Train Your Brain

The Neuroscience of Learned Behaviors

by
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CONTENTS

INVESTIGATION 1
What Makes You, You?
Inherited Traits and Learned Behaviors

OVERVIEW. Students will learn that they have inherited some of their characteristics from their parents and other characteristics and skills have been acquired through practice and experience.

BACKGROUND
The lessons contained in this teacher guide look at how behaviors are learned and remembered, The teacher guide title, "Train Your Brain," refers to the many ways in which our brains and nervous system acquire new skills and knowledge every day—and to the ways in which teachers can help students develop awareness of how they learn and remember. This guide also provides comprehensive coverage of concepts related to learned behaviors and inherited traits.

Characteristics of organisms, including physical features and actions, can be inherited or they can be acquired through learning. Many actions and movements are learned behaviors. These behaviors help organisms respond to immediate changes in their environment and promote survival and reproduction.

Every living thing has a set of genetic instructions that specify its traits or observable characteristics. Traits can include physical appearance, disease tendencies and even certain behaviors or abilities, such as a mammal offspring knowing how to nurse. Traits are determined by segments of DNA called genes. Most genes have more than one variation. These variations contribute to differences in the appearance of offspring. Each individual has two sets of DNA—one set is inherited from each parent. In this way, each parent contributes one copy of a gene that stores information needed to express a trait.

Inherited traits are passed on from the parents or their ancestors to their offspring. The combination of your parents' genes is called your genotype. Your actual traits are called your phenotype. Most often, an inherited or genetic trait is the product of interactions among several genes. Some traits are considered single gene traits, although there is still debate as research continues.

The following characteristics are currently considered as examples of single gene traits.

Cleft or smooth chin
Dimples
Widow's peak hairline
Colorblindness
Freckles

Most characteristics are the result of the actions of several different genes. These types of characteristics are referred to as complex inherited traits. Below are examples of complex traits.

Eye color
Muscle structure
Bone structure
Height
Hair Texture (curly, straight or in between)
Hair color
Finger and toe length
Facial features
Disease tendencies (such as Type 2 diabetes)

For more information about inherited traits see:
Learn.Genetics (HHMI) http://learn.genetics.utah.edu/content/inheritance/observable/

The combination of your parent's genes is called your genotype. The actual traits are called your phenotype.

Animal species have innumerable inherited behaviors. They create webs, build nests, burrow, hunt singly or in packs, hibernate, etc. Humans also have inherited behaviors include babies crying when hungry, babies nursing, grasping and falling reflex, and making noise. These behaviors are not learned. They are basic survival instincts. They are like blueprints that your brain follows, but they do not involve conscious thought.

Learned behaviors, however, are not passed on genetically. They are gained through experience, and are stored in connections among nerve cells in the brain. Learning is the process of acquiring information and skills. Behaviors that include specific balance and motion functions, such as using tools, skills in sports, knowledge acquisition, and reading and language, all must be learned.

Motor coordination, which is the coordination of balance and muscles in movement, develops at relatively regular intervals as a human being grows from child to adult.

GUIDING QUESTION

What are inherited traits?

CONCEPTS

Some characteristics of organisms are inherited, while others are learned behaviors.

TIME

Setup: 5 minutes to create chart and make copies of inherited traits
Class: 2 sessions of 45 minutes to 1 hour, and one optional homework assignment

MATERIALS

- Science notebooks
- Register tape or sentence strips

SETUP:

Create chart and make copies of inherited traits

PROCEDURE

Part 1

1. Make a two-column chart without headings. Later, you will add headings. Place eye color and dimples in the left column, and riding a bicycle and reading in the right column of the chart.

2. Ask students what the two columns might represent. Label the columns “Inherited Traits” and “Learned Behaviors.” Discuss and make sure students understand that the left column lists traits that are inherited and come from parents or other ancestors, while the second column lists learned behaviors that must be acquired through experience.

3. Ask students to contribute to the chart listing any inherited traits they can think of. Discuss their ideas. Explain that each person receives two sets of genes or information packets, from their parents. The way the genes are combined determines our inherited traits. Explain that this is called their genotype.

4. Have students create a chart. Along the left side of the chart they should list their inherited traits like eye color, hair color and other that have been discussed. Explain that this is called their phenotype. Across the top of the chart create columns for relatives, i.e. dad, mom, sister…or other relatives depending on their situation. Then have students take a poll among their family to see who shares similar traits. Have students bring their polls back to class to share. Ask, Are you more like your father or mother or sister or brother or another relative? If they do not have access to any data you may ask them to imagine what their biological parents traits might have been based on their own traits. Have students create a chart with their inherited traits along the left side and a list of mom, dad, brothers and sisters or other relatives along the top.

4\. Next, have students contribute learned behaviors to the chart. Explain that in the next lesson they will investigate more about these behaviors.

Part 2

1. Our life experience, environment, interests and more create our learned behaviors. Explain to your students that while we can't change our inherited traits, we can take control of many learned behaviors. The brain is the central processor for learning. It takes in information from all our senses and puts it together to make meaning. When we learn to ride a bicycle, for example, our brains process our movements and adjust them from moment to moment. Eventually, riding a bicycle becomes almost automatic. We do not have to "think" through every step in the riding process. We "train our brains." Ask students to contribute other activities that become easier and more effective as they are learned. Examples might include other sports, reading, playing video games or playing a musical instrument.

2. Have students use register tape or sentence strips to make a time line with words and pictures of their learned behaviors. On the strip students should record the approximate developmental times when they learned major behaviors, such as the following list.

   - First time to crawl
   - First time to walk
   - First words (talking)
   - Beginning drawing
   - Reading
   - Writing
   - Counting
   - Playing team sports
   - Playing a musical instrument

   The timeline can be done in class or as a homework assignment that parents or family members could help create. The dates will need to be approximate, possibly by year. For instance:

6 months –1 year	Crawl
1-2 years	Walk, talk, hand/eye coordination
2-3 years	Erratic coloring, block stacking
4-5 years	Beginning drawing
5-6 years	Reading and writing
7-8 years	Texting, bicycle riding
9-10 years	Play team sports
11-12 years	Play musical instrument

3. Place the timelines on a bulletin board. Have students look for similarities. Ask, *Do most lines indicate walking and talking between one and two years?* Why? Discuss how physical development and motor coordination enable learned behaviors to develop within rather specific time intervals.

4. Close the lesson by having the students write a brief story imagining how their day would be if one of his or her inherited traits could be changed. Not science fiction!!

INVESTIGATION 2

Amazing Learned Behaviors

Memories and Learning

OVERVIEW. Students will investigate learned behaviors by developing a new motor skill (reverse drawing with a mirror image).

BACKGROUND

Learning is the process of acquiring information and skills. Everyday new information enters our brain, much of it is processed and stored so that it can be found and used again. Often, learning is a conscious effort, like learning to read, learning to play a sport or musical instrument. Mainly we learn by association, repletion or imitation. Learning actually changes the physical structure of the brain and, in turn, these structures change the way we perceive the world.

When learning is meaningful, it is connected to information that a person already knows—and is more easily learned and remembered. Memory is the storage of information in the brain and remembering is the process of finding the pieces in memory and putting them back together.

Two basic types of memories are declarative and procedural. Declarative or explicit memories are either semantic, having to do with words, or episodic, which are event related. These facts or events can be recalled by conscious thought and can be described in words. Declarative memories are stored in the part of the brain called the cerebrum.

With procedural or implicit memories you may not be able to fully articulate the memory, but are able to perform a specific action like roller skating or riding a bike. These memories involve skills that are acquired through practice over time and recalled without conscious thought. Although the thinking part of the brain, the cerebrum initiates an action, a different part of the brain, the cerebellum, actually is involved in the processing and storage of this type of memory. The cerebrum also helps with storage and recall of routine information such as multiplication tables.

GUIDING QUESTION

What can we learn about learning and memory?

CONCEPTS

Learning is a process of taking in information and then processing it into memory. Memory is the recall of learned information. Learning can happen in a number of ways. Practice is an important component of procedural learning (motor skills).

TIME

Class: 1 session

MATERIALS

Per Student

- Science notebook
- Mirror Writing worksheet
- Small plastic mirror
- Pen or pencil

SETUP

Make copies of mazes for each student.

PROCEDURE

1. Have students list five skills or kinds of knowledge they believe they have learned well in their lifetimes. Have students each contribute one item from their lists as you call on students around the room. Continue until all the learned items have been recorded. Allow students to pass if all of their items are already on the list.

2. Record the answers in one of two columns, but do not explain the listings. Ask, w*hat can you tell about the two columns?* Next, label the columns. Explain that one column is "Declarative" (explicit) memories, either semantic, having to do with word or episodic, event related. These are facts or events that can be clearly described. The other column includes "Procedural" memories (implicit) or memories that you may not be able to fully articulate, but are able to perform, like riding a bike.

3. Explain that the class is going to investigate declarative and procedural memories. Place eight words on the board. Ask the students to take five minutes to remember the words: bulldog, banana, car, exit, candy, mom, cake, and road. Next, cover the words and have them write them down. Have a couple of volunteers read their lists. *Were the lists correct?* Ask, *Was it easy?" How did you try to remember the words? Did you have a plan? Were you thinking about how you remember?* This type of recall is considered rote memory and normally does not last very long.

4. Next, ask the students to make a story using these eight words: candle, dark, street, bicycle, balloon, chair, swing, apple. Let them work in groups for five minutes. Again, cover the words and have student write the words down. Ask, *Was it different this time? Was it easier or more difficult to remember the words?* Hopefully, with scaffolding or connections, it should become easier. And it will be remembered longer than isolated facts! Real learning must actively make connections. Explain that this is considered declarative or explicit memory.

5. Explain that next, students will examine a procedural or implicit memory. Give each student an Amazing Mirror Writing worksheet and a small plastic mirror.

6. Direct the students to place the mirror on the top edge of the maze so that the reflection of the maze on the worksheet is visible in the mirror. Then, have students make their way through the maze while ONLY looking at the image of the maze in the mirror.

7. After all the students have completed the first maze ask them to lay down their pencils and examine their work. Ask, *Were you able to complete the maze? Was it difficult? Why or why not? Explain that they are in the process of creating a new procedural memory.* Ask, *Do you think it will get easier as you repeat the trip through the maze?*

8. Have student work through the set of mazes and then examine their work, comparing their first trial to their last. Ask, *Did it become easier? Do you think you are beginning to learn a new skill?* Students will begin to understand that with procedural memories practicing the actual behavior "trains" the brain. Once a skilled task is learned, it becomes automatic. Skilled movements are stored in a separate part of the brain called the cerebellum. The cerebrum or thinking part of the brain initiates the activity, but once a task becomes a stored memory, the cerebellum can take over coordination of the movements.

9. Show the students the "Racing Maze." Ask if they are ready for a race. Remind them that many procedural memories take practice to perfect. Next, explain that they will work in teams. One person will observe and record how long it takes to complete the maze. Let students practice the maze 3 times while their partner times them. Then they will exchange positions and repeat.

10. Ask students if their time through the maze decreased as they practiced. Hopefully they will notice that they are becoming more accomplished maze "runners"!

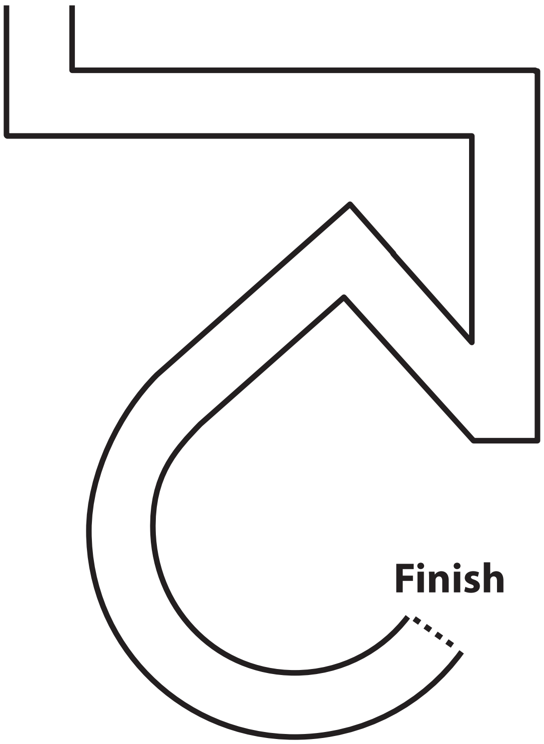
11. Have students analyze their data. Ask, *What is the difference in your first and last trial*? Give each student a sticky note. Ask them to record the difference between their first and last times. Create a class bar graph with the all of the students' time differences. Discuss, *What does the graph display?* The graph demonstrates that performance improves with practice. It also illustrates that people learn new procedural memories at different rates.

EXTENSION

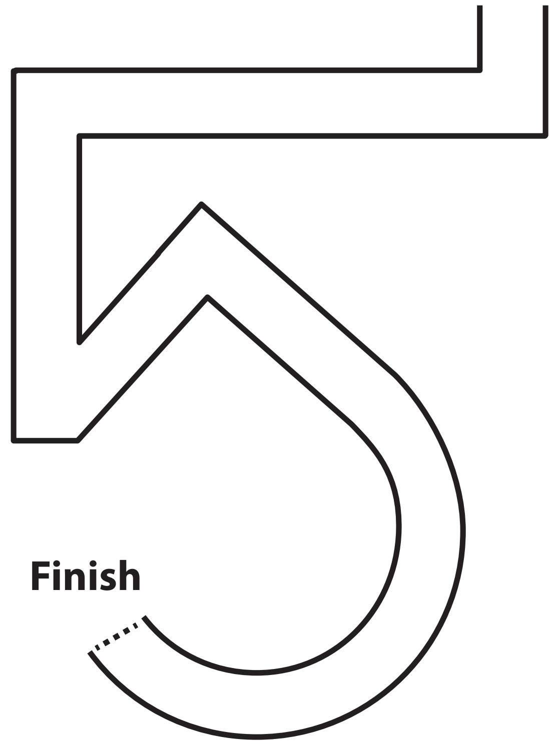
Ask, *Have you ever tried to write with your non-dominant hand?* Challenge students to write their names as carefully as possible in their notebook. Then below the name, have them write it again, using the non-dominant hand. Ask*, How does the second signature compare to the first? Is there a reason? Can you do any better?* Have them repeat the signature at least ten times. Ask them, *Any changes? What if you practices ten times every day for a week?*

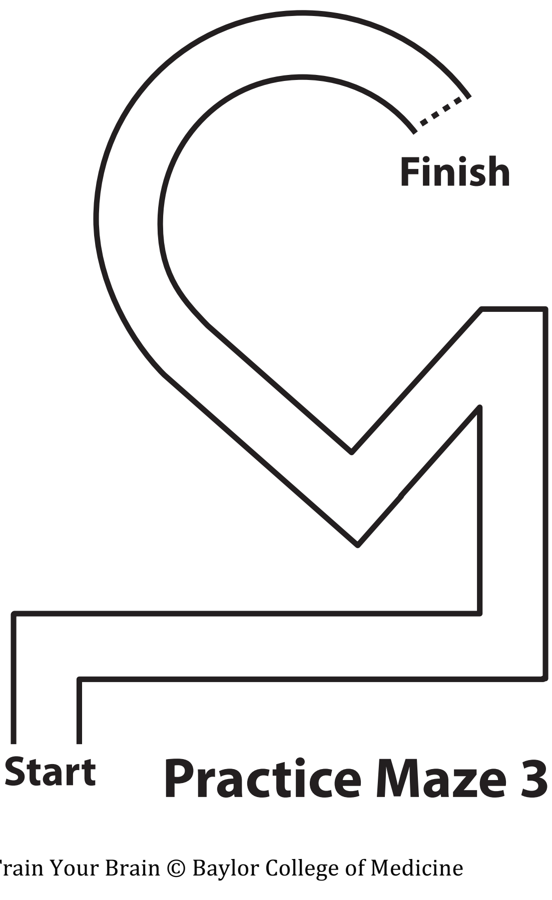
Note: If you have ever been singing with the radio you know that you sometimes can learn something without even consciously trying. Latent learning is not the result of a focused effort and is not evident as it is occurring, but it remains latent or hidden, until a need for it arises. Then, you can sing the song, or find the way home!

