with your eyes open and ten times with your eyes closed.
b) Repeat part a) on the second paper with a 2 g Simulator taped to your forearm.
c) Remove the 2 g Simulator and immediately repeat the procedure on the third paper.

➤ Compare your drawings of the circles on your 3 papers.
- Compare your ability to retrace the circles in each of the drawings.
- Compare your ability to draw circles before using the 2 g Simulator and after you removed it.
- Were they the same?
- Why or why not?

Hint: Move quickly to complete the experiment after removing the Simulator from your forearm.

➤ Compare and discuss the results with other team members.
- Were each member's findings the same?
- What conclusions can you draw?

➤ Together, discuss how you could relate this to what the astronauts experience. Do you think the shuttle astronauts would experience the same effects if they were asked to perform the tasks before, during and after their mission?

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Materials:

For each team or group:
- blank papers – 3 per student
- 2 markers
- masking tape
- 2 g simulator

➤ Have the students complete the experiment in teams of 3 or 4, following the instructions on *Drawing Circles, Student 5*.

➤ Remind them that there are three parts to the experiment.

Discussion:

➤ As follow-up to the group work, discuss the findings as a class.
- Compare their ability to retrace the circles in each of the drawings.
- Compare their ability to draw circles before using the 2 g simulator and after it was removed.
  - Were they the same?
  - Why or why not?

➤ Have them apply their findings to answer the following question: Do you think the shuttle astronauts would experience the same effects if they were asked to perform the tasks before, during, and after their mission?

Hint:
Students should move quickly to complete the experiment after removing the Simulator as their reflexes will return to normal quite rapidly once the weight is removed from their forearm.

VISUAL CUES IN SPATIAL ORIENTATION EXPERIMENT

Introduction

What our bodies have learned to do on Earth does not necessarily work in outer space. This experiment, sometimes referred to as the "virtual reality" experiment, was designed to investigate how astronauts orient themselves in microgravity while working in space. In our daily lives, gravity provides a constant anchor for us to use as a reference for orientation. In space, astronauts lose this reference. They lose sense of what is UP and DOWN, and often suffer from motion sickness as a result.

STS-90 crew member Jim Pawelczyk

This "space motion sickness" affects nearly half of the astronauts. A contributing factor may be a conflict between the astronauts' visual cues and the absence of inner ear and somatic sensations (pressure on your feet when standing or on your seat when sitting). Space motion sickness is a significant cost in terms of astronaut "down time", reduced work quality, and danger due to impaired co-ordination.

The Visual Cues experiment attempted to discover how quickly astronauts switch from using the balance organs in their inner ears to using strictly visual cues. It also investigated whether "fake gravity" (like putting pressure on the bottoms of their feet) could override these strange new visual cues in space and how long it takes to re-adapt on their return to Earth. The results of this experiment could indicate if virtual reality pre-training for astronauts might be more effective than current training practices.

Dave Williams at CRESTech Labs in a cubic room rotated 180 degrees

Astronauts' perception of their orientation was tested in three different environments – a spherical room with no UP or DOWN cues, a furnished cubic room, and a cubic room that is not furnished. The astronauts were tested in real rooms before and after the flight and in "virtual reality" rooms, created by NASA's Virtual Environment Generator, while on the space shuttle. The experiment may help improve our understanding of the human orientation system and the information obtained can be applied to situations on Earth. This virtual reality research may contribute to understanding and

VISUAL CUES IN SPATIAL ORIENTATION EXPERIMENT

solving the problem of motion sickness which is one of the more serious problems of human travel. Pilots, especially trainees, can experience sensory conflict and become disoriented, which can be fatal.

Vocabulary

Circular vection – the perception of self-rotation induced by visual stimulation.

Coriolis effect – additional forces of acceleration that act on a moving body in a rotating system of reference.

Polarity – having two opposed poles.

Looming effect – a distorted or invested image resulting from motion or quick changes.

Motion sickness – dizziness or nausea, often experienced during travel.

Proprioception – a physical sense of one's body or the position of one's limbs.

Vestibular system – the balancing organs of the body, especially the inner ear which contains crystals of calcium carbonate (otoliths) which when tilted impart changes to the hairs beneath. The eyes and certain sensory cells in the skin and internal tissues also help the body maintain balance.

Setting a Context

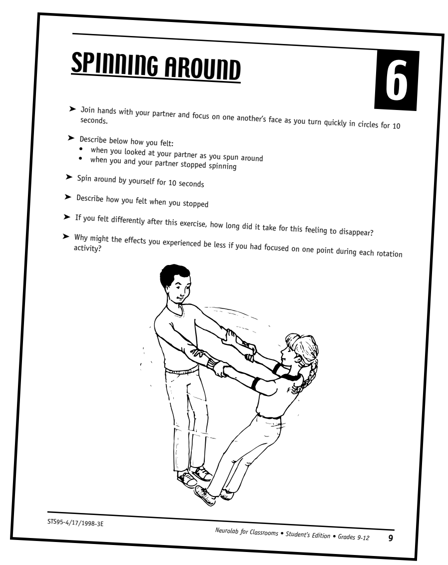
Class Discussion

➤ To get students thinking about the connection between motion and visual cues:
- brainstorm times when they feel they are moving, when in actuality, they are not.
- ask if they have felt nauseous or dizzy in a moving car or on an amusement park ride. Why did they feel that way?

