Berkeley Engineers and Mentors

The Sixth Sense(s)

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Field(s) of Interest: Psychology, Cognitive Science, Anatomy

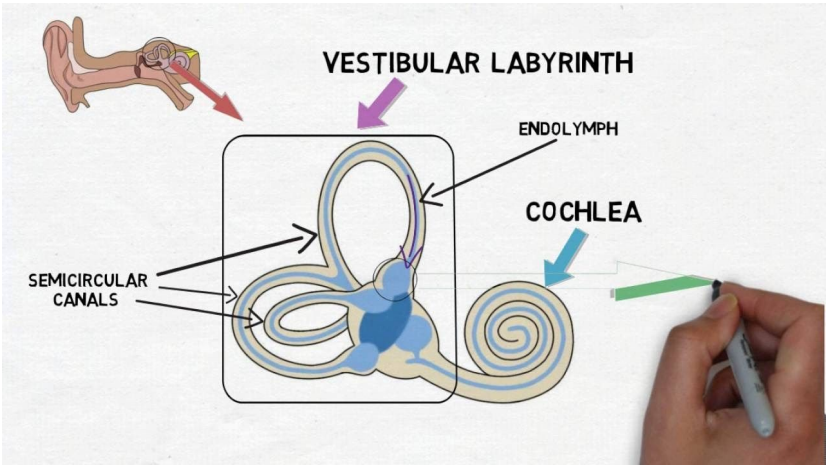
Brief Overview:
In this lesson, the mentees will be learning about the more mysterious human senses, such as the sense of time, balance, and temperature. Through a series of demos and interactive activities, we aim to help mentees further understand the amazing capabilities of their bodies.

Agenda:

- Introduction (5 min)
- Module 1: Sense of Balance / Vestibular System (15 min)
- Module 2: Sense of Time (10 min)
- Module 3: Sense of Temperature (10 min)
- Conclusion (5 min)

Teaching Goals/Key Terms:	**Mentor Development Goals:**
➔ **Sense**: A person's capacity to react to an external or internal change ➔ **Vestibular System**: A part of the inner ear that is responsible for providing our brain with information about motion and balance ➔ **Heat**: A form of energy arising from the random motion of the tiny molecules that make up an object ➔ **Temperature**: A measure of hot and cold, or a measure of the amount of heat ➔ **Time Perception**: A person's unique understanding of the duration of events based on their past experience and other factors.	

Background for Mentors - Module 1

Module 1 ● Vestibular System ● Acceleration ● Motion Sickness	**Sense of Balance** When your body is in motion, it needs another system besides vision to help coordinate its movement and maintain its balance. The vestibular system does just that; it is an intricate part of the inner ear that is responsible for providing our brain with information about balance and spatial orientation. The vestibular system comprises two components, the **semi-circular canals** and the **otoliths**, which indicate rotational movements and linear accelerations respectively. When the head is rotating, the fluids in the semicircular canals (**endolymph**) flow according to the rotation and send electrical signals to the brain. *Note that there are 3 semicircular canals, as each is responsible for the rotation in one dimension.* The otoliths (**blue circles**) use a very similar mechanism to detect linear acceleration, but it uses tiny calcium carbonate crystals instead of endolymph.  **Figure 1:** an diagram of the vestibular system Once the brain receives any signals, it diverts them to neural structures that control eye movement and stabilise vision. Muscles around the body also receive these signals to keep humans upright and maintain a good posture in general. Learn more: https://www.youtube.com/watch?v=P3aYqxGesqs

Background for Mentors - Module 2

Module 2 ● Time ● Time Perception	**Sense of Time** Time perception is the subjective experience of time, which is measured by the duration of indefinite and unfolding events. In simpler terms, time perception is how fast a person thinks time is elapsing. The study of time perception spans several disciplines, such as philosophy, neuroscience, ecology and physiology. We will mostly focus on the neuroscientific and physiological aspects. Unlike the vestibular sense, time perception does not rely on a single dedicated sensory organ. Instead, it is a complicated system that involves multiple parts of the brain (cerebral cortex, cerebellum, and basal ganglia). In general, timekeeping can be divided into two types: **circadian** (daily) rhythm and **ultradian** (short) rhythm. Different parts of the brain are responsible for each of these two rhythms, working together to complete our sense of time. Interestingly, time perception varies greatly between species. For example, compared to humans, a day might feel much longer for a hare and much shorter for a tortoise. Children also experience longer days than adults in general, since their “one day” is a smaller portion of their life than that of adults. Finally, there are many external factors that can temporarily affect one’s time perception. Emotions, like awe and fear, are known to slow down time while in cold body temperature and depressants can accelerate time. Learn more: https://www.youtube.com/watch?v=alx2N-viNwY  **Figure 2:** a hare and a tortoise

Background for Mentors - Module 3

Module 3

- Heat
- Temperature
- Thermoreceptor
- Heat Conduction
- Conductivity

Thermoception, by definition, is the ability to detect temperature changes caused by heat conduction. In humans, this ability is mostly carried out by thermoreceptors, which are located in many organs like skin, cornea, and even the bladder. Thermoreceptors include **cold** and **hot** receptors, which are each further divided into **low-** and **high-threshold receptors**. Low-threshold receptors operate mostly in temperatures between 15°C (59°F) and 45°C (113°F). Since this region is mostly innocuous to the human body, these receptors are able to be more sensitive to changes in temperature. The high-threshold receptors, on the other hand, operate in temperatures outside of the innocuous region. *It signals temperature changes in the form of pain, which explains why humans can't really sense temperature changes in very hot or very cold environments.* Thermoception protects humans against unfavourable environments and danger that others senses can not foresee (sunburn, frostbite, dehydration).