Practice Maze 1

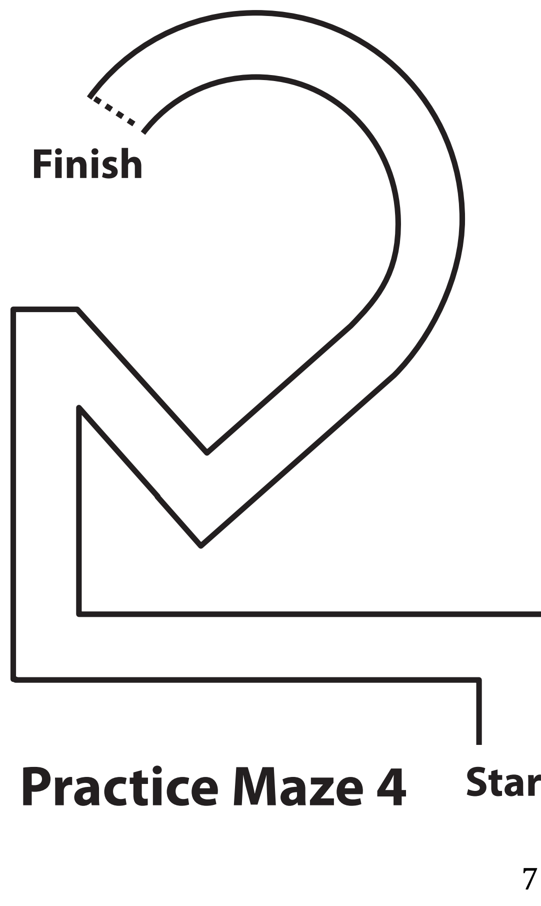


Practice Maze 2





Practice Maze 3

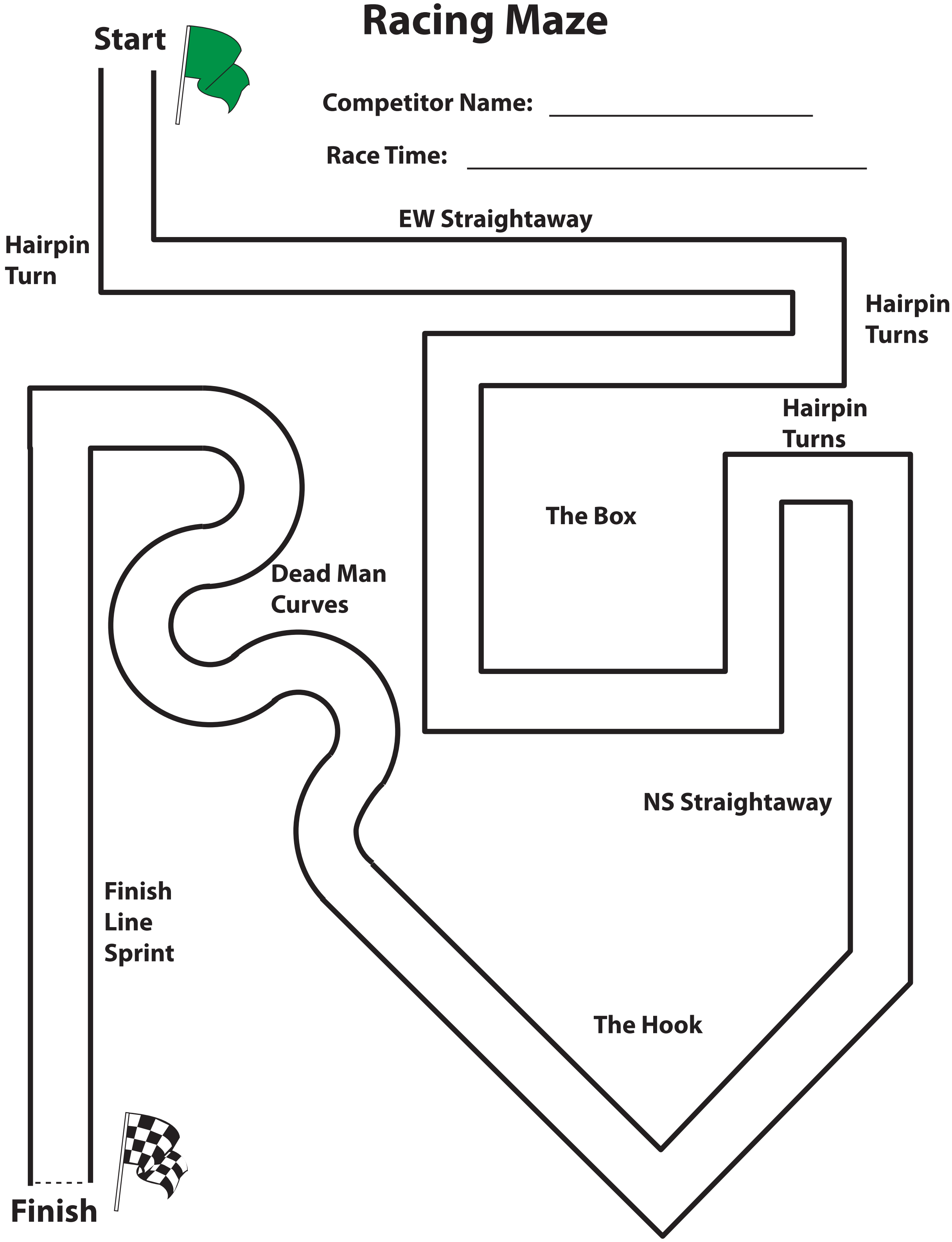


Practice Maze 4

Racing Maze

Competitor Name: ____________________

Race Time: ____________________



INVESTIGATION 3
Where It All Happens
The Brain Model

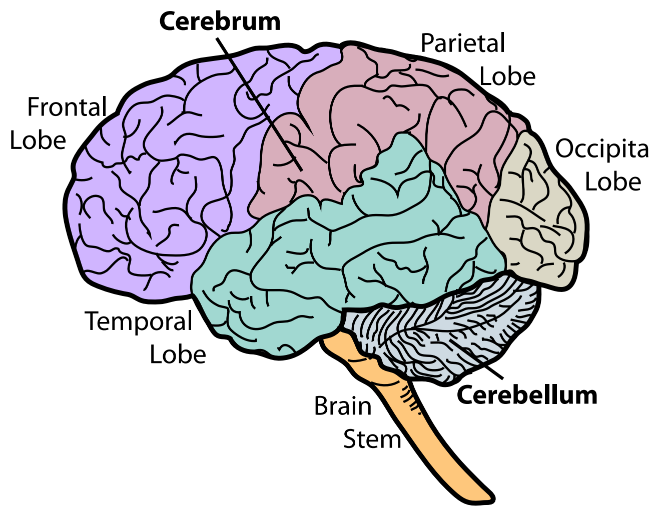
OVERVIEW. Students will construct a paper brain cap and begin to associate structure with function.

BACKGROUND

You are born with certain innate abilities and traits. These characteristics are fixed. If you have blue eyes you will continue to have blue eyes, unless you get colored contact lens. The same applies for dimples, face shape, hair color and so on. Get the picture? But, did you know that you can train your brain? Your brain is not fixed. In neuroscience this is called brain plasticity.

You can train your brain to do many things. Some things are considered declarative or explicit memories, such as learning and remembering facts and events that can be expressed with conscious thought. These represent higher-level functions of the brain and include thought, memory, emotions, aspects of personality and reasoning. Explicit memories all are formed and stored in a part of the brain called the cerebrum. The cerebrum also controls talking, reading, writing and expressing our feelings.

The cerebrum is composed of a left and a right hemisphere, and occupies about the top one half of the head. The brain has about 100 billion neurons, which are a kind of nerve cell. Each neuron, on average, is connected to approximately 1,000 other neurons. Each connection between neurons is called a synapse. You have about 100 trillion synapse connections in your brain. The cerebrum accounts for two-thirds of the total volume of the brain. The top layer of the cerebrum, called the cerebral cortex, is particularly important. It contains the cell bodies of neurons responsible for thinking and remembering. Each neuron in the cerebral cortex also has many long branches that extend below the cortex, where they make the thousands of connections with other neurons. The cerebral cortex is only 2/3 of a centimeter thick. However, if you could unfold the cerebral cortex, it would cover an area about the size of a newspaper page (a square about 50 cm on a side).



Cerebrum - Thinking, learning, remembering, sensing, speaking, feeling emotions, voluntary movements, planning, decision making, and reasoning

- **Frontal lobe** is responsible for thinking and creativity and includes the motor area.
- **Occipital lobe** receives nerve impulses from the eyes and translates them into images.
- **Parietal lobe** regulates memory of objects and their uses and direction and includes the sensory area.
- **Temporal lobe** regulates hearing, speech and memory.

Cerebellum - Controlling balance and movement, remembering well-learned tasks and skilled movements

Brainstem - Automatic body functions like swallowing, breathing, sneezing, heartbeat, blinking

Almost all thinking and action begins in the cerebrum and one of the most important thinking/actions is creating procedural memories, or memories of how to do things. As you repeat or practice these procedural memories, another area of the brain gets involved. The cerebellum, sometimes referred to as the “little brain,” sits at the back of the head, right below the cerebrum. It is about the size of a fist and looks a bit like a small cauliflower. This part of the brain regulates and coordinates movement, posture and balance. It is responsible for storing automated movements and other skills that require little thought once learned.

To become a procedural memory the action must be mastered. With practice, or training, we are able to form memories of how to do things like walk, ride a bike, or play a sport. Think about dribbling a basketball or hitting a baseball. Could you do it the first time you tried?

Even more important, when you learned to play basketball, did someone tell you how to dribble the ball or did they show you? Many procedural memories are actually formed by imitating movements of a “teacher.” Once the procedural memory is mastered, it becomes a “motor memory,” stored in the cerebellum.

GUIDING QUESTION

Where are motor memories initiated and stored?

CONCEPTS

Two main areas of the brain are the cerebrum and the cerebellum. These brain areas work together to form and carry out memories of how to do things (procedural memories).

TIME

Class: 2 sessions

MATERIALS

Per Student

- Brain hat pattern (one left and one right hemisphere pattern for each hat)
- Clear plastic tape
- Pair of scissors

Optional: Colored markers

SETUP

Prepare a hat as an example for students to refer to.

PROCEDURE

1. Ask a student from the back of the room to walk to the front of the room. When the student arrives, ask the student if he or she thought about walking or just walked automatically. Ask if any student has a baby brother or sister. Have the student describe how that baby brother or sister learned to walk. What “steps” did they go through as they were learning – crawling, trying to stand, standing and plopping back on the floor, single steps, multiple steps, etc. Ask, *Do any of you need to go through those ‘steps’ today? Walking is now automatic. How is that possible?* (Answer: You trained your brain.)

2. Display a brain cap. Put it on the head of one of the students. Explain that procedural memories begin in the cerebrum. Point out this area of the brain cap. Then, explain that as the brain becomes trained, the cerebellum takes over and activities, such as walking, happen without conscious thought. Ask students if they can think of other things they do without thinking about them. Make a list on the board of their ideas.

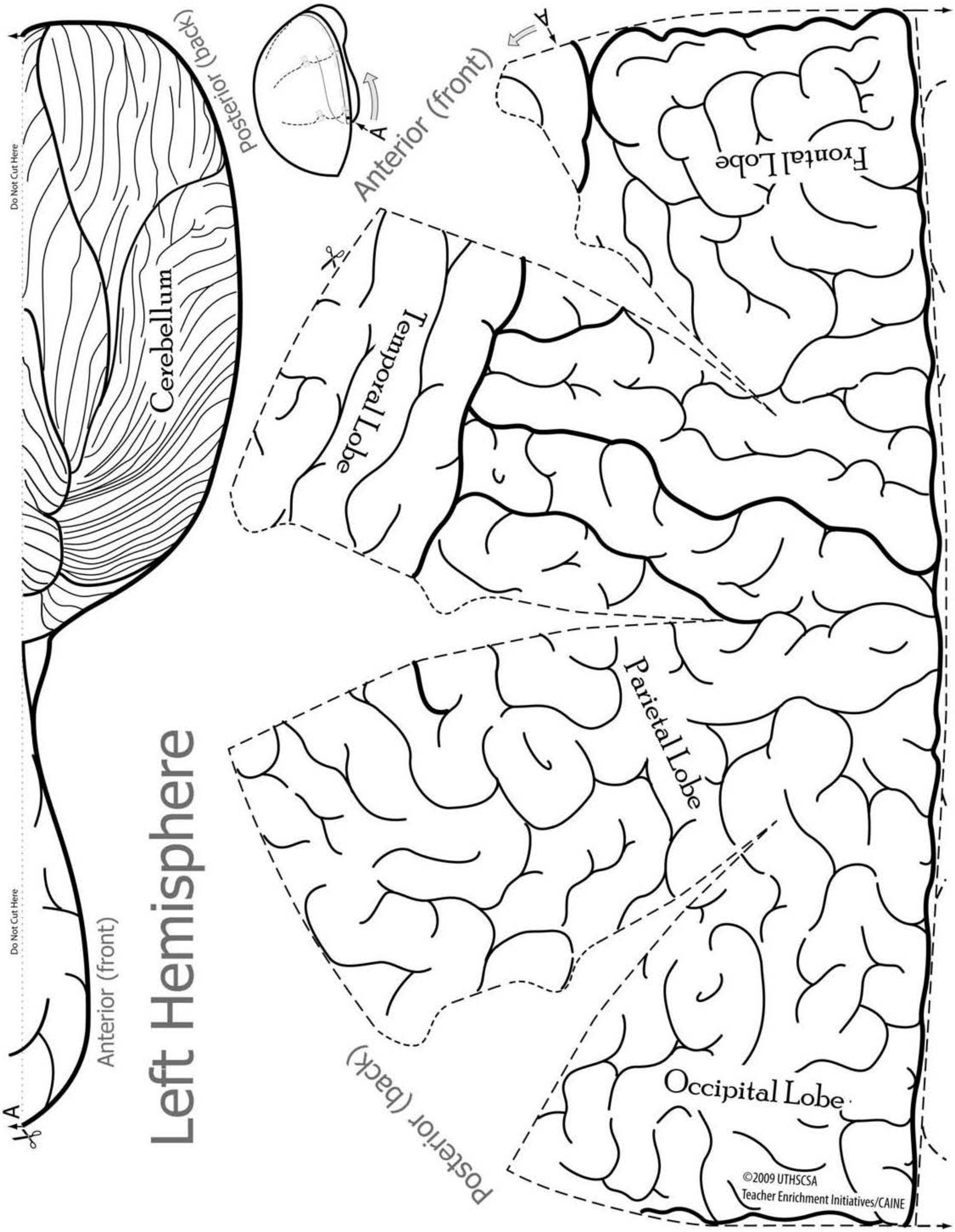
3. Pass out the cap patterns and have students examine. You may want to assign each team a lobe of the brain to research, using computers, if available. Or you may want to discuss the words, occipital, temporal, frontal and parietal and have students try to figure out the meaning of each or just write the parts on the board and briefly discuss the function of each.

4. Show how the brain cap is made. Explain that the patterns need to be cut out on the dashed lines. Accurate cutting of the pattern is essential for ease of assembly. Point out the bumps on the fan-

shaped segments overlap the matching edge. This makes it easier to assemble and tape the edges. Have students cut out the hemispheres and tape them first. Then have them join the hemispheres together. Last, have them cut out the cerebellum pieces and tape them to the cap rim as shown in the pattern illustrations.

5. Have students wear their brain caps and discuss the functions of each part of the caps.

Source: The pattern for the “brain cap” is used with permission from the University of Texas Health Science Center.



Left Hemisphere
Anterior (front)
posterior (back)
Cerebellum
Do Not Cut Here
Do Not Cut Here
A
A
A
Anterior (front)
Frontal Lobe
Temporal Lobe
Parietal Lobe
Occipital Lobe
posterior (back)
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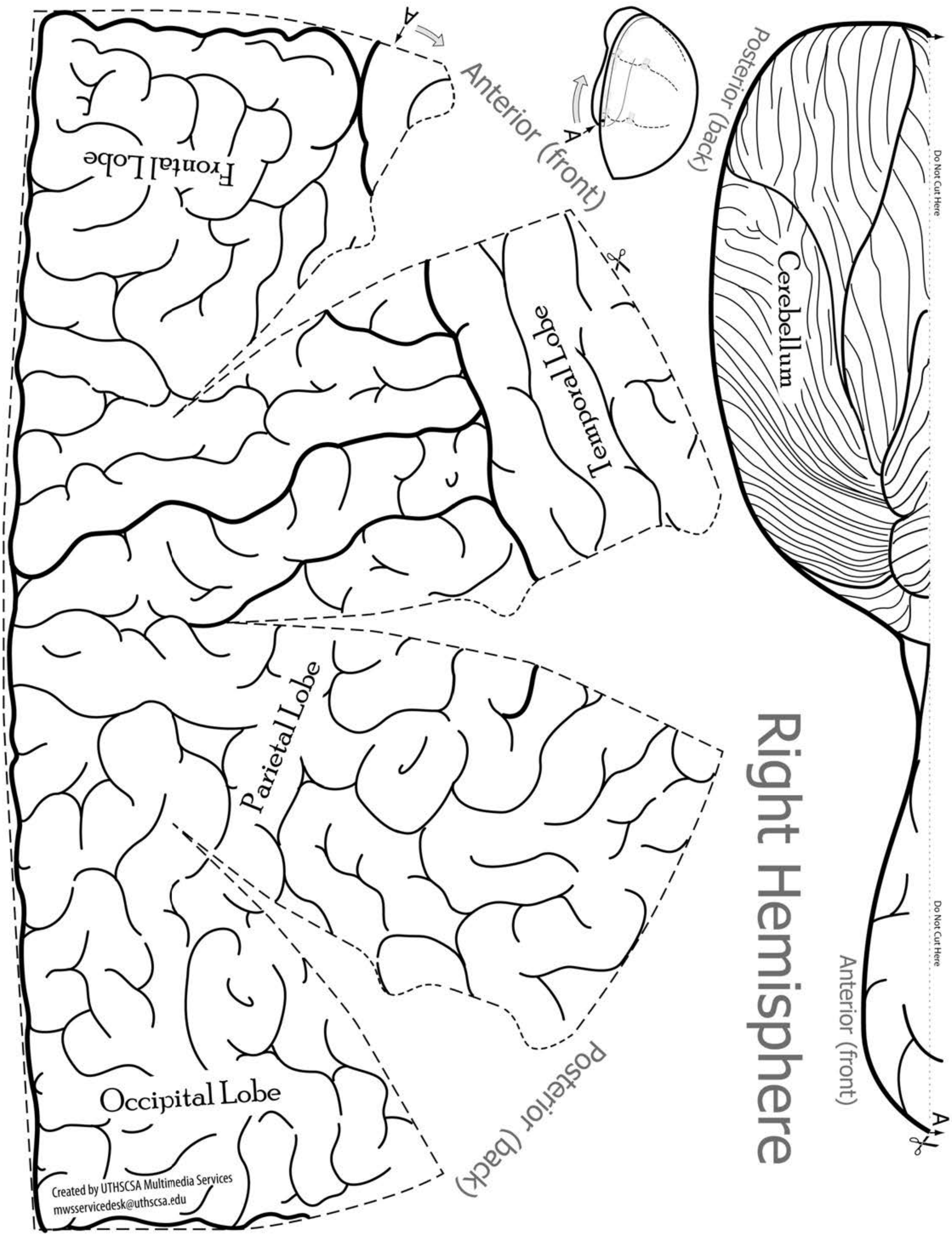

Right Hemisphere
Anterior (front)
Posterior (back)
Anterior (front)
Posterior (back)
Cerebellum
Temporal Lobe
Frontal Lobe
Parietal Lobe
Occipital Lobe
A
A
A
Do Not Cut Here
Do Not Cut Here
Created by UTHSCSA Multimedia Services
mwsservicedesk@uthscsa.edu

INVESTIGATION 4
Which Side Are You On?
Laterality

OVERVIEW. Students will investigate their inherited preferences for laterality (right handedness, left handedness, etc.) They will collect and analyze data on laterality for the entire class.

