Lesson Summary: Students use the Mindflex™ game to explore and measure different homeostatic autonomic nervous system functions, as they try to figure out how the game works.

Grade Level 9-12

Lesson Length
2-3 class periods

Standards Alignment

Next Generation Science Standards

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- HS-LS1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- **Framework for K-12 Science Education**: Science & Engineering Practices 3,4,6,7,8

Objectives—Students will be able to

- Develop critical thinking skills.
- Design and carry out an experiment that tests the contribution of the homeostatic autonomic nervous system functions to the signals controlling the Mindflex game.
- Understand how physiological signals can be translated into an electrical signal.

Assessment Options

- Award points for questions the students ask of each other during the lesson.
- Have students critique each others' reasoning.
- Written experimental proposal. Have students write up how they plan to test the mindset before they begin.
- Write lab report that compares what they actually did to what they intended to do and why and how the process changed.
- Evaluate the students' ability to explain what signal does or does not control the game and how that signal is captured by the apparatus. They must explicitly explain their reasoning behind how they ruled in or out the signals they considered.
- Informally assess group cooperation and ability to work together.

Teacher Notes

- Sitting still initially helps the headset to get its signal to the playing console and turn on the green light to start.
- If this does not work after several tries, place a piece of paper towel wet with salt water, saline, contact lens solution or phosphate buffered saline under the electrode and over the skin.
- Be sure hair is parted and the electrode touches skin. If students want to use the head set on backwards with the electrode over hair and scalp, part the hair and add the salty wet paper towel piece under the electrode.
- Wearing the headset more than 5-10 minutes may result in a headache as the metal sensor digs into the forehead.
- When trying to control the ball, there is a noticeable 2-5 second lag in response time. This is most likely due to the long sampling time required to measure such a low frequency signal. Students can discover this by getting the ball high in the air and then rapidly taking off the headset. The ball stays in the air for a measurable time.
- Multiple Mindflexes have trouble working in the same room. Student groups may have to work outdoors or at ends of corridors. Units need to be greater than 30 feet apart to keep their signals uncrossed.

Materials

- enough MindFlex™ games for students to be able to work in groups of 3-7
- web access or textbooks for reference material

Procedure

Engage

1. In front of the class, have a student put on the MindFlex™ headset and move the ball. Assure the class that they each will get an opportunity to use the unit.

2. Then have the class brainstorm and discuss ideas about how the headset may work to control how high the ball moves. Even though the product website claims it works one way, there are many other physiological signals that could be contributing to the headset signal. These include, but are not limited to:

Heart beat	EEG
Pupil dilation	Sweating
Galvanic skin response	Muscle tension (forehead wrinkling, ear wiggling)
Eye movements	Concentration
Blinking	Breathing

3. Have students figure out how the signal is used to control the ball once the headset detects the signal. This can be done together as a class or left to the groups as part of their work assignment.

Explore

1. Assure the class that each group will get a Mindflex to play with and use once they have initially designed an experiment to test one of the possibilities in the potential list.
2. Have each group design an experiment to find out what physiological signals are measured and how that signal controls ball movement.
3. Have groups report out their experimental strategy.
4. Engage students in challenging, constructive and critical evaluation of the strategies. “How are you going to do xyz?” “If you do abc, will that really measure what you want?” All questions don’t have to get answered, just thought about as strategies get revised.
5. At some point, students may decide they need to interact with the Mindflex to flush out their experimental designs. Now distribute the Mindflexes to each group. Have each group explore and see what they can get the units to do on their own. Have students use the “freestlye” game mode and only attempt one obstacle due to time constraints. Possible manipulations: Level of concentration, placement of the headband, eyes open/closed, looking at the console or away, etc. Does the ball still move when you remove the headband?
6. Have groups revise the experimental designs by next class period.
7. Once experimental designs are completed, let groups execute their experiments, collect and analyze data and interpret what these data mean.

Explain

1. Present experimental results to the whole group.
2. After each presentation, class discusses how the experiment could be made more successful.
3. At end of all presentations, class votes on which explanation is most believable and discusses why one explanation is more convincing than another.

Evaluate

1. Have students submit a formal lab report of their experiment.
2. Assess student understanding as presentations occur.

What is the scientific explanation of what going on with the Mindflex game?

1. According to the manufacturer, the physiological signal used by the Mindflex headset is EEG.
2. The core of the Mindflex game is a simplified one lead EEG sensor that is designed to read the amplitude of electrical discharges of neurons in the frontal lobe that are synchronized to in the 3-8 hertz Theta range. Recent studies using much more complex and accurate EEG machines and PET scans have shown that the power and amplitude of the discharges in the theta measured on the middle of the forehead is negatively correlated to the resting state or 'default mode'. It was also found that working memory tasks increase Theta rhythm discharges measured in that region.
3. Once the Mindflex headset recognizes brainwaves or some other low frequency signal, it transmits a signal to a fan within the console using wireless technologies. The strength of the signal coming from the headset, in turn, control the speed of the fan. The fan speed controls ball levitation. The stronger the fan blows, the higher the ball floats. According to the manufacturer, the more you concentrate, the stronger the Theta wave signal and the higher the ball is elevated by the console fan. Relaxing your mind relaxes the fan's airflow, which lowers the ball.

Wikipedia entry for EEG http://en.wikipedia.org/wiki/Electroencephalography (reviewed for science content)

Read about how to measure one's own EEG in the article Measuring Brain Waves in the Classroom by van Attevelt et al in Frontiers for Young Minds 2020, https://kids.frontiersin.org/articles/10.3389/frym.2020.00096.