Spinning Around

➤ To help students realize the importance of "points of reference", have them work through activities outlined on *Spinning Around, Student 6*.

➤ As an alternate activity, talk about the sensations they feel after spinning rapidly with and without a point of reference.



SPINNING AROUND 6

➤ Join hands with your partner and focus on one another's face as you turn quickly in circles for 10 seconds.

➤ Describe below how you felt:
- when you looked at your partner as you spun around
- when you and your partner stopped spinning

➤ Spin around by yourself for 10 seconds

➤ Describe how you felt when you stopped

➤ If you felt differently after this exercise, how long did it take for this feeling to disappear?

➤ Why might the effects you experienced be less if you had focused on one point during each rotation activity?

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ACTIVITIES

The following activities demonstrate the importance of visual cues and visual perception and how they relate to the functions of the inner ear.

Hint:
Before showing the transparencies, remind the students that they are to recall their immediate responses to each image as it is shown.

Tricky Images

Purpose:

To find out why some visual cues confuse perception and how people are able to compensate for the confusing cues.

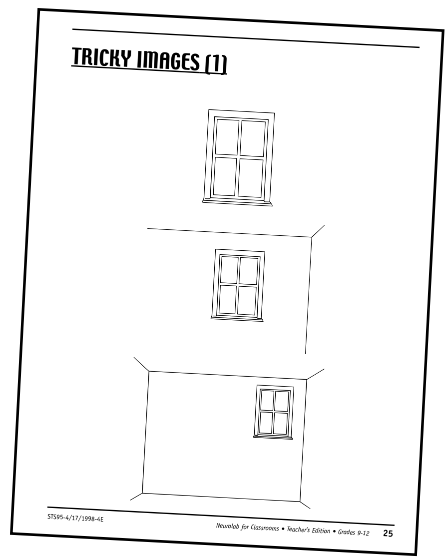
Materials:

- overhead projector
- *Tricky Images 1-4*

Tricky Images 1

➤ Show the class the pictures of the room, one at a time. For each view, ask what they see. Use student comments to initiate a discussion on the visual cues that we use every day to determine the orientation of our surroundings.

Our sense of orientation depends on vision, balance, and proprioception)



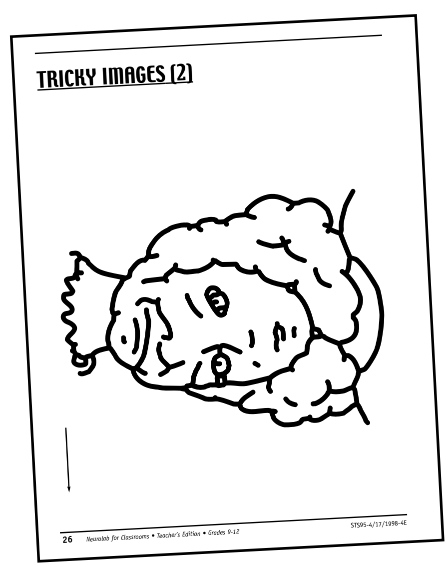
Tricky Images 2

➤ Show the picture in each orientation for about 10 seconds. Ask:
- In which orientation did you recognize a face?
- Which face was it?

➤ Have students tilt their heads to the left and then to the right as you show the picture with the arrow pointing downward.

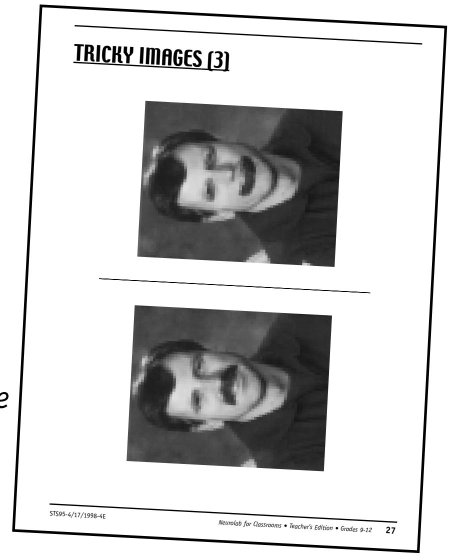
➤ Ask them to tell what they see each time.

This picture shows a face where the features that have polarity (eyes and nose) are not drawn to highlight an «up» and «down». Tilting the head helps you focus on the image.



ACTIVITIES

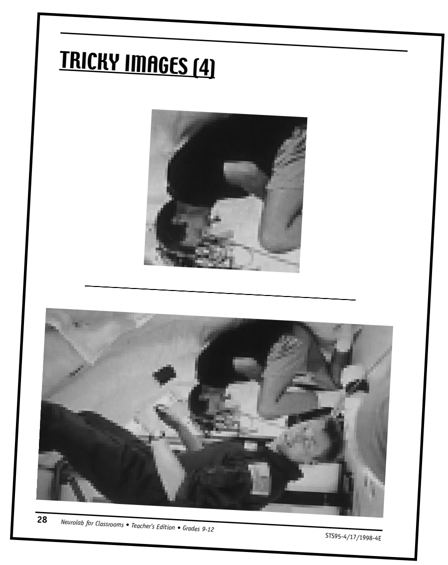
Tricky Images 3



➤ Show the students the first image of Dr. Dave Willams inverted for only a few seconds. Invite them to tell what they saw. Show the second inverted image for a few seconds and have them tell what they see. Then, show them both pictures side by side with the images in the normal position and have them comment.