BACKGROUND

People are often labeled as being right brained and more logical in their thinking, or left brained and more creative. These labels are false, because the two sides of the brain are connected and work together for almost all functions. Other brain myths are that people use only 10% of their brains, and that male and female brains are radically different.

However, even though the right brain/left brain theories are untrue, people do tend to favor a specific side of their body for many activities. In more than 95% of right-handed men, and more than 90% of right-handed women, the left hemisphere is dominant in certain aspects of language and speech processing. In left-handed people, the incidence of left-hemisphere language dominance has been reported as 73% and 61%, suggesting left-handed people tend to be less lateralized than right-handed people. In general, however, neuroimaging methods such as functional magnetic resonance imaging and magnetoencephalography show involvement of both hemispheres in many aspects of language processing, and the "dominance" of one hemisphere just refers to more brain activation relative to the other hemisphere. It is not the case that language is ‘localized’ in any one hemisphere laterally.

What are you? Are you right-handed or left-handed? If you say right, you are among the majority of humans. Nearly 90% of humans are naturally right-handed, but it is not just handedness. Most people also prefer their right eye, right foot, and right ear. Just why is not fully understood but the conjecture is that the left cerebral hemisphere of the brain not only controls the right side of the body, in most people, it is also the predominate language hemisphere. This implies that the left hemisphere is the dominant hemisphere of the brain. Consequently, the right side of the body is stronger and more adept in motor tasks.

Right or left-handedness is one component of the concept of laterality or the preference for one side of the body or the other. Laterality is most apparent in handedness and less apparent for eyes, ears, and feet. According to a 1981 study (C. Porac and S. Coren. Lateral preferences in human behavior, New York: Springer-Verlag, 1981. Source: http://en.wikipedia.org/wiki/Laterality) the following approximate statistics characterize laterality among humans.

Favoring right hand: 88.2%
Favoring right foot: 81%
Favoring right eye: 71.1%
Favoring right ear: 59.1%
Favoring same hand and foot: 84%
Favoring same ear and eye: 61.8%

In practice, most people have a mixed laterality. People who type, play the piano, and juggle need dexterity in both hands. We call this ambidexterity (equally adept in the use of both right and left hands, etc.), although true natural ambidexterity is rather rare, only about 1 in 100 people. Most people become partially ambidextrous through practice. Years ago, left-handedness was considered a fault and children were forced to use their right hands as often as possible. In schools, left-handers were made to write with their right hands. Part of this push to change handedness was due to practicality. Scissors, for example, are designed to be used by the right hand. (Try using a right-handed scissors in your left hand.) Left-handed scissors are now available. Another example of products designed for the right hand is the right-handed school desk (one arm writing desk AKA: combo desk). These were and still are very common in classrooms. (Left-versions and other designs that do not prefer one side to another are now available.)

Laterality is a big factor in sports. In baseball, for example, batters find it more difficult to hit a curve ball from a pitcher who favors the same side. The ball curves away from the batter. A right-handed batter (the right arm provides most of the power and speed in a swing) gains advantage when the pitcher is left-handed. The pitcher gains advantage when it is right throw, right handed batter or left throw, left handed batter. Especially prized is a batter that can hit equally well from the right or left side. This is called switch hitting, and it gives the batter the advantage regardless of which side the pitcher throws from. However, there are also switch pitchers.

In many other sports, being able to switch hands is very useful, such as when dribbling a basketball, and passing and taking shots. Ice hockey players shoot from either side. Skate and snow boarders will switch which foot is forward to perform more tricks.

Laterality, can be an advantage or a disadvantage in sports. It is harder to steal second base in baseball, when you are against a left-handed pitcher. The left-handed pitcher faces first base when he assumes the set position for the next pitch, and can more easily pick off a base stealer. Polo players are required to play right-handed as a matter of safety. Table tennis, badminton, tennis, and cricket have a high percentage of left-handed top players. This is believed to be because left-handers play most of their games against right-handers. They become well practiced in dealing with this asymmetry. Right-handers mostly play against other right-handers (90% percent of the population) and are less practiced in dealing with asymmetry.

GUIDING QUESTION
Do you have a dominant side?

CONCEPTS
- Laterality is the preference for one side of our bodies over another.
- Usually, the left cerebral hemisphere of the brain is the dominant hemisphere.
- Natural ambidexterity is rare but ambidexterity to some extent can be learned through practice.
- Laterality provides both advantages and disadvantages in sports

TIME
Setup: 5 minutes
Class: 2 sessions of 45 minutes each

MATERIALS
- Student notebooks or Future Sport Notebook
- Student worksheets
- Tennis ball or stress-relieving ball
- Foam soccer (inside use) or regular soccer ball (outside use)
- Small sealed cardboard box taped closed with a large paperclip loose inside.

SETUP
Draw the following chart on the whiteboard and provide dry marker for the students to use.

Strongly Right-Handed	Moderately Right-Handed	Weakly Right-Handed	Ambidextrous	Weakly Left-Handed	Moderately Left-Handed	Strongly Left-Handed

PROCEDURE

Part 1

1. Ask for a volunteer student to stand up. Tell the student to use one hand only. Gently toss the ball to that student. Have that student gently toss the ball to another student. Continue this for a few more tosses.

2. Ask your class if they observed which hand was used to toss and to catch the ball each time. Most tosses and catches will be with the right hand. Ask, *Why the right hand?* Students will probably answer that they are right handed. Ask students to hold up their dominant hand. Have them look around the room. Ask, *Is everybody holding up the right hand?* Discuss that being left handed is the exception with only about 10% of the population having a dominant left hand.

3. Explain the concepts of laterality and handedness. Each of us has a different level of handedness. Tell your students that they will determine their personal level of handedness by filling in a simple questionnaire. Be sure to point out that there are no correct or incorrect answers in the questionnaire. In addition, students will learn about the handedness of the class as a whole.

4. Distribute the survey, "Which Side Are You On." Have students calculate their handedness. Point out the chart on the board. When each student has completed the survey they should come up to the board and put a check mark for where they fall in the handedness survey.

5. When all students have made their check marks on the class graph, the class can use the data to create a class graph and/or individual graphs in their science notebooks.

6. Next, discuss the results. Ask, *Did anyone get a score of 24? What does that mean?* (a person is ambidextrous). Ask, *Do you think there might be any benefits from being left or right handed or ambidextrous?* Have students share any ideas. Explain that we will explore the idea further in future activities.

Part 2

1. On the board make the chart, *What is Your Dominant Side*? Or have the students use the student sheet. Have the students create a similar chart to record their findings as they investigate.

2. Tell your students, *Now that we know about your handedness, what about your eyes? Which eye is your dominant eye? Any ideas on how we can find out?*

3. After reviewing student ideas and if no one comes up with a workable idea, announce that determining your dominant eye is quite simple. Tell students to look at a distant object. If you have windows, point out a tree trunk, light pole, or some other narrow vertical object. Have them hold up an index finger so that it blocks the object and keep it steady. Then tell them to close one eye. Then have them open that eye and close the other one. Have them repeat this a couple of times.

4. Ask, *What did you observe?* With one eye, the right or the left, the finger seems to shift and no longer cover the object. With the other eye, the finger stays in the same place and does not shift. The eye without shifting is the dominant eye.

5. Ask, *Which is your dominant foot?* Again, ask for ideas how to determine that. Again, the answer is simple. Take your students into a hallway or outside to a play area. Place a foam soccer ball on the floor or ground. Send a couple of students to be fetchers. Pick a student and have that student kick the ball. Repeat with other students. The fetcher students can get their turn kicking the ball back. Have students observe which foot they naturally used to kick the ball. That is their dominant foot.

6. Challenge students to come up with a way to determine their dominant ear. One way to do this is to pass around a small sealed box with an unknown object inside. Observe which ear students hold the box near to hear the sound the inside object makes.

7. Have students record their data on the class chart using tally marks to combine the information each has gathered on their laterality (see example on worksheet).

8. From the information gathered, assist students in creating a class graph on laterality. Ask, *What does the graph tell you about dominant sides? Are there differences between males and females?*

9. Share the statistics regarding laterality with the students. Explain that most people have mixed laterality and many are ambidextrous to some degree, such as people who type, play the piano and juggle. But true ambidexterity, all left or right, is rare at only 1% of the population. Make sure that students understand that there the brain has two hemispheres. Show the students the Brain Laterality sketch and make sure they understand that certain parts take on specific function, but do so in coordination with the whole brain.

EXTENSION
In your notebook write a paragraph explaining your laterality and why it might matter?

Part One

Which Side Are You On? - Handedness

Are you right handed or left handed? This question will help you determine which one are you (you probably already know) and the degree to which you are one or the other. Answer the questions below by checking boxes for RIGHT hand, EITHER hand, or LEFT hand. Calculate your score with the instructions that follow.

	RIGHT	EITHER	LEFT
1. Which hand do you use to write?			
2. Which hand do you use to draw?			
3. Which hand do you hold a toothbrush?			
4. Which hand do us use to throw a ball?			
5. Which hand holds an eraser when you erase things?			
6. Which hand holds the TV controller when changing channels?			
7. Which hand holds a fork when you eat?			
8. Which hand holds a scissors when you cut things?			
9. Which hand do you catch a ball with?			
10. Which hand do you hold a pitcher when pouring things?			
11. Which hand to you bounce a ball with?			
12. Which hand do you use to turn on a light switch?			
TOTAL			

Calculate Your Handedness Score

1. Count the number of checks for right, either, and left and enter the totals in the spaces.
2. Multiply the total of RIGHT hand checks by three and enter it in the square → ☐
3. Multiply the total of EITHER hand checks by two and enter it in the square → ☐
4. Enter the total of LEFT hand checks in the square → ☐

TOTAL ☐

Interpret Your Score

Score	Handedness
33 - 36	Strongly Right-Handed
29 - 32	Moderately Right-Handed
25 - 28	Weakly Right-Handed
24	Ambidextrous
20-23	Weakly Left-Handed
16 - 19	Moderately Left-Handed
12 - 15	Strongly Left-Handed

Adapted from the Handedness Questionaire on the following site
https://faculty.washington.edu/chudler/rltablen.html

Answer the following questions about your handedness survey results.

1. Which handed are you? To what degree (strong, moderate, weak)?

2. How do you compare to your classmates?
Your teacher will place a similar chart on the board. Go up to the chart and place a mark in the square that best represents you. When all classmates have added their marks, put the totals in the chart below.

Strongly Right-Handed	Moderately Right-Handed	Weakly Right-Handed	Ambidextrous	Weakly Left-Handed	Moderately Left-Handed	Strongly Left-Handed

Make a graph illustrating these results. Put column titles in the top line.

3. What does ambidextrous mean?

Why is 24 the only score that classifies someone as ambidextrous? *Hint:* The highest score you can get in this survey is 36. The lowest is 12.

4. What sport do you think your right-handedness, left-handedness, or ambidexterity makes you especially good at? Explain why?

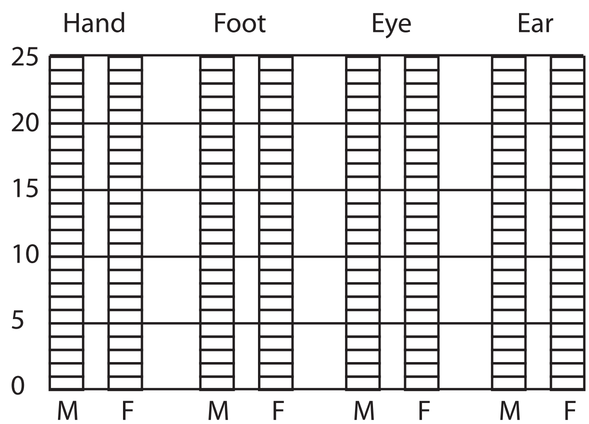
Part Two

What is Your Dominant Side?

1. Place a check mark in the boxes that best describe you.

	Males Right	**Males** Left		**Females** Right	**Females** Left
Hand			Hand		
Foot			Foot		
Eye			Eye		
Ear			Ear		

2. When you have completed fillling in the boxes, go to the board and place a check mark in each appropriate box for the choices you made.
3. When everyone has entered their choices, total them up and fill in the bar graph below.



4. Describe the graph. What does it tell you about dominant sides? Are there differences between males and females? Explain.

What does this investigation tell you about your brain?

Place this page and the part one pages in your FutureSport notebook.

INVESTIGATION 5
Think Fast
Reflexes and Well-learned Movements

OVERVIEW. Students will learn that reflexes are an instantaneous reaction to a stimulus and do not directly involve the thinking part of the brain. Learned reactions to a stimulus, such catching a thrown ball, involve rapid coordination of sensory information and signals to muscles.

BACKGROUND
Have you ever had someone yell “Think fast!” and toss an object for you to catch? It’s a game people sometimes play. Actually, thinking fast is not what happens. There isn’t time to analyze the flight path of the object, its time of arrival, where to hold your hand, when to grasp, etc.

Catching an object is complex, and involves visual pathways, muscle preparation in anticipation of the impact, and automatic nervous system feedback loops that do not involve the thinking part of the brain. The automatic parts of the response are called reflexes. Reflexes are instantaneous movements in response to a stimulus. They are fast, do not require conscious thought and normally protect the body. For instance, grasping on to something when you feel like you are falling is a reflex that you have from birth. Conscious thought would take way too long to initiate the quick reflex needed for many protective actions.

The anatomical pathway of a reflex action is called the reflex arc. It is a nerve pathway in the body that connects nervous system signals to certain muscle groups through the spinal cord or brain stem. The primary components of the reflex arc are sensory nerve cells that receive the stimulation, such as seeing a speeding fastball coming towards your head. The sensory nerve cells are, in turn, connected to other nerve cells that initiate muscle action, such as ducking.

It is interesting to note that many of our movements do not directly involve the brain. For example, the patellar reflex or knee-jerk is independent of involvement of higher centers (the brain). A doctor strikes the patellar ligament with a rubber hammer. The ligament is just below the patella or kneecap. Striking stretches the quadriceps muscle. This produces a signal that travels along nerves to the spinal cord. From there, motor neurons send a signal back to the quadriceps that triggers a contraction (knee-jerk). This reflex reaction is part of a larger system that helps us to maintain posture and balance.

The patellar reflex, which is important for walking, is one of many reflexes we are born with. The withdrawal reflex is especially important. When you touch a very hot object, receptors in the skin send a sensory impulse to the spinal cord, which, in turn, sends a response signal that causes muscles to pull away from the object. This happens in less than 0.5 seconds so as to minimize skin injuries. Another example of withdrawal reflex is the reaction of the body when stepping on a tack. Still another inherited reflex reaction is the blinking of eyes when objects get too close and the adjustment of the eye iris diameter when light levels change.

These survival reflexes do not directly involve the brain, but are controlled by the spinal column. If the signals had to travel first to the brain and then come back as a signal to muscles, the initiation of withdrawal, for example, would take one second or even longer to occur. During that longer time interval, greater injury would result. Some reflexes, such as blinking, are coordinated through the brain stem, which is located below the cerebellum.

Other seemingly reflexive actions are actually well learned movements. We do not have a natural ability to catch a ball. During play, small children are unable to catch balls tossed at them. Catching initially follows a bucket approach. The child eventually learns to form a bucket shape with arms and hands and a carefully tossed ball lands in the middle. Later, children begin catching balls by coordinating clasping their hands when the ball arrives. Being successful requires timing, knowing where the ball will be, shaping hands and fingers to match the ball’s size, and exerting the right clasping force to catch it. When the skill is mastered, the movement becomes nearly automatic.

Fast reaction to a stimulus is one of the main characteristics of a successful athlete. We can all train and practice, but athletes seem to be able to do things faster and more accurately. Becoming a successful athlete requires a lot of training. A big part of training is improving coordination of movements and response times. How long does it take you to react when you experience a stimulus like a baseball thrown towards the plate? Faster reactions are better when it comes to physical events. Fast reactions can make you a winner.

For instance, bat swinging is a complicated process. Hundreds off thousands of nerve cells have to work simultaneously to coordinate judging when and where the pitched ball will arrive, when to swing, and controlling the total body movements of the swing – arms, hands, legs, posture, etc. Complicating this process further is the very brief time interval from the released pitch to the completed bat swing. When nerves signal each other, a chemical substance has to cross the gap between nerve cells. This tiny gap is called the "synapse." The chemical transmitting the signal across the synapse takes about one two-thousandth of a second to cross the synaptic gap. This is called the "synaptic delay."

The synaptic delay seems insignificant, but there is much more to be done. First, the batter's eye tracks the incoming ball. In about 1/25th of a second, the visual input arrives at a region of the brain called the higher visual cortex. Although it is not understood how, a decision is made to initiate the swing. A signal is sent to the cerebellum, which initiates the complex series of muscle actions that have been fine-tuned through practice. Practice actually speeds up the decision-making process.

Even more complex than catching a ball is juggling. In juggling, catching balls is paired with throwing balls in a blur of motion. Again, practice is the key to making the muscles work in synchronicity-smoothly, without undue thought and with success! This activity gives students an opportunity to observe how practice improves their coordination and response time for a complex task that involves vision, balance and several muscle systems.

GUIDING QUESTION

How are reflexes different from learned movements?

CONCEPTS

Basic reflex reactions are inherited, while complex motor skills are learned through practice.

