Proprioception – The Sixth Sense
Neuroscience Teaching Team

Introduction
Proprioception is your body's ability to sense movement and location. It results from sensory receptors around your body. When you move, the receptors send detailed messages to the brain about your positions and actions. Your brain processes these messages and works to create your perception of where your body is and how you are moving. In this demonstration, students will be introduced to this sixth sense and how it helps us to interact with our environment. We will use muscle "stimulators" to artificially stimulate your muscle spindles and tendons.

Materials
Quantities per student/demonstration. Multiply by expected number of students.
Nine (9) muscle stimulators (e.g. Hitachi Magic Wands or similar)

Background Information: What Is Proprioception?
1. What are your five senses? (Hint: sight, hearing, touch, taste, smell)

2. What is your sixth sense? (Hint: not anything paranormal, but proprioception or kinesthesia)

3. When you are in the dark, how do you know where your arms are?

4. Proprioception (or kinesthesia) is how your body's ability to sense movement, action, and location. It is present in every muscle movement. Without proprioception, you would not be able to move without consciously thinking about it. It allows you to walk without thinking about where to place your foot next. It lets you touch your elbow with your eyes closed.

5. Motor neurons in your spinal cord project to and control muscle fibers throughout your body.

6. Muscle spindle is a sensor within muscles that detects the length of muscles.
    a. Muscle spindles are located at each joint, wrapped around the muscle fibers
    b. Sensory neurons from muscle spindles project back to the spinal cord, bringing information about the muscle length
    c. This allows motor neurons to change muscle length accordingly
    d. The muscle-spinal cord-muscle neuronal circuit is the basis of reflexive motion
    e. This same circuit allows us the sense of kinesthesia/proprioception.

<u>Demonstration #1: What Do Muscle Spindles Do?</u>
1. Ask the students to touch their noses with their eyes closed. They should be able to do this easily with no problems. Explain that you can move your arms even without other sensory input.

2. Have a student stand or sit with their arm straight out to the side. With their eyes closed, have them move their finger towards their nose and get as close as possible without touching. They should be able to get very close.

3. Use the “muscle stimulator” to stimulate the back of their outstretched arm above the elbow (their tricep). Again, with eyes closed, have the student move their finger towards their nose and stop before touching it. Their fingers will most likely end up way out in front of their face.

4. Explain what is happening: your muscle spindles sense how long your muscles are and tell your brain

5. Repeat until all students have had a chance to try. Depending on the number of volunteers and stimulators available, you can do multiple students at once.

Discussion Questions

1. How do your muscle spindles help your brain know how to move?
    a. Muscle spindles sense how long your muscles are and tell your brain
    b. If your arm is bent (triceps = long), then muscle spindles get excited and send a message to your brain that the muscle has lengthened
    c. If your arm is extended (triceps = short), then muscle spindles are not excited and do not send any message (or a weaker message) to your brain, so it knows the muscle is shorter.
    d. Imagine your muscles as rubber bands

2. What do you think the stimulator is doing to your muscle spindles?
    a. It is exciting the muscle spindles in the triceps, telling your brain that your triceps is long and your arm is bent. Your brain thinks your arm is more bent than it really is. You “feel” that your arm is very bent and already at your nose, but really it is far away

Demonstration #2: What Happens When The Achilles Tendon Is Stimulated?

1. Introduce the scientific method to the class: make an observation, formulate a hypothesis, then test with experiment.
    a. Observation: results of first demonstration
    b. Hypothesis: what will happen if we put the stimulators behind each leg of a student while they are standing up?
        i. Which direction will they fall? (Forwards or backwards)

2. Choose four students to help. One will be the subject, one will assist with applying the second stimulator, and two will be spotters (stand in front and back to catch the subject).

3. What senses do you use to keep yourself standing upright? Eliminate them one by one so that the subject is only using proprioception. Have the student keep their eyes closed (sight), their feet together (touch), and their arms folded. Also have them tilt their head back (hearing and balance - explain that both senses are localized to the ear).

4. With the assistant, apply the stimulators to both Achilles tendons at the same time. The student will fall backwards, so make sure the spotter is ready to catch them!

5. Ask the student what it felt like and what they were thinking as they fell.

6. Repeat until all students have had a chance to try. Depending on the number of volunteers and stimulators available, you can do multiple students at once.

Discussion Questions

1. Why does the student fall backwards when the Achilles tendon is stimulated?
    a. The stimulators excite the muscle spindles in the Achilles tendon, making the brain think the muscles are longer than they really are (foot bent upwards towards leg).
    b. This makes the student feel like they are leaning forwards, so they compensate by pushing down with their toes (trying to shorten the tendon), thus falling backwards.
    c. Muscle spindles are important even for simple tasks like standing up!