The upside down pictures do not appear to be an obvious 'cut and paste' of the eyes and mouth because its orientation is normal relative to the viewer, but the 'cut and paste' aspect becomes quite apparent when the picture is right side up. This is an example of how people have become accustomed to the face and use particular features as a means of detecting polarity.

Tricky Images 4



➤ Show the close-up of the astronaut exercising and ask which way is up. Show the expanded picture in which the surroundings are in view. Ask:
- Which way is up?
- What cues changed your perception?

➤ Discuss the fact that astronauts work independently of each other in the shuttle and position their bodies in varying orientations with respect to each other. How would an astronaut be able to reduce dizziness experienced while working in the Spacelab?

The problem of conflicting signals to the brain does not arise until the astronaut looks beyond her/his work environment to the positioning of colleagues.

ACTIVITIES

To help students understand and experience visual cues and how they both orient and disorient the body, have them complete some or all of the following activities. Suggest that students try as many of them as possible in the time available.

Extensions:

After the students have completed the prepared activities, engage them in some of the following activities.

➤ Students might brainstorm other experiences that result in sensory overload and conflict, as well as applications of sensory studies performed in space. Which of these might affect space travel?

➤ Some students may want to research questions or applications for:
- circular vection
- linear vection
- altered body positions and response time

➤ Have students create activities that would confuse each other's sensory input.

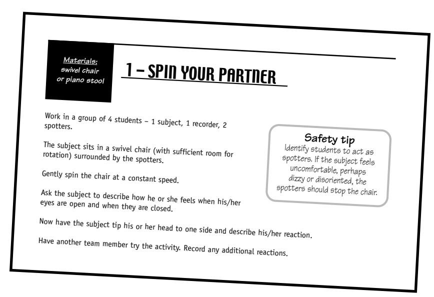
1– SPIN YOUR PARTNER

Materials:

Swivel chair or piano stool

Purpose:

To show students that spinning in the upright position (one plane) with the head tilted (second plane) causes conflicting messages to be sent to the brain.


Materials:
swivel chair or piano stool

1 – SPIN YOUR PARTNER

Work in a group of 4 students – 1 subject, 1 recorder, 2 spotters.

The subject sits in a swivel chair (with sufficient room for rotation) surrounded by the spotters.

Gently spin the chair at a constant speed.

Ask the subject to describe how he or she feels when his/her eyes are open and when they are closed.

Now have the subject tip his or her head to one side and describe his/her reaction.

Have another team member try the activity. Record any additional reactions.

Safety tip
Identify students to act as spotters. If the subject feels uncomfortable, perhaps dizzy or disoriented, the spotters should stop the chair.

The eyes' movement accurately reflects what happens in the inner ear. While the body is spinning, the eyes naturally move in a direction equal and opposite to the motion of the body.

The inner ear is very good at sensing the beginning or end of rotation. Constant rotation will create the sensation of sitting still.

Extension:

Have some students try to do a fine motor activity immediately after spinning and then describe what happened. They might write their name, touch their nose with their index finger, hop on one foot, etc. Students who perform the same activity could compare their results.

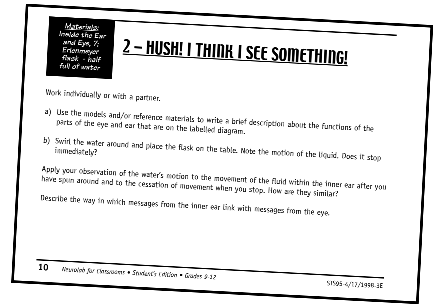
ACTIVITIES

2– HUSH! I THINK I SEE SOMETHING!

Materials:

Inside the Ear and Eye, Student 7, reference materials, flask, water

Display cross-sectional models of the eye and ear, if possible. Encourage the students to use a wide variety of reference sources including the Internet to find the information they need to complete the activity.



Materials: Inside the Ear and Eye, 7; Erlenmeyer flask - half full of water

2 – HUSH! I THINK I SEE SOMETHING!

Work individually or with a partner.

a) Use the models and/or reference materials to write a brief description about the functions of the parts of the eye and ear that are on the labelled diagram.

b) Swirl the water around and place the flask on the table. Note the motion of the liquid. Does it stop immediately?

Apply your observation of the water's motion to the movement of the fluid within the inner ear after you have spun around and to the cessation of movement when you stop. How are they similar?

Describe the way in which messages from the inner ear link with messages from the eye.

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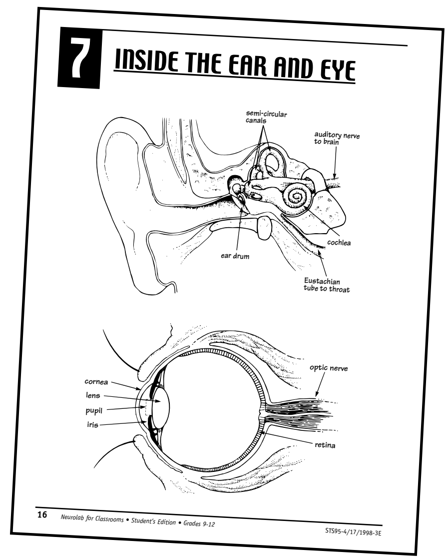
The inner ear senses gravity but when gravity is removed as it is in space, the nervous system is challenged and it can no longer provide meaningful information as to the direction of up or down.