TIME

Setup: 20 minutes
Class: 2 sessions

MATERIALS

Per Student Team

- Tennis ball
- Standard foot rulers
- Tape or glue stick
- Two empty egg cartons
- 24 dried beans in a sandwich bag– white and black or red (plus spares)
- Stopwatch (mechanical, cell phone timer, or wall clock with second hand)
- Candy bar (Flat bar like a Hershey's Bar - one for the class)

SETUP

Prepare the reaction timers in advance. See part 1, step 1 below. Remove the lids from the egg cartons. Count and place the beans in sandwich bags. Have students conduct the activity as they work in groups of two to three.

PROCEDURE

Part 1

1. Throw a ball toward a student several times. Discuss what happens as the action is repeated. Explain that we all have natural automatic reflexes, many of them protective. They include things like blinking or sneezing in response to dust in the air.

2. Have students make reaction timers by cutting out the reaction timer paper strip and gluing or taping it to a standard 12” ruler or strip of wood such as a paint stick. The end of the strip, marked 0.0, should match exactly with one end of the stick. This becomes the bottom of the stick. Each division is 1 centimeter high. The numbers are time intervals in thousandths of a second. The top number is 0.247 thousandths or 247 milliseconds. This reduces to $1/4^{th}$ or 0.25 of a second.

3. Have students work in teams of two or three. Using rotating jobs, one student may serve as the test conductor, another the recorder, and another as the test subject. Have students follow the procedures below.

   a. Test conductor: Hold the reaction timer vertically by its upper end (on the 0.247 mark).
   b. Have the test subject place his or her thumb and index finger on opposite sides of the stick directly aligned with the 0.0 mark. The thumb and index finger should not touch the stick and be spaced about 1 cm away on each side.
   c. Tell the subject that you will drop the stick sometime in the next few seconds. It is the subject’s task to catch the stick with the thumb and index finger.
   d. When ready, the stick is dropped. Look at where the thumb is located on the caught stick. Read the number directly below the thumb. The recorder will record the number in a table.
   e. When five drops are completed, students switch jobs. Repeat until all students in the team have been tested.

4. Have students calculate their average reaction times. Ask students if there were improvements in the reaction times going from drop test 1 to drop test 5. Ask students why they might have improved.

5. Invite a student to the front of the room. Hold up a candy bar. Have the student position his or her thumb and index finger around the middle of the bar (the middle S in the case of Hershey’s). Tell the student that he or she can have the bar if he or she catches it. Give the student only one chance to catch the bar. Unless the student anticipates the drop, he or she won’t be able to catch it. Be sure not to give any “tells” when you drop the bar. Let a few more students try it.

6. Ask students, *What is happening?* (Could the candy bar be too short for their reaction time?)

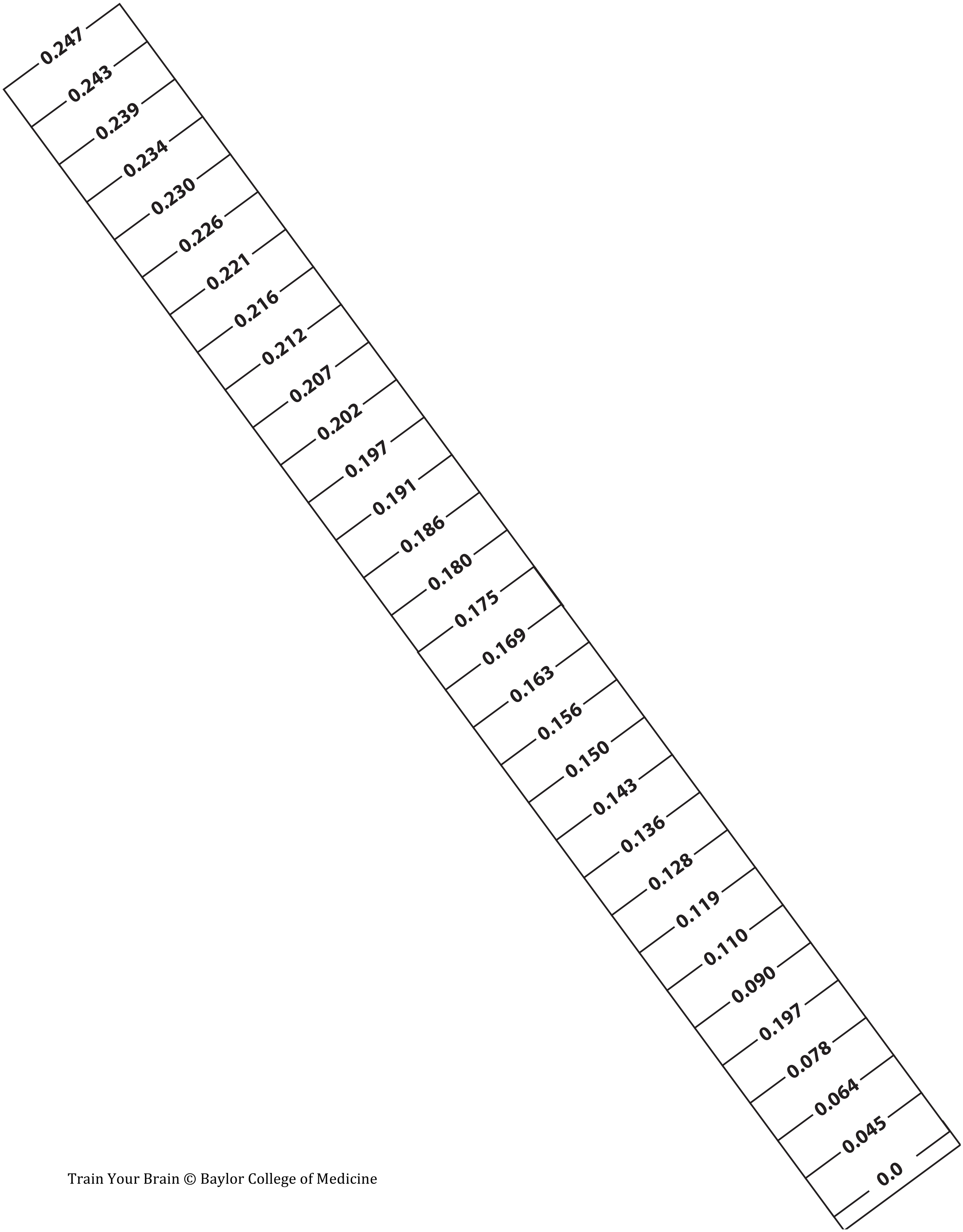
7. Explain that by “practicing,” their responses become faster, and a learned movement eventually is stored in the motor area of the brain (cerebellum).

   Mathematics Note
   The time numbers for the ruler were calculated with the following formula where t = time, d = falling distance, and g = acceleration of gravity: 980cm/sec^2.

   This equation is derived $t = \sqrt{\frac{2d}{g}}$ from the classic physics equation for determining the distance a falling body travels vs. time.

$$d = \frac{1}{2} g t^2$$

Test Subject Name			
Drop Test 1			
Drop Test 2			
Drop Test 3			
Drop Test 4			
Drop Test 5			
Average Reaction Time			


0.247
0.243
0.239
0.234
0.230
0.226
0.221
0.216
0.212
0.207
0.202
0.197
0.191
0.186
0.180
0.175
0.169
0.163
0.156
0.150
0.143
0.136
0.128
0.119
0.110
0.090
0.197
0.078
0.064
0.045
0.0

Part 2

1. To each team of two distribute two egg cartons with lids removed. Also provide teams with 24 dried beans (half white and half dark).

2. Tell teams to pour out the beans on the tabletop. Pick one team member to start the training activity. Another student will be the timer. The objective is to place one bean in each eggcup with colors alternating between light and dark beans.

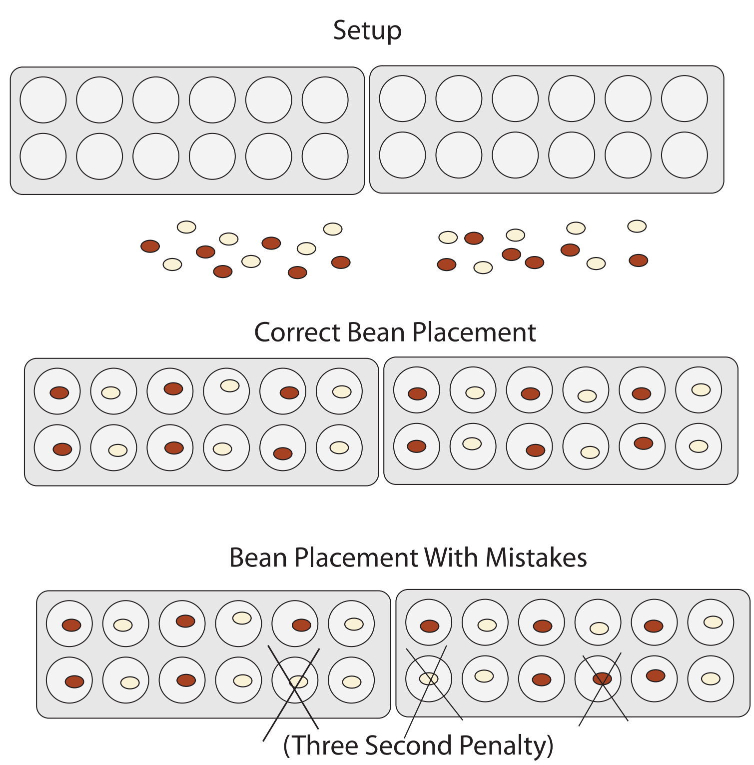
3. Have the recording team members begin the first run by calling start. When the acting student runs out of beans, the recorder should stop the timer, record the time and review the beans. Instruct students to add two seconds to the time for each missed cup, and one second to the time for any colors out of place.

4. Have students repeat the test two more times before switching students.

5. Ask, *Do you think you can get better with practice?* Encourage students to predict their scores after several practices.

6. Wait one day and repeat the test. Compare the times.

7. Review results and draw conclusions. Ask, *Who is the champion bean counter?* !!



INVESTIGATION 6
The Ball and Cup
Training Your Brain

OVERVIEW. A classic toy, the Ball and Cup, is used by students to learn how practice of a new task leads to improvement of accuracy and response times.

BACKGROUND

You can't teach an old dog new tricks. We are all familiar with this idiom. It has a couple of meanings. One is that when people age, they become resistant to change. The other interpretation has a more literal meaning. It implies that as we age, it becomes difficult to impossible to pick up new skills.

Brain research has shown that the second interpretation is simply not true. Learning is possible, including new information or skills, is possible throughout life. People can learn or relearn basic and complex physical skills during all stages of life, such as how to swim, play the piano, juggle three balls, and even cell phone texting with thumbs!

The brain has an amazing capacity to reinvent itself. This ability is referred to by the umbrella term neuroplasticity. It involves both synaptic plasticity and non-synaptic plasticity. Synaptic plasticity is the ability of synapses to form, strengthen or weaken over time, depending upon increases or decreases on their activity. Synapses are the part of the nervous system that enables a neuron (or nerve cell) to pass chemical or electrical signals to other neurons. Non-synaptic plasticity refers to changes the excitability (ability to pass signals) in other parts of the neuron, such as the dendrite structure.

Neuroplasticity essentially allows the brain to create new internal connections, strengthen or weaken connections, and reroute old connections in the event of injury.

The brain's ability reinvent itself or to learn new things becomes particularly clear for people who have sustained brain injuries and have had to relearn how to walk and to speak. Soldiers who have lost limbs have had to adapt to prosthetic devices that replace arms and legs. Many injured soldiers now successfully compete in athletic events with impressive accomplishments. Below are some examples of how neuroplasticity enables disabled athletes to become sports competitors.

Wounded Warrior Amputee Softball Team
http://woundedwarrioramputeesoftballteam.org/

Paralympic Movement
http://www.paralympic.org/

Disabled Sports USA
http://www.disabledsportsusa.org/

The doorway to neuroplasticity is practice. People learn how to play the piano, dance, throw and catch a ball, or ride a bike through practice. Repeated activity stimulates parts of the brain leading to new and stronger neuron connections, which result in increasing proficiency in the activity. In other words, the brain continually strengthens connections and rewires itself to increase efficiency and retain knowledge and skills.

GUIDING QUESTION

Will practice of a specific motor movement improve performance?

CONCEPTS
The brain is capable of changing its internal connections to permit learning and perfecting of new physical and mental skills.

TIME
Setup: 15 minutes to make a sample ball and cup
Class: 1 session

MATERIALS
Per Student
- Science notebook
- Ballpoint pen

Per Student Team of Three
- Set of the 3 ball and cup patterns, printed on card stock
- 140 cm (54 in.) of yarn
- 3 large wooden beads
- Clear plastic tape
- Masking tape
- 3 rulers
- Pair of scissors

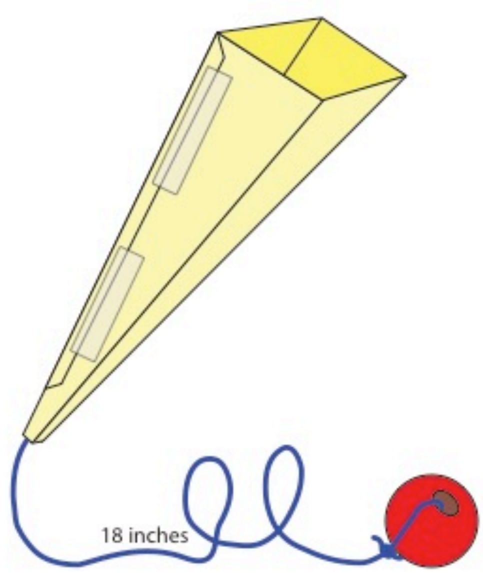
PROCEDURE
Part 1
1. Using the sample ball and cup you made before class, demonstrate the ball and cup toy in front of the class. Ask, *Do you think you can do this?* Explain they will be given the opportunity to hone their skills on the Ball and Cup after each team makes a set of three of the toys.

2. Divide students into teams of three. Give each team a set of three ball and cup toy patterns printed on cardstock paper (large, medium, and small).

3. Demonstrate how to cut and fold the patterns to form a cone. Begin by lining up one of the edges on a ruler with the dashed lines on a pattern. Draw a straight line over the dashes while pressing hard on the pen. The pen point will score the paper to make accurate folding easy. Cut out the pattern and fold the triangle sides to form a cone. Overlap the small flap and tape the cone.

4. Next show students how to tie a piece of yarn to the bead. Thread the other end of the yarn through the hole at the bottom of a cone. If the hole is too small, nip off the end with the scissors to make it larger. Tie a knot in the end of the yarn and wrap some masking tape around it so that the yarn doesn't slip back out the hole. Try to make the yarn length 18 inches for each of the three cones.

5. Explain that as they learn to catch the ball in the cup they will be collecting data. Model a recording scheme for them to use in their notebooks. The necessary data is the number of trials it takes to get the ball into the cup each time until they have had five successes.



Trial	# of attempts

Cup/Ball 1	
1	
2	
3	
4	
5	
Cup /Ball 2	
1	
2	
3	
4	
5	
Cup/Ball 3	
1	
2	
3	
4	
5	

6. Have each team member assemble one of their team's three "ball and cup" toys. Remind them that the object is to swing the ball upward and catch it in the cone. Have teams begin with the largest cone. The objective will be to catch the ball 5 times. Start with one team member. As that person tries to catch the ball, the team should count the number of tries required to achieve the objective. As each student completes their turn they will record their numbers on the personal data sheet.

7. When the first team member achieves the objective, the second team member tries catching the ball 5 times. As with the first team member, the data should be recorded on the personal data sheet. Meanwhile, the first team member should move on to the medium cone and collect data while working towards catching the ball 5 times.

8. When the second team member, has achieved 5 catches with the large cone, the third team member begins. Meanwhile, the first team member moves to the small cone and the second team member moves to the medium cone.

9. When all three team members have achieved their goals, have them begin plotting their data on graphs. Student pages feature four graphs. The first three graphs are for catching performance for each of the three different sized cups. The fourth graph combines the data. Review graphing procedures with the students and make sure they understand that graph four is different than the first three. The first three produce bar graphs. The fourth graph is a line graph.

10. When graphing is completed, ask several teams to volunteer to present their results to the class. *What did they learn about their ability to catch the ball with the cones? Did they improve their skills? How did starting with the largest cone help them eventually become proficient with the smallest cone? What does this investigation tell us about our brains?* This shows that our brains can change and learn new things throughout our lives. This ability is called brain plasticity.

