How Does the Brain Work?

Background: In this activity, the students participate in a simple **ruler drop experiment** and learn about the body's response behind it. When your friend drops the ruler in the experiment, you see it start to move. A nerve signal travels from your eye to your brain then to your finger muscles. Your finger muscles move to catch the timer. The whole process takes between 150 and 220 milliseconds. **This experiment does not test a simple reflex. Rather, this activity is designed to measure the response time to something that you see.** Catching a dropped ruler begins with the eye watching the ruler in anticipation of it falling. After the ruler is dropped, the eye sends a message to the vision section of your brain (visual cortex), which perceives that the ruler has fallen. The brain (visual cortex) sends a message to the motor cortex to initiate catching the ruler. The motor cortex sends a message to the spinal cord, which then sends a message to the muscle in the hand/fingers. The final process is the contraction of the muscles as the hand grasps the ruler. All of these processes involve individual neurons that transmit electrochemical messages to other neurons. **A person's reaction time depends on a couple of things that can be improved and a couple that cannot.** Practice does make perfect because you can create a "muscle memory" which means you do not have to think so much to catch the ruler. You can take the time it takes to decide things out of the equation. Much of the time it takes you to react to the ruler dropping is the time it takes electrical signals to travel along your nerves. Moving at about 100 meters per second, a signal telling a finger to move has to travel from your brain down your spinal cord and into your arm. Signals for muscle control generally move faster than other ones. (Pain signals, for example, move very slowly, often less than one meter per second). But these signals are "involuntary" which means that no matter how hard you try, you cannot control how quickly they occur. **The distance the reaction timer travels before you catch it has been converted to time using the equation $d=1/2at^2$ where a is the acceleration due to gravity.**

Objectives

- Describe how the nervous system responds to a stimulus.

Materials

- **Per Student Pair:**
  ruler
  Think Fast handout

Key Questions

- How fast is your reaction time?
- What had to happen in your body for you to catch the ruler?
- How can reaction time be improved?
- Does your reaction time improve with practice?
- Why was the ruler caught in the middle (after a lag period) rather than at the end (instantaneously)? What causes this hesitation?

What To Do

Engage:

How quick do you think you are? Could you catch a ball being thrown toward you? Could you catch a bird flying toward you?? Today, we will actually measure how quick you are.

Explore:

1. Have students form partners for the activity. Each pair should decide who is number 1 and who is 2.
2. Give each pair a ruler.
3. Instruct Student 1 to hold the ruler near the end (highest number) and let it hang down. Student 2 should put their hand at the bottom of the ruler and be ready to grab the ruler (however, they should not be touching the ruler).

There are rules!!

RULE #1

Droppers must hold the ruler so the 1 cm mark is between the Catchers' fingers.

RULE #2

Catchers can't move until they see the ruler drop.

4. Student 1 will drop the ruler and Student 2 must try to catch the ruler as fast as they can after it is dropped.
5. Record the level (in centimeters) at which they catch the ruler on the handout. Test Student 2 **three** times.
6. Swap positions so that Student 1 can test their reaction time. Student 2 will hold and drop the ruler while Student 1 tries to catch it. Repeat **three** times.

Explain:

In order to catch the ruler a lot of messages have to be passed along different nerves:

- The eye sees the ruler drop.
- The eye sends a message to the visual cortex in the brain.
- The visual cortex sends a message to the motor cortex in the brain.
- The motor cortex sends a message to the spinal cord.
- The spinal cord sends a message to the hand/finger muscle.
- The finger muscle contracts to catch the ruler.

This happens almost instantaneously. How fast it actually happens is called the **reaction time**.

If you were to compare reaction time for each hand, you would usually find that their dominant hand is faster. Because the dominant hand is used more often every day, the neurons that carry messages between that hand and the brain are faster at transmitting electrochemical signals. They are communicating along well-worn pathways. By running the same messages along the same pathway repeatedly, students can improve their motor skills. The phrase "practice makes perfect" is scientifically accurate.

Elaborate:
Go through the same test again, but this time use your other hand. Each partner should test 3 times and then compare the reaction time in these 3 tests to the reaction time in the first 3 tests.

Evaluate:

1. What is it called when we look at how fast it took for you to catch the ruler after seeing it drop? Reaction time

2. What had to happen in your body for you to catch the ruler? Signals pass from eye, brain, to muscles in hand

3. How can reaction time be improved? Practice; doing an action multiple times

4. Why was the ruler caught in the middle (after a lag period) rather than at the end (instantaneously)? What causes this hesitation? There is a delay between seeing the ruler fall and being able to catch it due to the message traveling from brain to hand muscles.