7 INSIDE THE EAR AND EYE

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Extension:

Some students may wish to research the role of calcium crystals in the inner ear and how the inner ear perceives gravity.

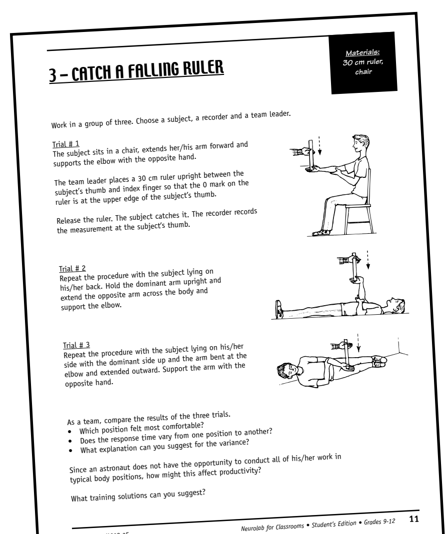
3– CATCH A FALLING RULER

Materials:

30 cm ruler, chair

Purpose:

To show that orientation affects response time until we train ourselves to our altered state.



3 – CATCH A FALLING RULER

Materials: 30 cm ruler, chair

Work in a group of three. Choose a subject, a recorder and a team leader.

Trial # 1
The subject sits in a chair, extends her/his arm forward and supports the elbow with the opposite hand.

The team leader places a 30 cm ruler upright between the subject's thumb and index finger so that the 0 mark on the ruler is at the upper edge of the subject's thumb.

Release the ruler. The subject catches it. The recorder records the measurement at the subject's thumb.

Trial # 2
Repeat the procedure with the subject lying on his/her back. Hold the dominant arm upright and extend the opposite arm across the body and support the elbow.

Trial # 3
Repeat the procedure with the subject lying on his/her side with the dominant side up and the arm bent at the elbow and extended outward. Support the arm with the opposite hand.

As a team, compare the results of the three trials.
- Which position felt most comfortable?
- Does the response time vary from one position to another?
- What explanation can you suggest for the variance?

Since an astronaut does not have the opportunity to conduct all of his/her work in typical body positions, how might this affect productivity?

What training solutions can you suggest?

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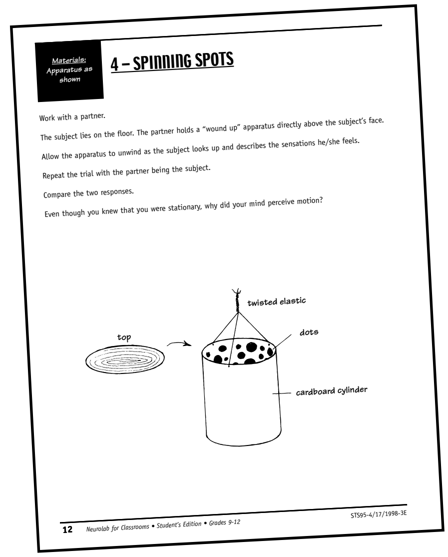
ACTIVITIES

4- SPINNING SPOTS


Materials:
Apparatus as shown

4 – SPINNING SPOTS

Work with a partner.

The subject lies on the floor. The partner holds a "wound up" apparatus directly above the subject's face.

Allow the apparatus to unwind as the subject looks up and describes the sensations he/she feels.

Repeat the trial with the partner being the subject.

Compare the two responses.

Even though you knew that you were stationary, why did your mind perceive motion?

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Materials:

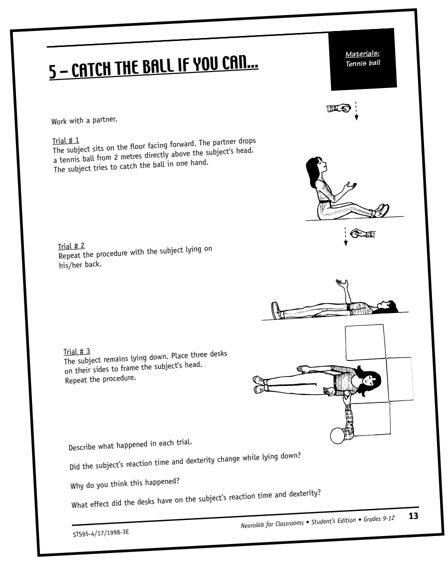
1 sheet Bristol board, 3 elastics, black marker, hole punch

Purpose:

To have students use a stereoscopic display as an example of circular vection.

Prepare spinning spots apparatus beforehand or ask students to make one.

5- CATCH THE BALL IF YOU CAN...


Materials:
Tennis ball

5 – CATCH THE BALL IF YOU CAN...

Work with a partner.

Trial # 1
The subject sits on the floor facing forward. The partner drops a tennis ball from 2 metres directly above the subject's head. The subject tries to catch the ball in one hand.

Trial # 2
Repeat the procedure with the subject lying on his/her back.

Trial # 3
The subject remains lying down. Place three desks on their sides to frame the subject's head. Repeat the procedure.