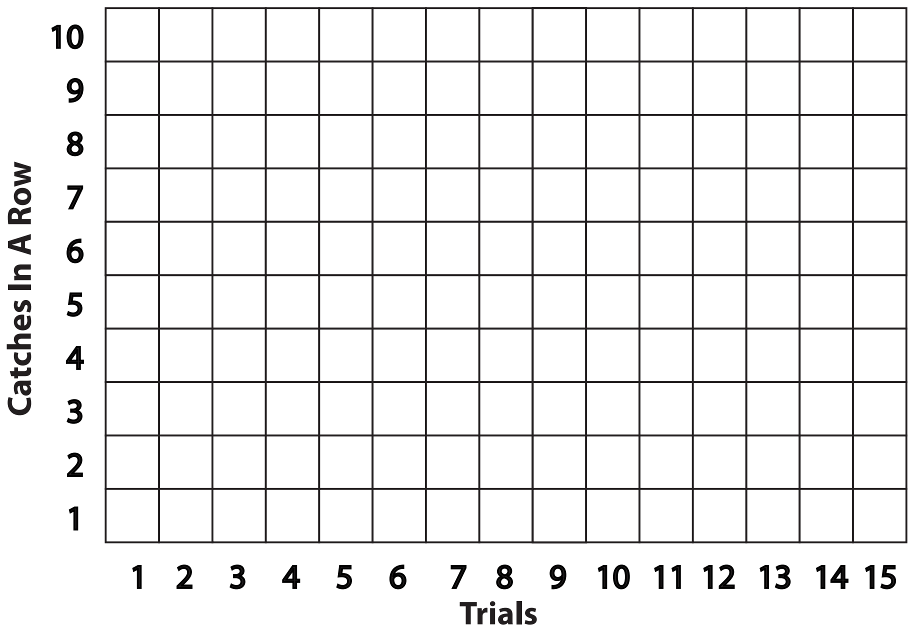
Ball and Cup Investigation

Subject Name: ________________________________

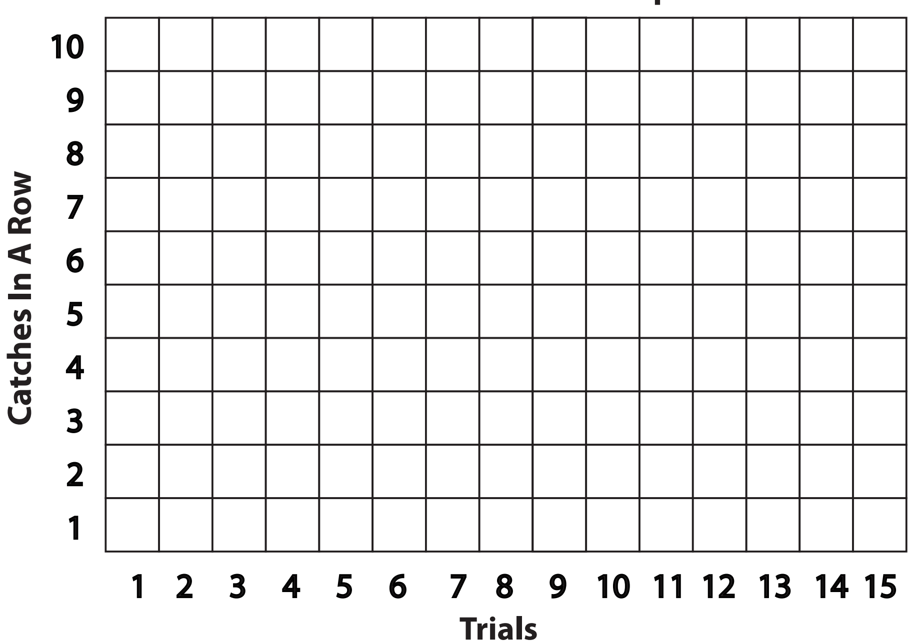
Instructions:

Your objective it to catch the ball with the cup 5 times or more in a row. Keep track of your progress with the graphs below. If you catch the ball on your first try, color in the first square for trial 1. If you catch it again, fill in square 2 above. If you miss, move on to trial 2 and repeat, marking in the squares for each catch in a row you make. Continue until you are able to make at least 5 catches in a row. When completed, move to a smaller cup.

Large Ball and Cup



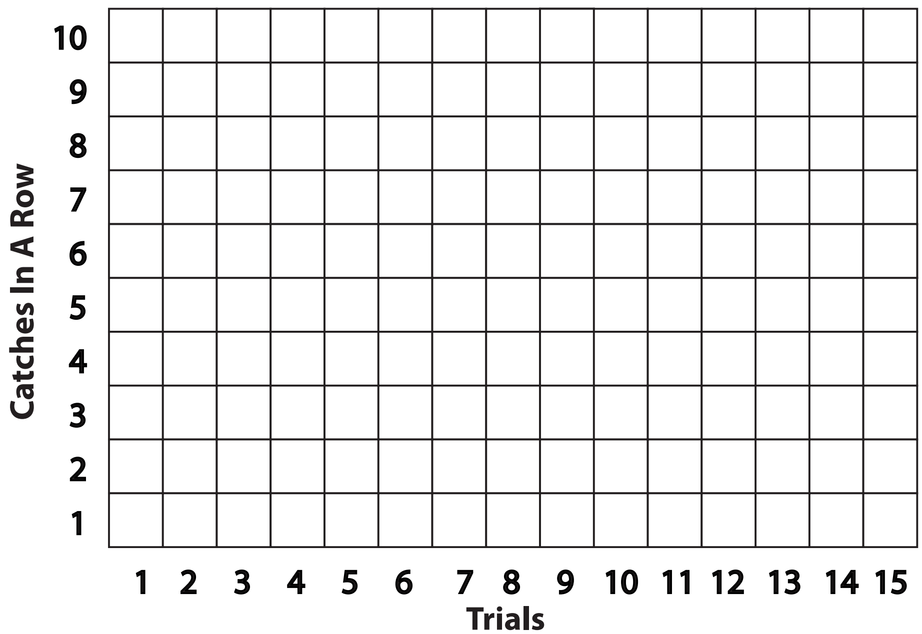
Medium Ball and Cup



Ball and Cup Investigation - 2

Subject Name: ___________________________________

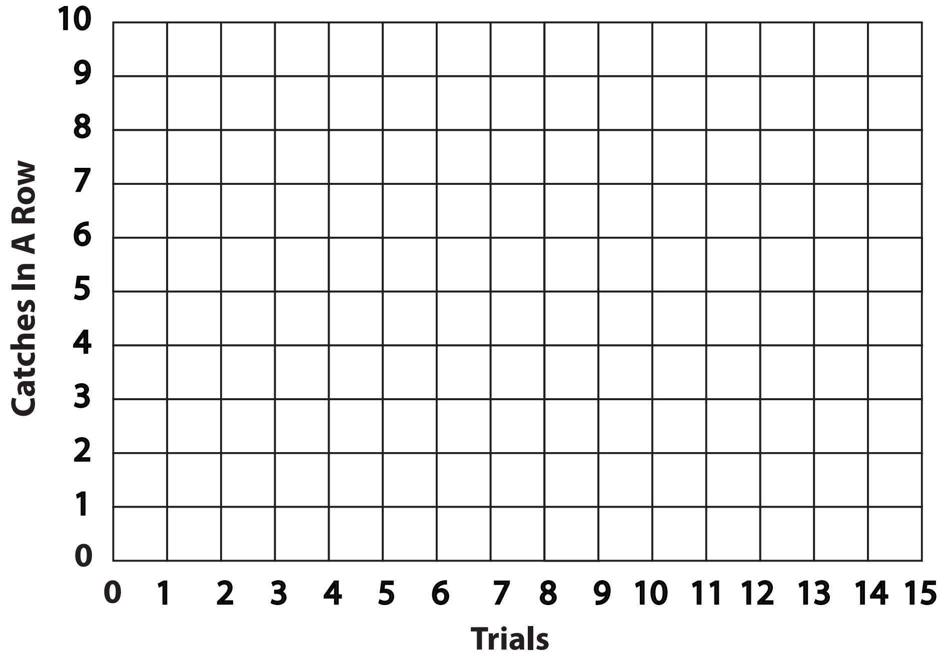
Small Ball and Cup

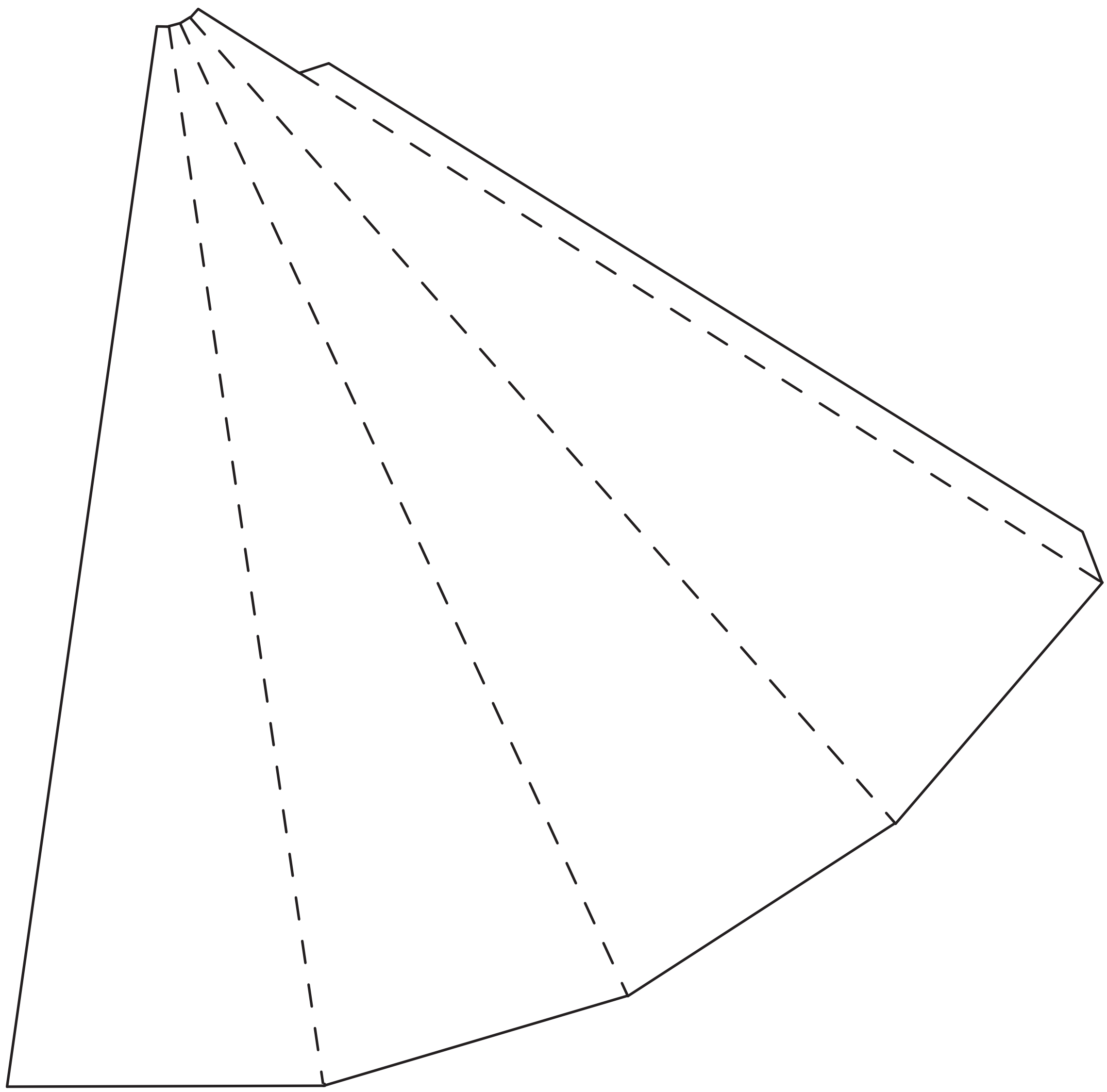


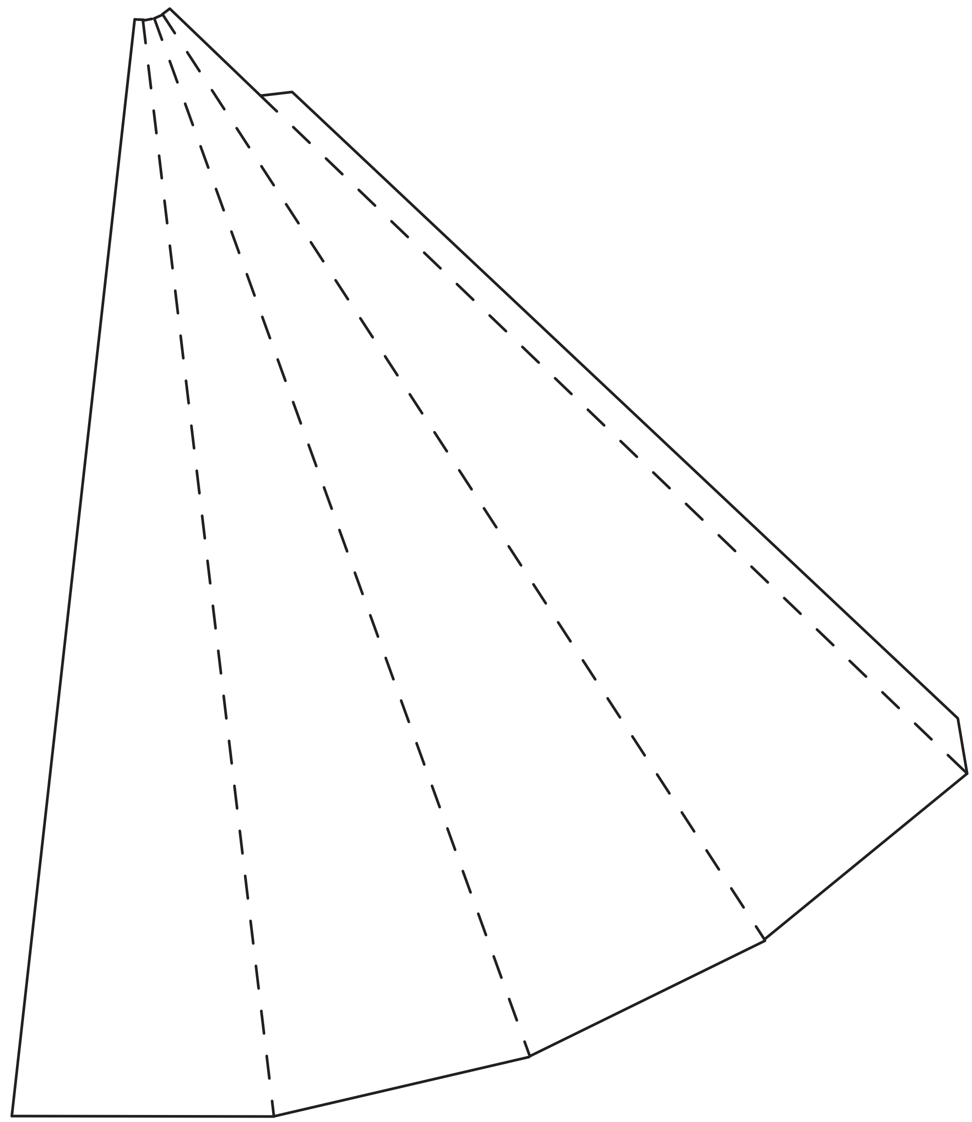
Final Graph Instructions:

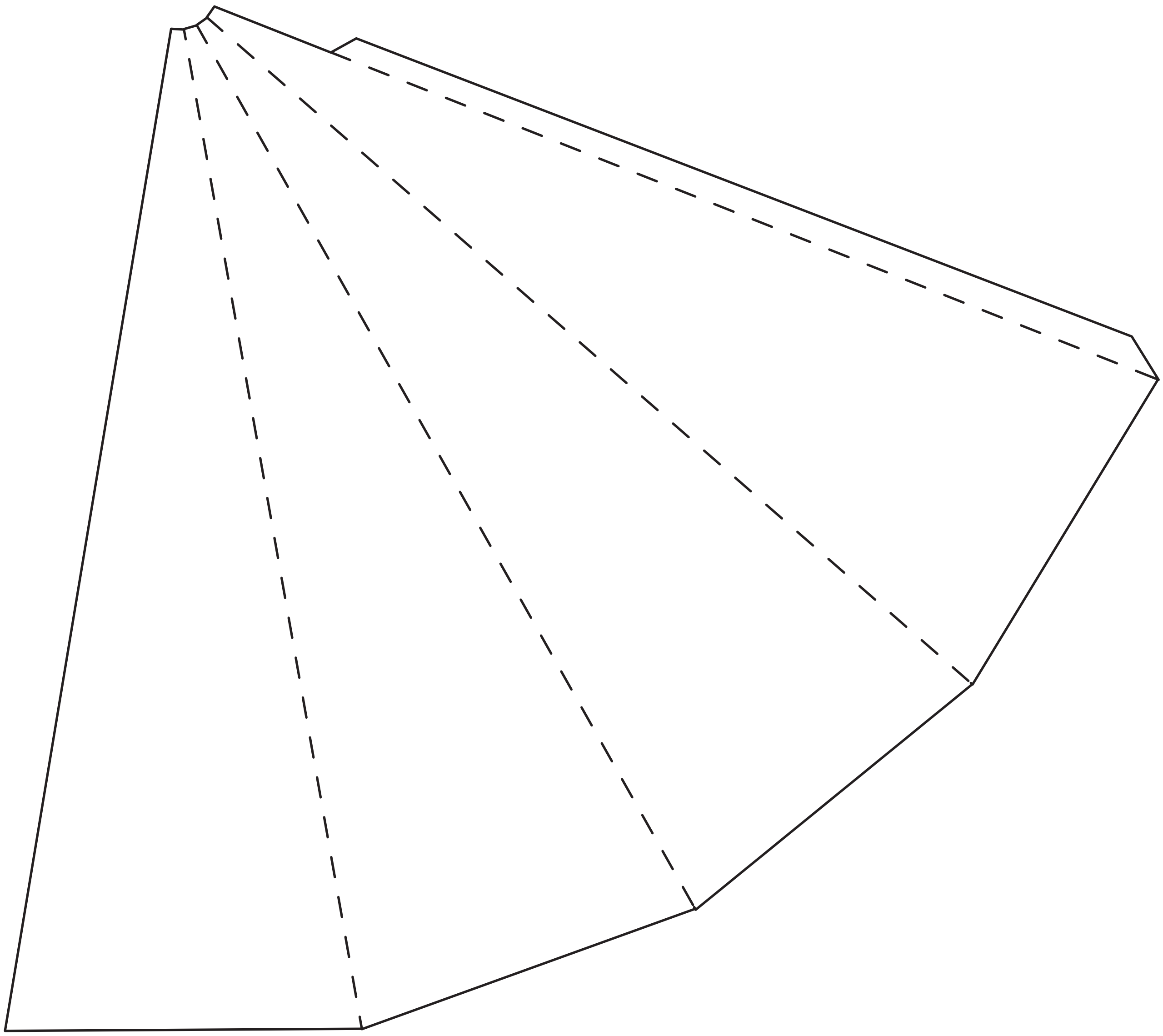
Combine the results of your three graphs using the graph below. Notice that the graph is a little different. Instead of filling in squares, you place dots at the line intersections. When done, connect the dots. Be sure to use a different color for each line and identify what each color stands for. For example, use red for the large cup investigation, green for medium, and blue for the small one.