Describe what happened in each trial.

Did the subject's reaction time and dexterity change while lying down?

Why do you think this happened?

What effect did the desks have on the subject's reaction time and dexterity?

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Materials:

Tennis ball

Purpose:

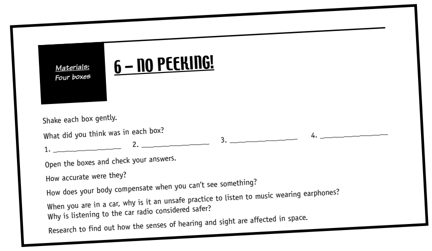
To show that we normally track and receive things in a polar environment (distinct north-south direction).

Changing the polarity with respect to the environment changes dexterity and reaction time.

6- NO PEEKING!

Materials:

4 boxes, assorted materials


Materials:
Four boxes

6 – NO PEEKING!

Shake each box gently.

What did you think was in each box?
1. ______________ 2. ______________ 3. ______________ 4. ______________

Open the boxes and check your answers.

How accurate were they?

How does your body compensate when you can't see something?

When you are in a car, why is it an unsafe practice to listen to music wearing earphones?
Why is listening to the car radio considered safer?

Research to find out how the senses of hearing and sight are affected in space.

Purpose:

To show that the body can compensate for certain senses that are not functional in a given situation.

Prepare four small boxes each containing one type of material such as rubber stoppers, marbles, bird seed, marshmallows, etc., that will provide an interesting sound cue when the box is shaken. Seal the boxes.

ACTIVITIES

7– GOING MY WAY?

Materials:

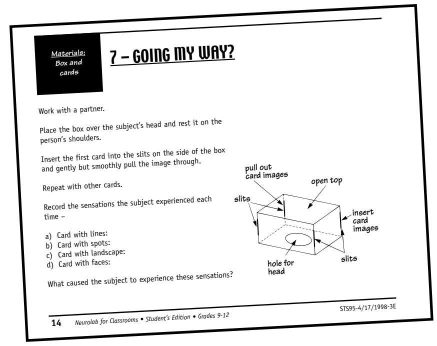
Decorated box

Purpose:

To show the "Looming Effect"

Prepare boxes or have students make them ahead of time.

The box must be able to fit over a student's head with sufficient clearance so it can be rotated.



Materials: Box and cards

7 – GOING MY WAY?

Work with a partner.

Place the box over the subject's head and rest it on the person's shoulders.

Insert the first card into the slits on the side of the box and gently but smoothly pull the image through.

Repeat with other cards.

Record the sensations the subject experienced each time –

a) Card with lines:
b) Card with spots:
c) Card with landscape:
d) Card with faces:

What caused the subject to experience these sensations?

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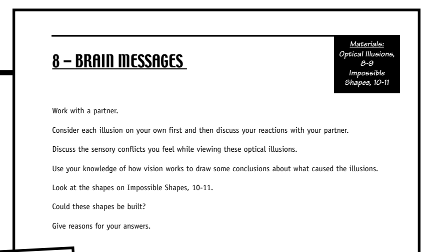
This experiment demonstrates circular vection.



Materials: Optical Illusions, 8-9 Impossible Shapes, 10-11

8 – BRAIN MESSAGES

Work with a partner.

Consider each illusion on your own first and then discuss your reactions with your partner.

Discuss the sensory conflicts you feel while viewing these optical illusions.

Use your knowledge of how vision works to draw some conclusions about what caused the illusions.

Look at the shapes on Impossible Shapes, 10-11.

Could these shapes be built?

Give reasons for your answers.

8– BRAIN MESSAGES

Materials:

Optical Illusions, Student 8-11

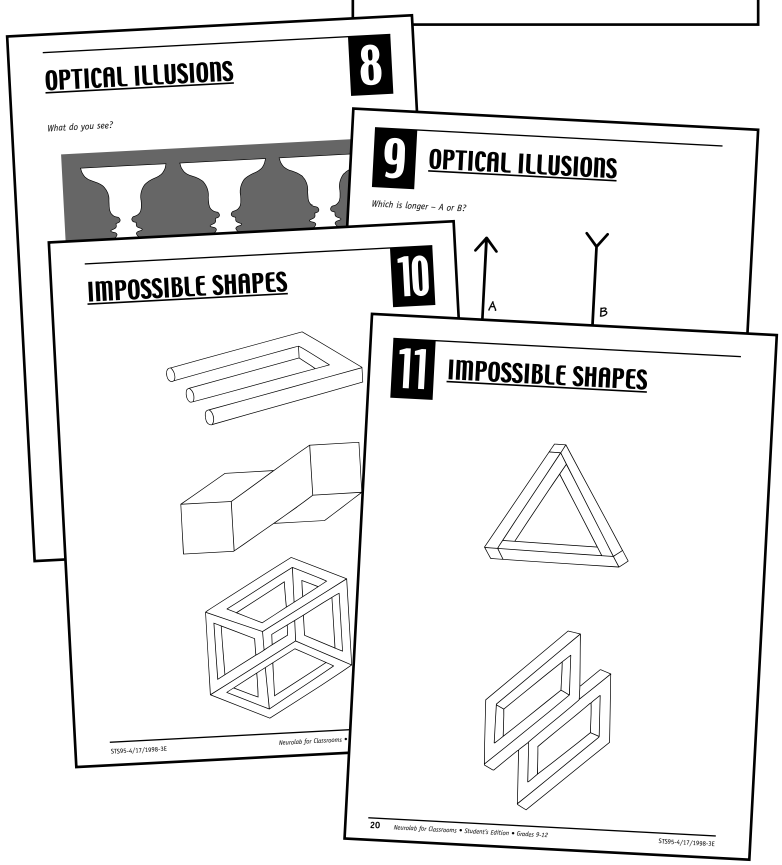
Purpose:

To demonstrate how visual cues may not be clearly interpreted by the brain.

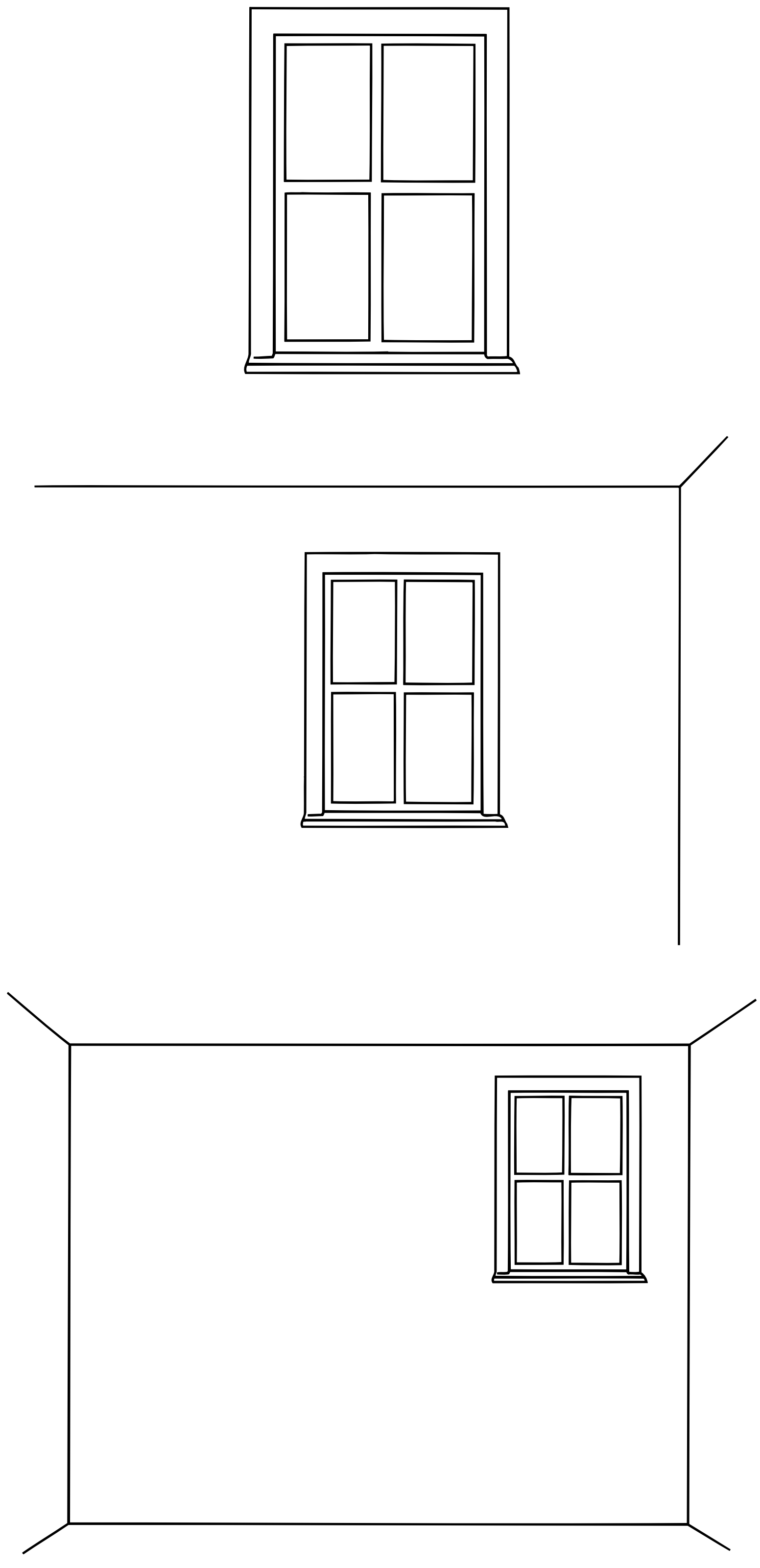
Notes:

We do not come across illusions as powerful as these in daily life because there are usually many visual cues in our surroundings to help our brain interpret what it sees. The illusions shown on these pages are confusing because the images have been simplified – the brain is not given the contextual cues that it needs, so it must guess as to what it "sees".