Combined Ball and Cup Graph

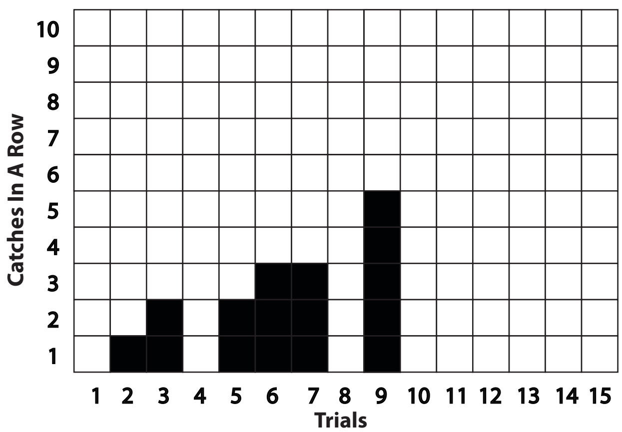




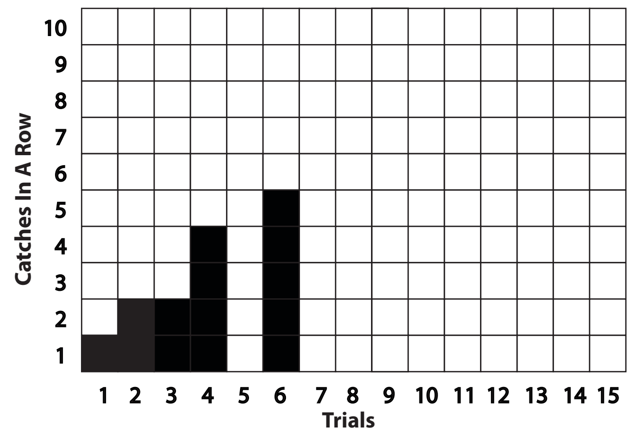




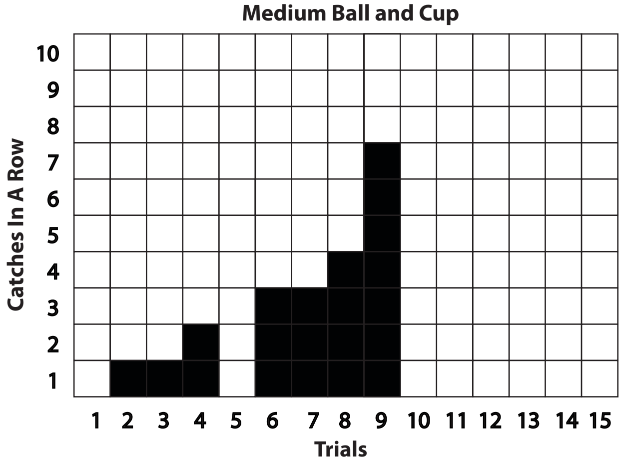
Large Ball and Cup



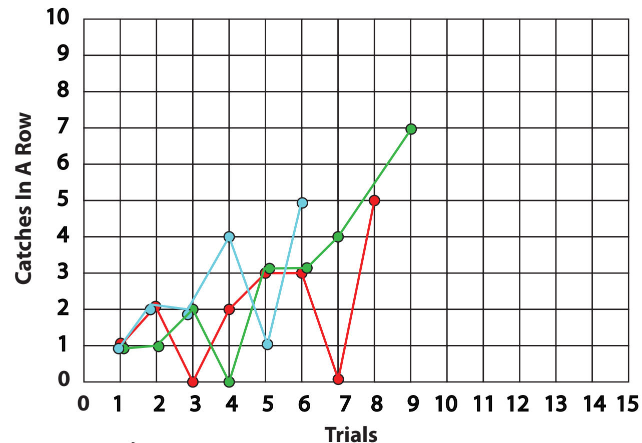
Small Ball and Cup



Medium Ball and Cup



Combined Ball and Cup Graph



Red - Large
Green - Medium
Blue - Small

INVESTIGATION 7
Getting Shifty
Vision Shifting Goggles

OVERVIEW. Students learn about neuroplasticity and adaptability of the brain by investigating what happens when they wear goggles that alter their visual perception.

BACKGROUND
Most of our knowledge about the world comes from the sense of vision. Vision occurs when light energy is received by transmitters in the back of the eye and converted to nervous system signals that are sent for interpretation by the brain. Have you ever experienced an optical illusion in which it is possible to see either one of two different images or drawings? Optical illusions can help us understand how the brain appears to make assumptions or fill in gaps about what is seen. The brain tries to make sense of the information that is detected, and often fills in missing parts or makes other adjustments.

In addition, vision plays an important role in helping the brain make adjustments in movements and responses. For example, by using a special kind of lens, it is possible to "trick" the brain into thinking that the position of objects has shifted. Vision shifted in this way makes it very difficult to throw an object accurately to hit a target. However, after a few tries, the brain adapts to the new sensory input and is able to coordinate muscle movements to compensate for the vision shift. This is an example of the brain's plasticity.

In this activity, students will use Fresnel lens to shift the focal point of their vision by about 20%. /French physicist Augustin-Jean Fresnel was the first to create this kind of lens. The design of the Fresnel lens allows the construction of lenses of large aperture and short focal length, without the mass and volume of material that would be required by a lens of conventional design. A Fresnel lens can be made much thinner than a comparable conventional lens, in some cases taking the form of a flat sheet.

With vision-shifting goggles that employ Fresnel lenses, we can test the brain's ability to make sense of a situation and adjust. Students will be challenged to hit a target with a beanbag with and without wearing vision shifting goggles. Observers will draw sketch of the Setup: and predict where the bags will land relative to the target.

CONCEPT
Students use vision shifting goggles to understand how the brain handles and adapts to altered perceptions.

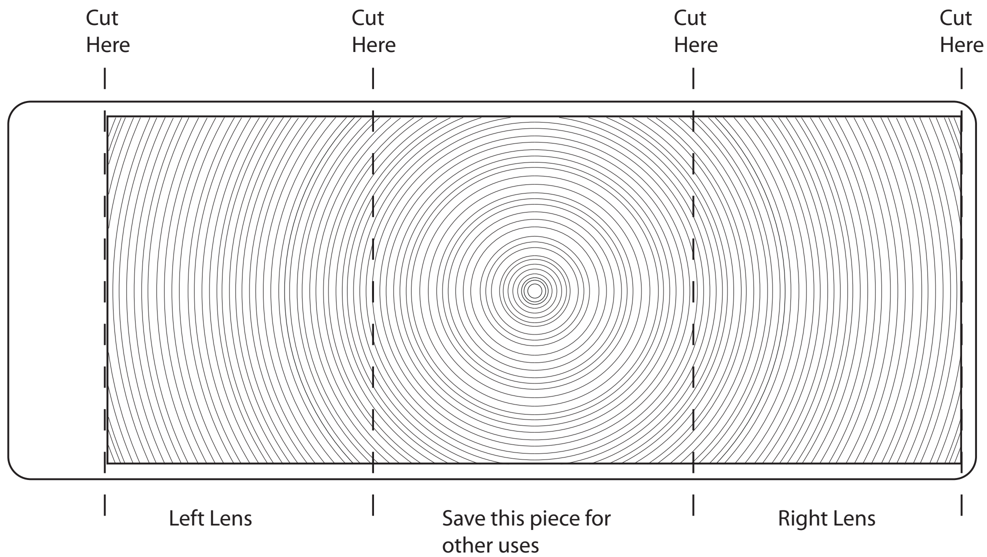
TIME
Setup: 30 minutes to assemble goggles
Class: 1 session

MATERIALS
Per Class
- 2 pairs of goggles
- 2 Fresnel lenses (flat plastic lenses for enlarging type - bookmark size)
- Bean bags or soft rubber balls (To make your own beanbags, fill heavy weight zip locking bags with rice or beans, 1/2 cup per bag. Use double bags for added security.)
- Round wastebasket or box to serve as a target

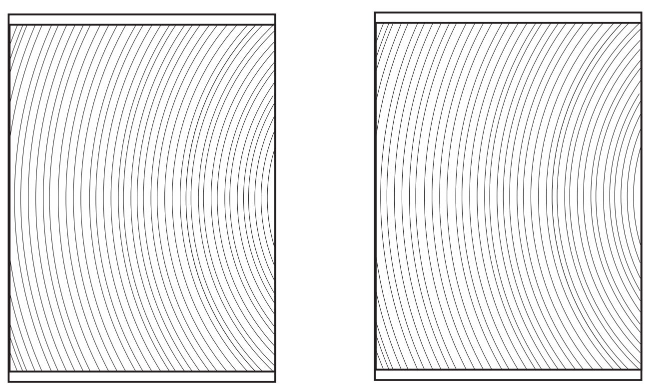
SETUP
1. Create goggles (see instructions that follow) and set up a throwing range.
2. Make 10-15 beanbags if soft balls are not available.
3. Prepare two (or more sets of vision shift goggles). See instructions that follow. Make one set that shifts vision to the right and another set that shifts vision to the left.

Instructions: Make vision shifting goggles

a. Carefully cut the ends of the bookmark Fresnel lenses according to the pattern below. The centerpart of the lens will not be used but it can be saved and used as a small magnifier.



b. Reverse the right lens so that the very fine curved lines curve the same direction as do the lines in the left lens.



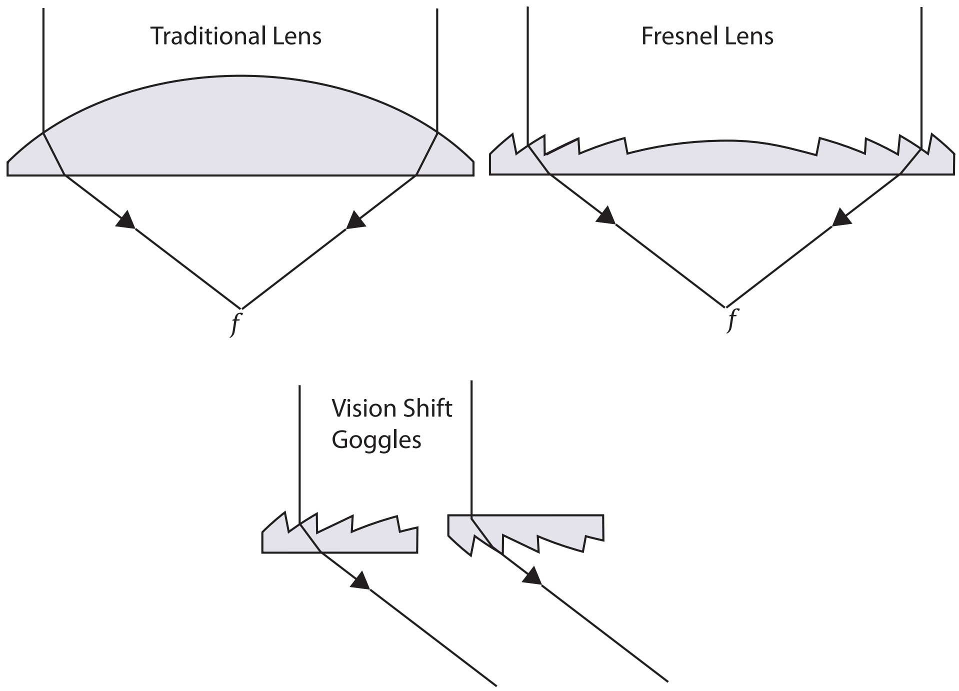
Turn right lens over so that the curved grooves curve the same direction.

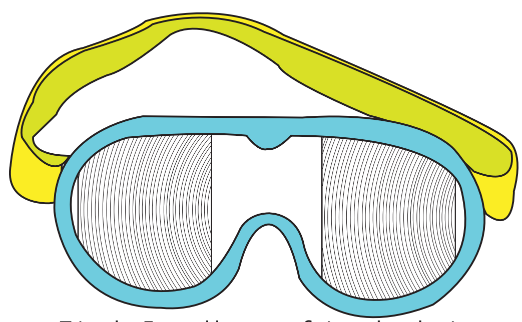
c. Trim the two lenses to fit into the frames of plastic safety goggles. Place the lenses on top (to the outside) of the goggle's plastic lens. Remember to align the curves.

How the vision shift goggles work

Fresnel lenses are much thinner than regular lenses. They have the same curve that creates a magnified image but the curve is segmented so that Fresnel lenses are much thinner. They were first designed for lighthouses where very large lenses were needed.

For the vision shift goggles bookmark Fresnel lenses are cut in half. One piece is reversed so that it bends the light passing though it in the same direction as the other. This produces a shifted image that is to one side or the other.





Trim the Fresnel lenses to fit into the plastic frame of a pair of goggles. Leave the clear lens of the goggles in place. Just place the Fresnel lenses in front.

d. Test the goggles. Put the goggles on and check the view. The view will be slightly blurred but objects are easy to make out. Look at an object a few meters in front of you. Remove the goggles. The object's position should shift to the right or left. The Fresnel lenses shift your view about 20 degrees to one side or the other.

   Note: If you reverse the direction of the two lens curves – to the right or the left, you will reverse the vision shift.

Set up a throwing range. Keep the beanbags or whiffle balls in a jar or a basket. Place a line of tape or other marker on the floor to create a throwing line, and place a target about 5 meters in front of it. A short wastebasket or cardboard box works well as a target.

PROCEDURE

1. At the beginning of the lesson, demonstrate how to throw a beanbag into the target. Ask students if they can hit the target. Explain that they will be challenged to hit the target, but will need to wear goggles.

2. Select a student to show how the goggles work. Place the student behind the throwing line and put on a pair of goggles. Stand next to the student and tell him or her to toss a beanbag or whiffle ball into the target. Make sure the student uses an overhand throw*. (It is important that the student does not see his or her hand during the throw!) Hand a beanbag or ball to the student and have him or her toss it at the target. The student will miss widely to one side or another. Let the student make more tosses. Gradually, the student will learn how to correct the throw. After the student begins hitting the target with every throw, stop. Remove the goggles and immediately have the student throw again. The tosses will now miss to the other side.

3. Have other students try the activity. Let students act as spotters to retrieve the beanbags or balls and hand them to the thrower.

4. Discuss what is happening. Ask, *What are your observations*? Gather student ideas. Explain that the goggles forced the thrower's vision to one side or another. Through practice, the thrower's brain compensated for the shift in vision and they were able to hit the target. When the goggles were removed, the initial throws were off to the other side. The new way of throwing was retained temporarily until the brain re-adjusted the throw.

5. During the day, or over several class periods, have each student test the goggles. Each student should record the number of throws required to hit the target after he or she puts on the goggles. Have students write their number of throws and sticky notes and create a class graph of the number of throws needed for adaptation of the visual and motor systems.

6. To conclude have each student investigate a sport or everyday activity that requires coordination between vision and muscles (playing baseball, sewing, stirring soup, etc.). Students should write a descriptive paragraph, create a PowerPoint slide or draw an illustration of the activity and what it takes to become proficient.

   Note: The reason throws should be made overhand is that by doing so, the beanbag or ball is released from the hand before the hand comes into the thrower's view. If an underhand pitch is used, the hand becomes visible before the beanbag or ball is released. The thrower sees that the hand is in the wrong place and the hand position is corrected before release. This is called tracking. You can see how tracking works. Put on the goggles and select an object in front of you. Start with your hand at your side and move your arm towards the object as though you are going to poke it with your finger. As soon as you glimpse your hand, you will see that it is pointing incorrectly and you correct its direction.

INVESTIGATION 8
Juggle Your Brain
More Training

OVERVIEW. Students use three-ball juggling to learn about proprioception, which is the ability of the brain to sense the relative position of parts of the body and strength of effort being employed in movement.

BACKGROUND

In many sports, hand and eye coordination is essential to becoming proficient. Athletes who participate in fencing, ping-pong, badminton, tennis, racquetball/squash, volleyball, soccer, and martial arts all have superior hand and eye coordination. Another hand and eye sport, which also is a performing art, is juggling.

When we hear the term juggling, we typically think of toss juggling where the juggler manipulates several objects in the air at the same time. Usually, the objects are some sort of balls, clubs, or rings. Advanced jugglers juggle knives, fire torches, or even chainsaws. In the classic three-ball cascade, the juggler tosses one ball through an eye-height arc to the other hand. Before that ball can land, another ball is tossed back to the first hand. Three balls are kept in constant motion. The cascade is the actual movement pattern of the hands and arms that make the routine possible. With lots of practice, a juggler is able to keep 4, 5, or more objects in motion.

Jugglers must be able to catch and toss balls or other objects in a regular pattern, track them in flight, and move their hands to catch the balls repeatedly. Many neurological studies have been made of the effects of juggling on the brain. Typically, two groups of volunteers, who do not know how to juggle, are given functional magnetic resonance imaging (fMRI) scans to set a baseline measurement. Half of the group is then challenged to learn how to juggle during 30-minute daily practice sessions. After several weeks, more fMRI scans are made of the juggling and non-juggling groups. In some studies, scans showed changes in the white matter (bundles of nerve fibers connecting different parts of the brain) in the juggling group. In other studies, changes have occurred in areas of the brain responsible for computation and processing. At the very least, juggling improves hand-eye coordination, reflexes, peripheral vision, and motor skills.

Throwing and catching balls is a way of observing another of the amazing properties of the brain/body interaction. Proprioception is the ability of the brain to integrate information on body position, movement and acceleration. It is another one of the body's senses. For example, a mosquito lands on your back and starts to sting you. You reach around with your hand and smack the mosquito without being able to see it or the spot on your back toward which your hand is moving. You are able to do this because of proprioceptors, or sensors, in skeletal muscles and body joints. These sensors even measure the effects of gravity on the body. When you hold out your arm, for example, gravity tugs on it. Even with your eyes closed, you can tell where your arm is, because your brain interprets the signals from the proprioceptors.

Juggling can help train and sharpen the sense of proprioception. This can be important if you are a doctor, artist, mechanic, pilot, etc. Experienced jugglers do not have to look at their hands when catching and throwing balls. They sense their hand positions for catches and the amount of force and direction needed for each toss.

GUIDING QUESTION

How does proprioception work?

CONCEPTS

Good hand-eye coordination is essential in many sports and leaning a new skill, such as juggling, can cause improvements in brain structure and function.

TIME

30 minutes the first day, and a few minutes of daily practice time

SETUP

1. Try to master 3-ball toss juggling yourself before conducting this activity with students.
2. Select a clear area for juggling practice.

MATERIALS

- Several sets of beanbag juggling balls (3 balls per set)
- See instructions below if you want to make juggling balls. You will need the following items.
  - 3 round helium balloons per juggling ball (9 balloons per 3-ball juggling set)
  - 1/2 cup of uncooked white rice per ball
  - Empty plastic water bottle
  - Funnel
  - Scissors

PROCEDURE

1. Introduce the topic of juggling to your students. If you are able to juggle, do a three-ball cascade several times for them. Ask, *Have any of you ever watched a juggler perform? Can you juggle?* If one of your students can juggle, have that student demonstrate his or her skill. Talk about the importance of hand-eye coordination to juggling. Ask students if they can think of any other activities in which hand-eye coordination is important. Make a list of their ideas on the board. Discuss how hand-eye coordination is used in each of the activities they suggest.

2. Point out to your students why practice is important in any new skill. The brain actually changes as you learn the skill. The more you practice, the better you get.

3. Show an Internet training video on how to juggle. The following site is excellent for learning how to juggle three balls. It features three videos that take beginners through the steps to becoming jugglers.

   http://www.thejimshow.com/juggle/

4. Invite non-juggler students to try simple ball tosses as shown in the video. As students master simple tosses, have them work through the other parts of the video to reach the three-ball toss level.

5. Prepare a table on the board with student names and days. Encourage students to practice whenever they have some free time. Have students enter the maximum number of seconds they are able to keep three balls moving continuously during their practice sessions. Challenge students to achieve continuous juggling for 60 seconds. Make sure students also log their training times in their notebooks and create a graph of their progress.

6. When students start showing progress in their juggling, hold a class discussion to discuss their observations. *How long did it take for them to successfully toss and catch the three balls the first time? How fast did they progress through the learning process until they achieved their goal? How much conscious thinking did they do about catching the balls when they first started? How much thinking do they do now that they can juggle for 60 seconds? What does this experience tell them about training their brains to master a new skill?*

7. As an assessment, have each student write a paragraph about his or her experiences with learning to juggle three balls. Each paragraph should have an introductory sentence, a description of the challenges faced by the student, a description of how they met the challenge, and a conclusion.

EXTENSION

Proprioception Training

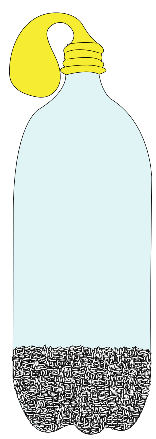
1. Challenge students to toss a juggling ball over their shoulder and then move their throwing arm backward and catch the ball without looking at it. This will take some practice but catches will be made.
2. Have students track the number of times they toss the ball before they catch it for the first time. Then have them track the number of times before they catch it the second time. Continue to track the number of throws between catches. Soon, students will catch the ball without misses.
3. Discuss the results of the backward catches. Why is there improvement? What does this say about the ability to train the brain (and body)?

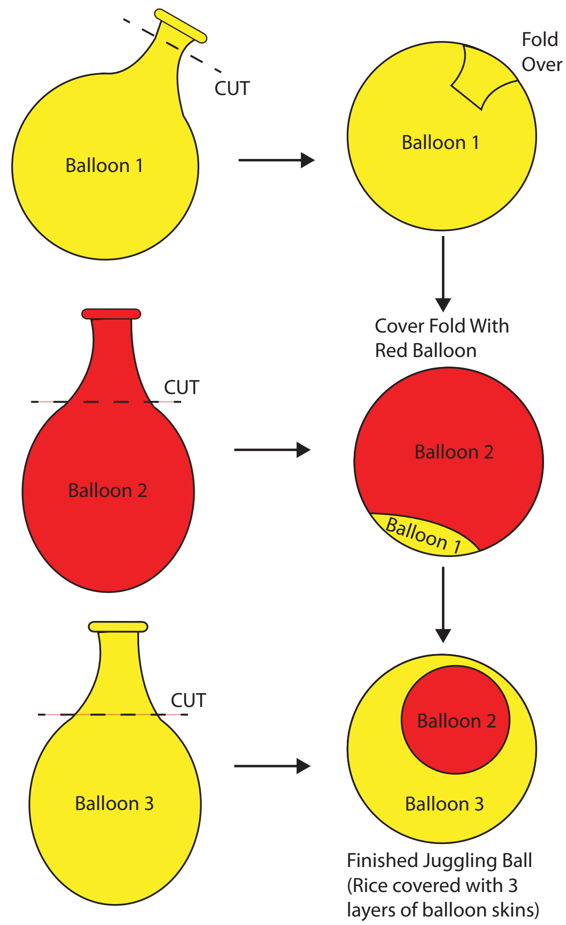
HOW TO MAKE JUGGLING BALLS

Juggling balls are usually made from leather or vinyl and are filled with beans or millet. This provides weight for easy throwing and no bounce for easy catching or retrieval if the ball falls to the floor. Very serviceable juggling balls can be made from round balloons and uncooked white rice.

Materials

- 3 round helium balloons per juggling ball (9 balloons per 3-ball juggling set)
- 1/2 cup of uncooked white rice per ball
- Empty plastic water bottle
- Funnel
- Scissors





Procedure

1. Using the funnel, pour 1/2 cup of rice into the bottle.

2. Inflate one balloon and twist the nozzle to temporarily seal the balloon. While the nozzle is still twisted, stretch it over the bottleneck.

3. Invert the bottle and the rice will pour into the balloon.

4. Remove the balloon and let the air out.

5. Cut the nozzle as shown. Fold the nozzle to one side.

6. Cut the second balloon and stretch the balloon so that it covers most of the first balloon. The nozzle should lay flat under the second balloon.

7. Cut the third balloon as shown and stretch it over the other two from the opposite direction. *Note:* There may be air bubbles but these will gradually work their way out.

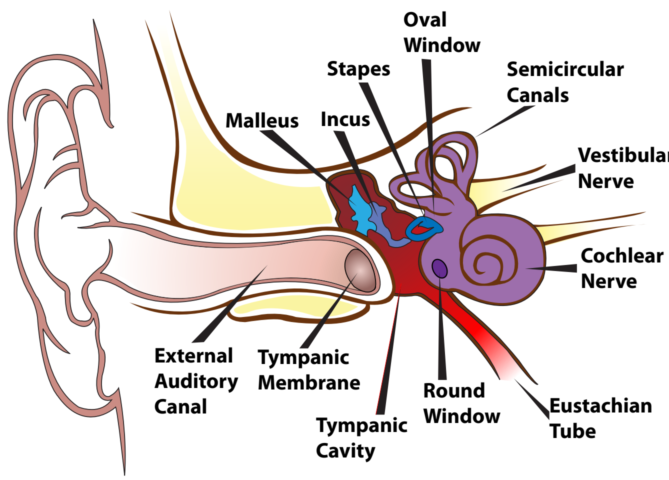
INVESTIGATION 9
More Than Five
The Senses

OVERVIEW. Students investigate the physics behind the ability to detect motion, both straight line and angular, and learn about a sense that is critical to maintaining balance and posture.

BACKGROUND
We all are familiar with the question, “How many senses do humans have?” The answer we hear most often is five: sight, taste, smell, hearing, and touch. Actually, we have more senses. One of these other senses is our ability to detect body motion and maintain balance. It is based on tiny structures in our inner ears that comprise the vestibular system.

The vestibular system has the ability to sense and determine the direction and speed in which a body is moving (linear acceleration, also known as straight line movement, and angular acceleration, also called rotational movement) and maintain the body’s balance (postural equilibrium). Human have the ability to walk a tight rope, combine twists and turns when high diving, and perform turns and triple toe loops while ice-skating. How does the human body sense and control the movement so precisely? How do we maintain our balance while putting ourselves through a wide variety of spinning and tumbling activities which are inherently “unbalancing?”

Maintaining balance and sensing movement are essential parts of performance in sports. These actions require the precise integration of several of the body’s sensory and response systems including visual, vestibular, somatosensory (touch, pressure and stretch receptors in our skin, muscles, and joints), and auditory. Acting together, these body systems constantly gather and interpret sensory (input) information from all over the body and allow us to act on that information in an appropriate and helpful way.



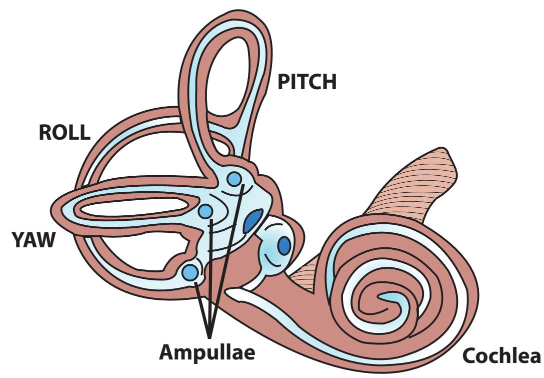
The vestibular system is located in the inner ear on each side of the head, and is composed of structures that sense motion and orientation. It is comprised of three semicircular canals and two membranous sacs called the saccule and utricle. The saccule and utricle are often referred to as the otolith organs.

The semicircular canals are oriented along three planes of movement, with each plane at right angles to the other two. Pilots and astronauts call these three planes pitch (up and down; nod your head “yes”), roll (cartwheeling left or right; move your head from your left to your right shoulder or vice versa) and yaw, (lateral movement left and right; shake your head “no”). The semicircular canals allow us to sense the direction and speed of angular acceleration. The otolith organs allow us to sense the direction and speed of linear acceleration and the position (tilt) of the head.

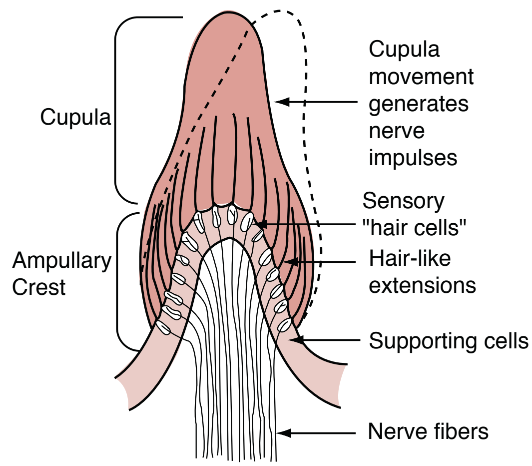
What’s the difference between angular and linear acceleration? Linear acceleration is a change in velocity (speed increasing or decreasing over time) without a change of direction. In other words, motion in a straight line. Angular acceleration is rotational motion.

These linear and angular senses are constantly at work. For example, imagine riding in the back seat of a car. Even with your eyes closed, you can tell when the car starts moving, speeds up, slows down, or makes a turn to the right or left. Your vestibular system tells you what is going on.

In addition to sensing motion, the vestibular system also helps maintain a fixed gaze on a stationary or moving external object while you are undergoing complex head and body movements. Imagine that a baseball player hits a fly ball deep into center field. You are the center fielder and have to run and catch it. While running and raising your glove, you are able to keep the image of the fast-moving ball steady so that you can get to the exact place to catch it. Your vestibular system steadies your eyes in spite of your complex movements. Try this. Focus your eyes on a wall clock or other object. While watching the clock, quickly move your head from side and up and down. Thanks to the vestibular system, the clock mage remains steady.



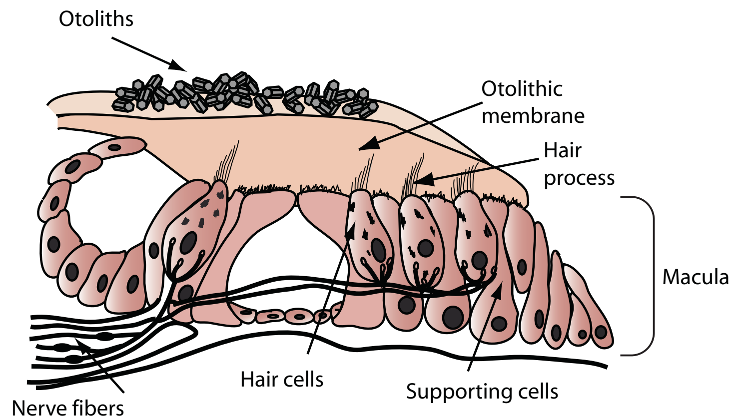
The semicircular canals of the vestibular system are tubular membranous structures imbedded within a bony structure of the same shape. The central cavity of each of the three tubular structures (canals) is filled with a fluid called endolymph. Each endolymph-filled canal has an enlarged area near its base called an ampulla. Parts of the vestibular nerve penetrate the base of each ampulla and terminate in a tuft of specialized sensory cells (hair cells). The hair cells are arranged in a mound-like structure, the ampullary crest. Rising above the ampullary crest is the cupula, consisting of hair-like extensions of the hair cells surrounded by a gelatinous material arranged into a wedge-shaped structure called the cupula.



During rotational motion, the endolymph fluid momentarily remains stationary because of its inertia. The sensory hair cells in the canal, oriented in the same direction as the motion, become stimulated due to the pressure exerted by the stationary endolymph fluid as the canal moves with the body. The sensory cells send signals to the brain that are interpreted that motion has begun. Soon, the internal friction of the canal causes the fluid to move with the canal. The pressure on the sensory cells lessens and the sensation of motion lessens. Later, as the rotational motion stops, the endolymph fluid continues to move because of its inertia. The hair cells are again stimulated. This time, they signal the brain that motion is taking place in the other direction. This is a false sense since motion has actually stopped. This false sense of motion makes us dizzy.

The utricle and saccule, or otolith organs, sense straight-line motion. To see how these gelatinous sacks work, fill up a plastic sandwich bag with water and seal it. Apply a force to push the sack across a desk top. The inertia of the sack causes it to resist the push. In the vestibular system, sensory hair cells transmit this resistance to our brains and we feel straight-line motion. To increase the inertia of the gelatinous sacks, small crystals of calcite form on the outside of the sacks, which increases their mass and thus their inertia. (The crystals are sometimes called ear stones.)

In spite of the finely tuned motion and balance systems in our bodies, sensory conflict can occur. This sometimes happens to airplane pilots who are flying through clouds or at night. The sensation of rotational motion occurs and the pilot tries to correct the motion by adjusting the airplane controls. If the motion is imaginary, this can lead to dangerous situations.



Sensory conflict also can occur under unusual conditions. Try spinning around with your eyes closed and then walking a straight line. What happens is that the spinning motion starts to move the endolymph fluid in the yaw canal. When you stop and try to move in a straight line, the fluid keeps circulating in the yaw canal for a few moments. This causes a conflict with what your eyes see and with the signals sent from the vestibular system. For a few moments, you feel unsteady and out of balance.

There are other vestibular illusions that can occur – the sensation that you are moving when you are not, that you sense you are not moving when you are. Scientists investigate these and other illusions with the use of a rotating chair named the Barany Chair after its inventor, Nobel laureate Robert Barany.

Air Force personnel conduct a test with a Barany chair. After rotation, the test subject attempts, with some difficulty due to continued motion of endolymph fluid, to point accurately
at targets on a board.

GUIDING QUESTION
How does the body sense motion?

CONCEPTS
The vestibular system, in conjunction with other body systems, enable us to sense motion and maintain balance in a variety of situations, especially in the conduct of sports.

TIME
1-hour class session

SETUP
Construct the Vestibular Inertia Model. If you do not have access to tools for cutting and drilling the PVC pipe, ask for assistance from a parent or friend who does. See construction plans below.

MATERIALS

- Baseball bat
- 2.3 L Click Clack food storage jar or similar clear storage jar
- 10-inch non-skid cabinet turntable or similar lazy Susan type turntable
- 4 Mini Shy Bite Floats (pencil type fishing bobber manufactured by Thill) or similar
- 3-inch diameter PVC pipe cut to just fit inside jar when lid is in place
- 16 inches of braided fishing line or string
- 1/16th inch drill bit and drill

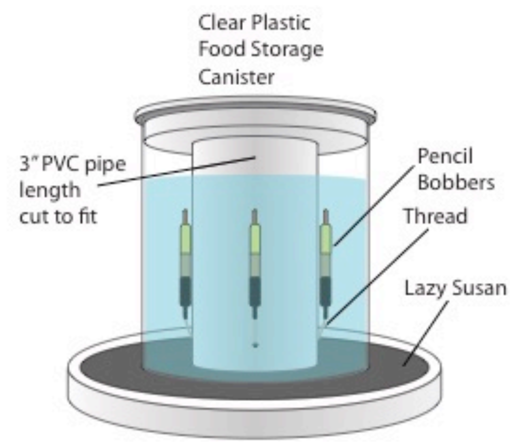
Sources
http://www.fishusa.com/product/Thill-Mini-Shy-Bite-Float (2 or 3 inch)

http://www.amazon.com/Copco-2555-0191-Non-Skid-Cabinet-Turntable/dp/B0036OQU1U/ref=lp_3744181_1_2?s=kitchen&ie=UTF8&qid=1424967324&sr=1-2

http://www.clickclack.com/products/pantry/3525

PROCEDURE

Part 1. Construct the vestibular inertia model



1. Cut a piece of 3-inch PVC pipe to just fit inside the jar. If cut precisely, the curved bottom of the lid will anchor the pipe in the center of the jar. (Tip: if you do not have the tools, a parent volunteer may be able to help you cut the pipe.)

2. Using the drill and drill bit, drill four holes about 1 inch from one of the ends of the PVC pipe. The holes should be spaced 90 degrees around the pipe.
3. Tie a fat knot in one end of the fishing line. Thread the line through one of the holes starting from the inside. Slip the bobber on to the line, so that the bobber end is about 1 inch from the hole. Cut the line and repeat for the other three bobbers.