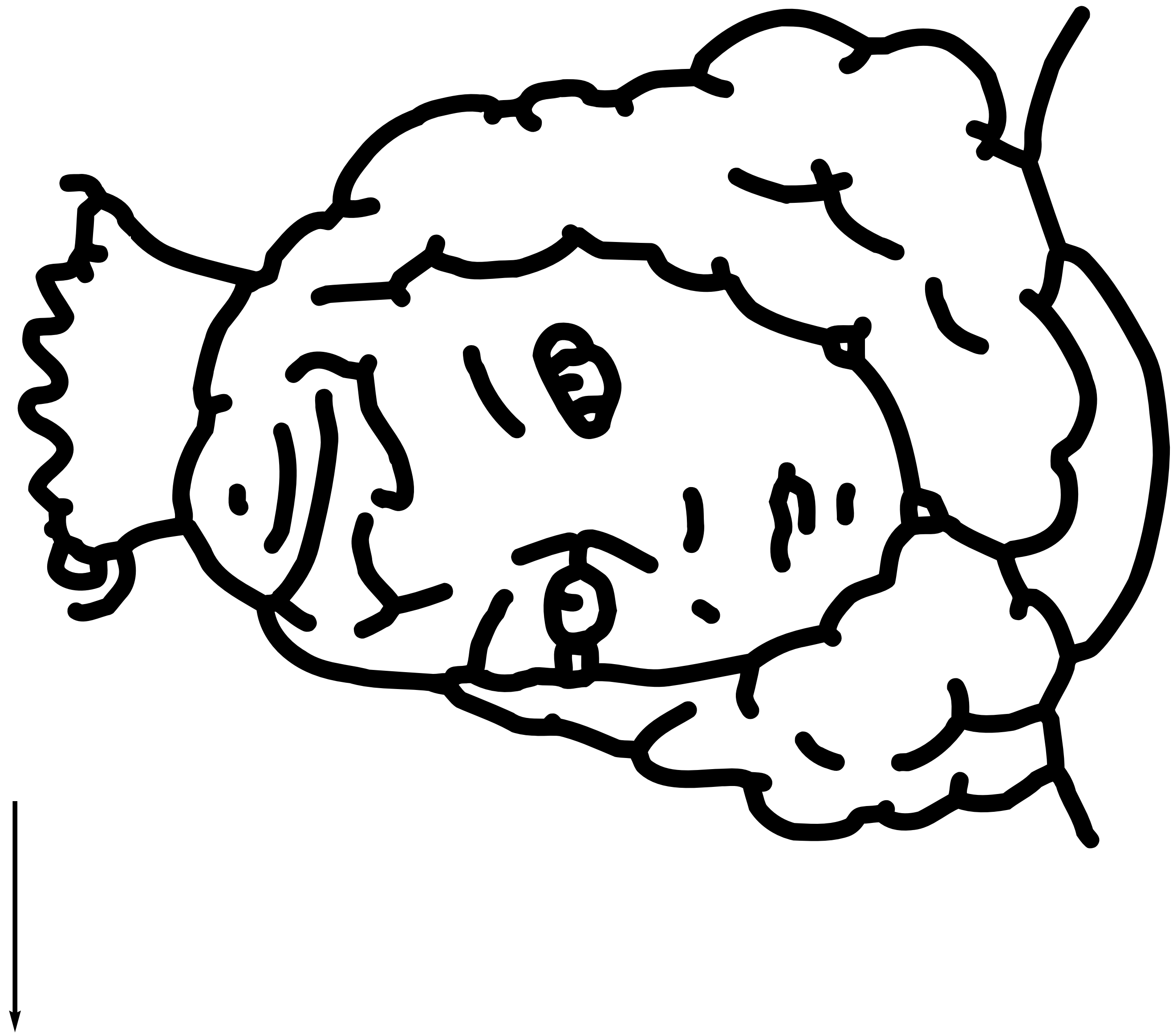
As the students look carefully at the images on *Impossible Shapes, Student 10-11*, they will see that it is physically impossible to construct these shapes.



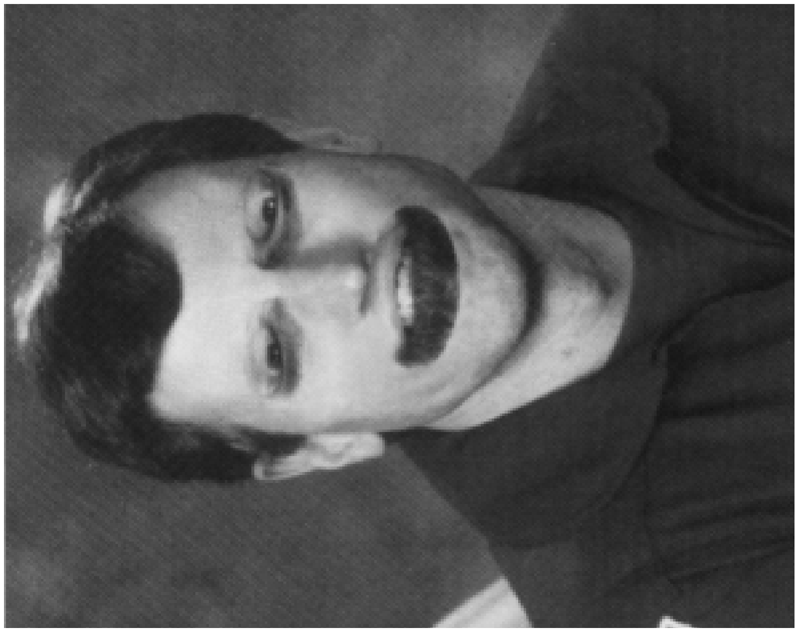
TRICKY IMAGES (1)

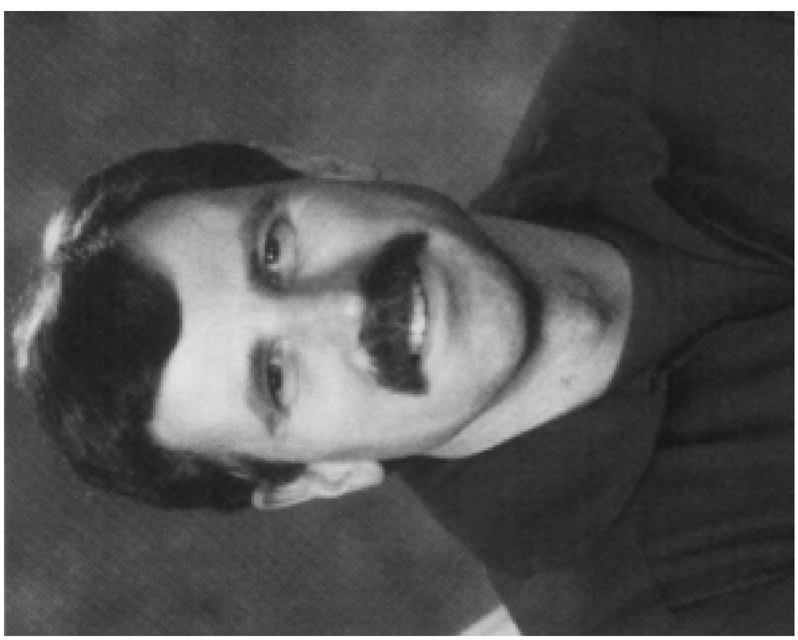


TRICKY IMAGES (2)



TRICKY IMAGES (3)





TRICKY IMAGES (4)

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REFERENCES:

The Space Shuttle, Dr. Robert Thirsk, Canadian Space Agency (1997)

The Space Environment, Dr. Robert Thirsk, Canadian Space Agency (1997)

Microgravity Speaker Handbook, Canadian Space Agency (1994)

Microgravity – A Teacher's Guide, NASA (1997)

ON-LINE RESOURCES

Canadian Space Agency Web Page:
http://www.space.gc.ca

CSA KidSpace:
http://www.space.gc.ca/kidspace

Newrolab Mission Web Page:
http://www.space.gc.ca_sectors/human_presence/en/canastronauts/astro/sts90/index.htm
then click Kid Space!

Link to NASA website :
http://lsda.jsc.nasa.gov

Neuroscience For Kids
http://weber.s.washington.edu/~chudler/neurok.html

Neurolab Online:
http://quest.arc.nasa.gov/neuron/

DAVE WILLIAMS STS-90 MISSION CREST

The STS-90 Mission, known as Neurolab, sees the Space Shuttle Columbia *transformed into an orbiting laboratory for neurosciences. The EEG (electroencephalogram) waves emanating from the shuttle represent the experiments to be conducted during the mission. There are four waves: one for each of the payload crew members who will be carrying out the experiments.*

The constellation Ophiucus ("The Serpent Bearer"), associated with Asclepius, the Greek god of medicine, appears in the upper right side of the patch. The nine stars in the constellation represent the nine crew members who have trained for STS-90. The cadueus on the left is the international emblem of physicians. The traditional wings of the emblem have been modified to aviation "flight wings" symbolizing Dave Williams' combined experience as medical doctor, neurophysiologist, and mission specialist.

A graphic illustration of a neuron stretches over the Earth below, representing the application of Neurolab's research to terrestrial neurosciences.

Canadian Space Agency Educational Outreach Reply Form

The Canadian space Agency through its educational outreach program seeks to involve teachers and students in its educational activities. To this end, please provide us with your comments and suggestions on the material in this package.

Your opinion counts! Please take a moment to fill out the evaluation form below and return it to:

Manager, Youth Outreach, Communications Directorate, Canadian Space Agency
6767 route de l'Aéroport, Saint-Hubert, Quebec J3Y 8Y9

Indicate the extent to which you agree with each statement by circling ONE number in the right hand column	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
As an instructor, I found the STS-90 outreach material useful.	1	2	3	4	5
The students responded positively to the material.	1	2	3	4	5
I would welcome similar material for future missions.	1	2	3	3	3
The presentation of the material attracted learners.	1	2	3	4	5
The content of the material was engaging.	1	2	3	4	5
The science content was appropriate for the level of the learners.	1	2	3	4	5
The delivery vehicle was the best one to use in this case.	1	2	3	4	5
I would prefer more general information to make my own lessons.	1	2	3	4	5

Prov. or Terr.: ______________________ Put me on your mailing list: ❑

Subject taught: ______________________ NAME: ______________________

Level materials were used: ______________________ ADDRESS: ______________________

Which of the following best describes how the materials were used:

❑ **A.** Background information ❑ **B.** Group discussion ❑ **C.** Integration into existing curricula ❑ **D.** Lecture
❑ **E.** Group activities ❑ **F.** Demonstration ❑ **G.** Hands-on activities
❑ **H.** Interdisciplinary activities ❑ **I.** Other: Please specify: ______________________

Which features of the material were most useful? ______________________

Which features need to be improved? ______________________

Additional comments: ______________________