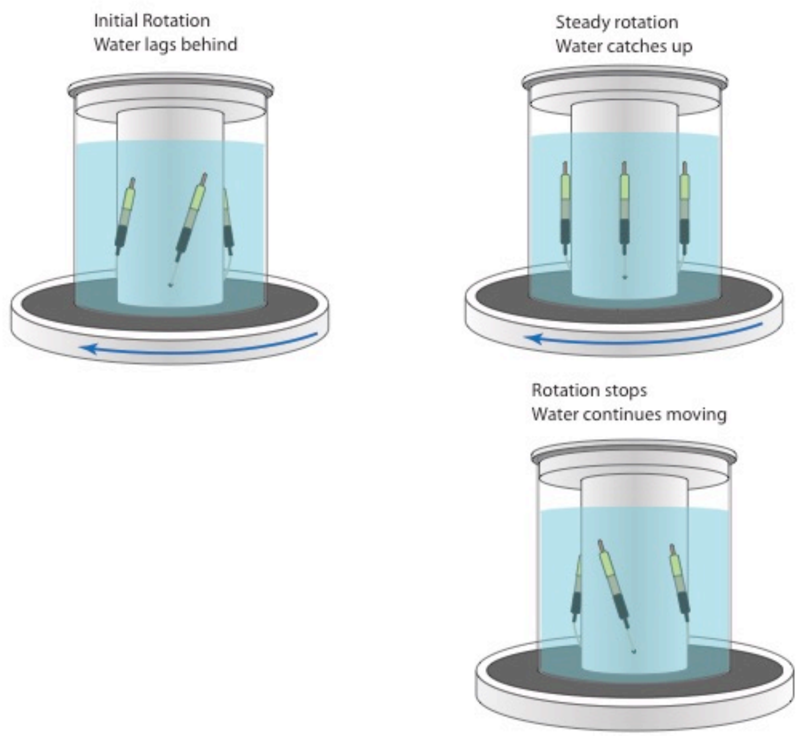
Part 2. About the vestibular system
1. Ask your students if they are well balanced. Explain that you mean, *Can they stand on one foot without falling over*? Ask for a volunteer to come to the front of the room. In an open area, have the student balance on the toes of one foot. Stand nearby to act as a spotter. Then, tell the student to close his or her eyes. The student should still be able to continue balance for a time with his or her eyes closed, but it will be more difficult.

2. Explain that in addition to our eyes, we have an internal system that helps us maintain balance and stand upright. Describe the vestibular system using the background information.

3. Explain that athletes need their vestibular systems to help them play well. Ice skaters, for example, need to be able to spin on the ice, etc. Next, explain that the vestibular system can be fooled under certain circumstances. It takes brain training (practice) to be able to perform even when the senses are in conflict. Call for another volunteer. Before selecting the volunteer, point out that people who easily get motion sickness, should not volunteer. Have your volunteer stand in an open area. Give the volunteer the bat and have him or her place one end of the bat on the floor while holding up the other end. Then, have the volunteer place his or her forehead on the top end of the bat and then walk around the bat several times quickly. Stand nearby as the spotter. Have the volunteer, stop, stand upright, and then try to walk a straight line. You might also have the volunteer try to point at a target on the wall or toss a paper wad into a wastebasket.

4. Have other volunteers try circling the baseball bat. Discuss what the volunteers observed during the spinning. *How did they feel? What did their see when they stopped? Was the world around them swirling? Why?* Explain that these effects were the result of the vestibular system and you can show how the system works with a model.

Part 3. Using the model



1. Fill the jar with water up to about 5 cm from the top. Place the tube with the bobbers into the jar with the bobber end down. The water level is correct if the bobbers are under water and are able to move freely.

2. Snap the jar lid in place and place the jar in the exact center of the turntable.

3. Describe the jar model to your students. The jar represents a semicircular canal. The water represents the endolymph fluid. The bobbers represent the ampulla and sensory cells that send signals to the brain. Please Note: The model is not anatomically correct. It shows, however, how inertia makes vestibular system works.

4. Start the turntable rotating. The inertia of the water will cause it to lag behind the turning jar. The bobbers will all tilt in the opposite direction. As you continue to rotate the jar, internal friction of the water and the jar wall will cause the water to catch up with the turning. The bobbers will return to the vertical position even while the jar continues to move. Then, stop the jar. The inertia of the water will cause it to keep moving for a few moments and the bobbers will tilt the other direction. Gradually, the water stops moving and the bobbers will be straight up again.

5. Compare the bobbers to the sensations student volunteers felt as they circled the bat and then stopped and stood straight up. The continued motion of the water when the jar stopped is analogous to the dizzy sensation we feel when spinning motion stops. This sensation can be lessoned through practice (training your brain).

6. As an assessment, have each student write and illustrate a paragraph explaining how the vestibular system uses inertia to detect both rotational and straight-line motion.

INVESTIGATION 10
Are You Well Balanced?
Balance and Movement

OVERVIEW. Students enhance their learning about the senses of balance and motion detection by walking a straight line and using balancing sticks with and without masses added to increase inertia.

BACKGROUND

We take for granted our ability to stand, walk, run, and climb steps safely because these are just normal parts of daily living. Yet, they are only possible because of an amazing interaction of our brains and our sensing systems. Just standing upright, for example, involves our eyes, the utricle and saccule of our vestibular system, and proprioceptors in our muscles and skeletal joints. When you lean one way or another, a whole suite of senses signal minute changes in balance. The appropriate muscles in your legs contract to return the posture to equilibrium (balance). If you trip while walking, arms and body posture automatically begin adjusting in an attempt to catch yourself. This happens far faster than you can consciously think of what to do to stop the fall.

Many athletic events depend heavily on our ability to remain balanced. The balance beam in women's gymnastics is an excellent example of the importance of balance. Beam routines involve athletic leg swings, handstands, flips, and handsprings all on a 4-inch-wide beam several feet off the floor. When an athlete does a leg lift, her body starts to go out of balance. Her balance sensors immediately communicate with other parts of her body and the appropriate muscles in her legs, arms and torso go into action to reposition the rest of her body so that balance is maintained. Because the athlete has practiced for years on the balance beam, her movements are smooth with no trace of shakiness.

GUIDING QUESTION

Can balance improve with practice?

CONCEPTS

Our sensing organs continually provide information on our bodies and trigger instantaneous adjustments of our musculoskeletal system to maintain balance. Repeated practice fine-tunes the balance system for athletes.

TIME

Class: 60-minute session the first day and occasional practice when time permits.

SETUP

Prepare balancing sticks.
Optional activity. Construct a balance beam.

MATERIALS

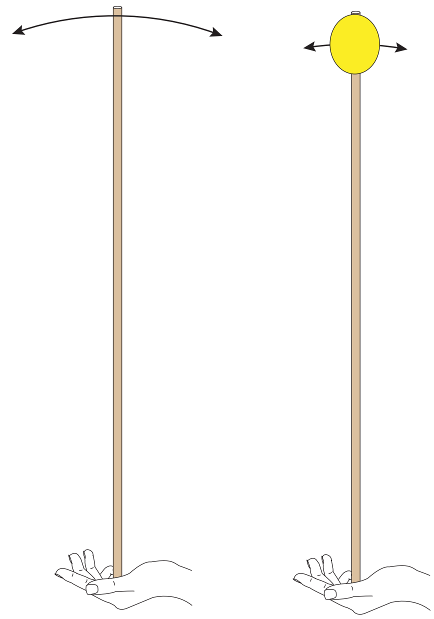
- Duct tape
- 2 ½ in. wood dowels, 3 ft long
- ¼ lb of modeling clay
- Gymnastics mat (optional)

PROCEDURE

Note: This activity can be done at the same time as the optional activity, "Balance Beam."

1. Ask your students if they are "well balanced." Explain that you are referring to athletic balance. People that engage in gymnastics have to have a good sense of balance to do hand stands, cartwheels, and other floor exercises. Ask if anyone in the group can do a cartwheel. If yes, ask the student to perform a cartwheel on a gym floor mat. If you have an available video camera, make a video of the stunt and then show it on a screen to the group. Use computer video controls to slow the action and have students analyze what took place. Have them point out examples of moments where

balance is important (for example, being able to end the cartwheel standing up rather than flopping to the floor For more information and an animation on cartwheels, check the following site: http://en.wikipedia.org/wiki/Cartwheel_%28gymnastics%29



2. Tell your students that you will be testing their sense of balance in different ways. Begin by giving a wood dowel to a student. Have him or her stand apart from other students and try to balance the dowel in the palm of one hand while it is standing on its end. Keeping it balanced is a bit tricky, and involves a lot of correction by moving the hand in the same direction the dowel is tipping. Over correction is easy.

3. Ask your students if they can think of a way of getting better in balancing the stick. Write their ideas on the board. Borrow the dowel and show that you too have a problem balancing it. Then, press about 1/4 pound of modeling clay around one end. Hold the dowel in the palm of your hand with the clay at the top. Try to balance it again. It will be much easier. Let your student try it. Next, try balancing the stick with the clay end in your hand. Balancing will be much harder again.

4. Ask why it is easier to balance the stick with the clay at the end? As we have learned, all objects have the property of inertia or a resistance to a change in motion. The clay greatly increases the mass of the upper end. The more mass, the greater its inertia. To experience this relationship more directly, pick up a lightweight book in one hand. Swing it side to side quickly. Do the same with the heavyweight book. *Which is harder?* The heavy book has more inertia and it takes more strength to move it quickly than the lightweight book. The same applies to the balance stick. With more mass (and inertia), the upper end is more resistant to tilting. Only small hand corrections are needed to correct the dowel.

5. Ask students if they can think of an athletic feat where the inertia of long poles is useful. Two examples are given below.

The boat used by this rowing team is called a shell. It is long and narrow so that it glides easily through the water. It is also very tippy. To keep balance, the long oars provide a counter force when they touch the water. Photo Credit: Joshua Sherurcij.

Maria Spelterini crossed Niagara Falls on a tightrope on July 4, 1876. She really is wearing wooden buckets for shoes. Notice the long pole. The pole is used to enhance her balance on the tightrope through the inertia of the pole ends. Photo Credit: George E. Curtis, Niagara Falls Public Library

6. As an assessment, have students create a class list of things and experiences where physical balance is important (E.g. buildings, boats, playground equipment, horseback riding, skating, etc.) Have them explain how balance affects each item on their lists.

7. As an extension, obtain a Jenga® game and allow students to play the game in their spare time. Discuss how balance is essential for playing the game.

Optional Activity: Balance Beam

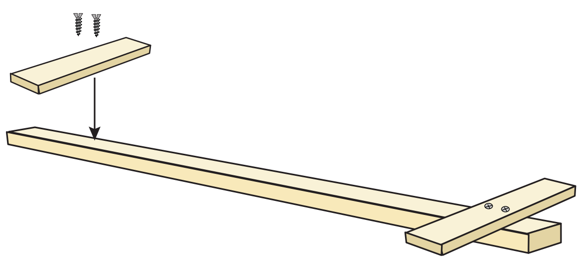
Olympic level balance beam competitors have to start somewhere. A regulation balance beam is a somewhat scary piece of athletic equipment. Rather than starting out on a regulation beam, future Olympic gymnasts start out closer to the floor. They develop their balance skills by walking on a fat white line on the floor or by walking on a beam resting on the floor.

MATERIALS

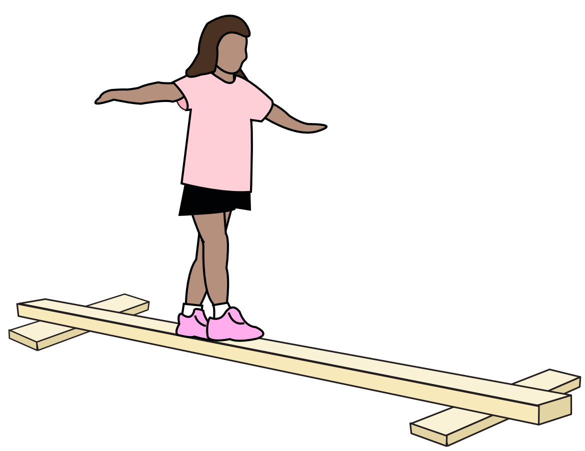
- 2-in. x 4-in. x 72-in. board
- 2 24-in x 3-in. x 1-in boards (usually available as precut boards at the lumber yard; check to see that the wood is not warped and is not split or splintered.)
- 4 2-in. wood screws (number 10 or 12)
- Drill and bit (for making pilot holes) OR wood glue
- Screwdriver
- Blindfold (opaque scarf or other cloth)

SETUP

Place the two 24-in. x 3-in. x 1-in. boards perpendicular to the two ends of the 72-in. board. Join together using either with wood screws or nails. Screws are better. It is advisable to drill small pilot holes into the wood to prevent splitting. Pilot holes are made with a drill bit that is slightly smaller in diameter than the screws.



Turn the beam over and it is ready to use.



PROCEDURE

1. Describe the Olympic balance beam event. Show a video of the 2012 Olympics balance beam competition. See the two choices that follow.

Gabrielle Douglas - Balance Beam - 2012 U.S. Olympic Trials Podium
http://www.youtube.com/watch?v=bmWICdhvyJw

2012 London Olympic Games: Deng Linlin wins Balance Beam
http://universalsports.com/video/2012-london-olympic-games-deng-linlin-wins-balance-beam/

2. Explain that performing on the balance beam is a very demanding sport that involves great athleticism and grace. The balance skills that are honed in this competition are useful in other gymnastic events for men and women in floor exercises, vaulting, still rings, parallel bars, uneven parallel bars, high bar, etc. Check for a description of many gymnastic events at the following site: http://en.wikipedia.org/wiki/Gymnastics

3. Ask your students if they can walk a straight line. *What if the straight line is very narrow?* Stretch two 10-foot long parallel strips of duct tape on the floor. The parallel strips will create a 4-inch-wide walking path. Ask students, one at a time to walk the path without placing a foot off the path. Have them look at the path and their feet as they do it. Have other students act as spotters. Tell them to call out if they see a foot straying off the path. Have students try it again, but this time purposely staring straight ahead at a distant object. Ask, *Which way is it easier to keep one's balance?* Staring straight ahead enables eyes and the internal balancing system — otolith organs (utricle and saccule) and the semicircular canals — to work together to make balancing easier.

4. Challenge students to perform some simple tricks on the tape balance beam. Possible tricks include the following.

   - Bend over and touch the line with one hand.
   - Turn 180 degrees.
   - Swing one leg forward and back.
   - Turn sideways and stretch out arm and legs
   - Jump straight up and land on the line.
   - Sit on the line and then stand up without touching the surrounding floor.

5. *Optional:* Introduce the wooden balance beam. Explain that many future Olympic gymnasts start with tapelines and low balance beams. As their skills improve, the beams are raised higher and higher until they reach Olympic height. Doing so helps build the athlete's confidence. Have your students walk the beam while others observe. Ask, *Is it easier or harder to do than walking the tapeline? Use the blindfold and have them try it again.* D

   Safety note: Don't forget to have spotters on either side of the person on the balance beam!

   Official Olympic Balance Beam Specifications
   Height: 124 cm (4.07 ft)
   Length: 500 cm (16 ft)
   Width: 10 cm (3.9 in)

INVESTIGATION 11

A Talent Improvement Plan

Have You Trained Your Brain?

OVERVIEW. In this culminating activity students demonstrate a behavior/skill that they have, discuss how they learned it, and create a plan to continue improving.

BACKGROUND

Throughout this unit students have learned about how practice makes changes in their brains to improve skills. Any hobby or talent that students have represents practice and effort to "train their brains." By committing to continual practice, students can continue developing any skills in which they are interested.

GUIDING QUESTION

What learned behaviors and skills do students have?
How were they able to develop these behaviors and skills?

CONCEPTS

Learning skills takes patience and practice. Students can share a skill that they have learned, practiced, and are proud of.

TIME

Part 1: 30 minutes
Part 2: 60 minutes (approximately 3-5 minutes per student)
Optional follow up sessions.

MATERIALS

- Copy of "My Train Your Brain Talent Show Skill" form
- Student materials required for talent show
- Computer with projector to show videos of talents that cannot be performed live

PROCEDURE

Part 1

1. Ask students, *Do you have any special talent or skill that you are proud of?* Have students share examples. Ask students to think about how they gained or developed the skill. Who first taught them or introduced them to the skill? How long did it take for them to pick up the skill. Do they still work on improving at the skill?
2. Tell students, *We will have a class talent show where students will demonstrate their special skill and explain to the class how they were introduced to the skill, how they improved at the skill, and if/how they plan to continue to improve at the skill?* The skills can be any of the activities from throughout the unit (juggling, balance beam, stick balancing, etc.) or another skill that they have learned such as dribbling a basketball, playing an instrument, ballet, drawing, or painting. Each performance should be limited to between 3 and 5 minutes.
3. Have student complete their "My Train Your Brain Talent Show Skill" form.

Part 2

4. Hold a Train Your Brain Talent Show and have students share their talent with the class and explain how they developed their talent skill and how they plan to improve it. If the skill requires materials that they cannot bring into class (for example, playing a piano) or cannot be performed live, have students and their parents/guardians video record their performance to show in the class.
5. Challenging students to execute their Talent Improvement Plans throughout the next month.
6. Optional: At the end of the month (as time permits) hold a follow up Train Your Brain Talent Show and have students demonstrate how they improved using their Talent Improvement Plans.

My "Train Your Brain" Talent Show Skill

1. What is the talent/skill you will demonstrate to the class?

2. How did you get started with the talent/skill? Who introduced you to it?

3. How did you develop and improve in the talent/skill?

4. Using what you learned about training your brain, create a Talent Improvement Plan to continue improving at the talent/skill. How will you develop the skill? How often will you practice? How will you receive feedback? How will you track improvement?