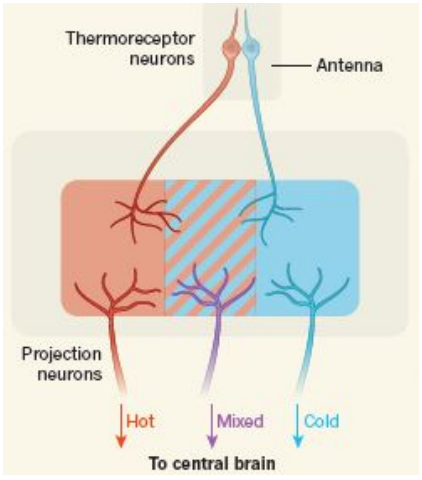


Figure 3: the system that involves cold

To better understand temperature, it might be important to talk about heat and heat conduction. Heat is a form of energy arising from the random motion of the tiny molecules that constitute an object; heat conduction is the transfer of heat via these tiny molecules. Naturally, heat flows from an area of high temperature to an area of low temperature. For example, ice will take heat away from your finger, giving it a cold sensation because ice is **changing** the temperature of your finger. I highly recommend watching the first 8 minutes of the following video for a more detailed explanation.

Learn more: https://www.youtube.com/watch?v=W96CpefSxoQ

Introduction

Sensation, or senses, is the physical process during which the sensory nervous system responds to stimuli and provides data for perception. In general, senses can be divided into **external** and **internal**, which correspond to the types of stimuli they react to. Sensation is an important concept to understand because it is the most rudimentary faculty that every living organism has. Senses monitor and regulate our daily activities, allowing us to optimise our behaviour and preventing us from danger. Therefore, by understanding our own senses, we capitalise on this powerful capability and use it to our advantage.

Many of us have learned that humans have five basic senses, which include vision, hearing, touch, smell, and taste. However, there are many other senses that are responsible for the normal functioning of our human body. Since sensation is a rather commonplace phenomenon, it is quite relatable even to children. To introduce this lesson, mentors can simply ask mentees about their experience with senses so far. They will likely mention the five basic senses and mentors can continue the lesson from there.

<table>
<tr>
<td>Concepts to Introduce
Sense: A person's capacity to react to an external or internal change
Mentors can explain this teaching goal by asking a few of the questions mentioned below
Sensory Nervous System: A part of the nervous system responsible for collecting and processing signals from sensory organs like ears, nose, mouth, and eyes.
The sensory nervous system is like the roads that connect your house (the brain) and other places (sensory organs) where signals (people) are transmitted.</td>
<td>Current or Past Events
Studies on sensation can be traced back to early civilisations. Many senses are better understood with more research on human anatomy and cognitive science.
Currently, many companies are working to build robots that mimic human senses like sight, touch and sound. However, these robots also have the capacity to implement nonhuman senses like detecting infrared light, magnetic fields, and global positioning.</td>
</tr>
<tr>
<td>Questions to Pique Interest
What are the five basic human senses? (sight, hearing, touch, smell, taste)
When do you use these senses in your daily lives?
Can you think of any other senses that you have? (pain, hunger, time, temperature, balance, stretch, suffocation)</td>
<td>Inspiring Scientists, Careers, Applications
Cognitive science is the study of the mind and mental processes.
On February 14, 2013, researchers developed a neural implant that gives rats the ability to sense infrared light. This feat marks the first time living creatures can gain new abilities instead of simply replacing or augmenting existing abilities.</td>
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Module 1: Sense of Balance / Vestibular System

This module introduces and explains our vestibular system, which coordinates our sense of motion and balance. The mentees will be learning the vestibular system through a few demos.

Teaching Goals	**Materials**
1. **Vestibular System:** A part of the inner ear that is responsible for providing our brain with information about motion and balance 2. **Acceleration:** An increase in speed or a change in an object's motion 3. **Motion Sickness:** Discomfort results from a disagreement between vision and the sense of balance **MD Goals** *Hi MD!*	• Cup • Water • Food Dye (mentors only)

Procedure

1. Prepare a glass of water that is roughly ⅓ full.
2. Add a few drops of food colouring for demonstration purposes (optional but recommended).
3. Gently move the cup in many ways (rotate, shake, accelerate) and ask the mentees to observe the resulting behaviour of the water.
4. Display or draw a picture of the vestibular system as shown in Figure 3.
5. Explain the components of the vestibular system by drawing an **analogy** to the water demo. For example, the mentees can picture the vestibular system having many of these "glasses" full of water. Whenever your head moves, the water inside these cups will also move accordingly. By sensing the movement of these liquids, your body can therefore understand how it's moving.
6. **Optional**: cut out three thin strips from a piece of paper. For each of the strips, attach one end to the other with tape. Then, orient the three loops so that each loop occupies a distinct plane. The structure of these three loops is

Figure 4: A glass of water in motion

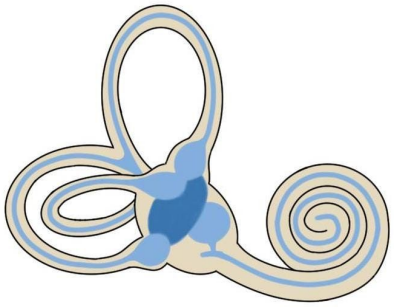

Figure 5: Vestibular System without labels

similar to the semicircular canals in the vestibular labyrinth, where each canal is responsible for movement in one cartesian direction.

7. **Activity**: Have the mentees find an open area inside or outside their house. Ask them to close their eyes and slowly spin in place for 5-10 times.
8. Then ask the mentees to try to walk around, **make sure to emphasise that they shouldn't be running**.
9. Ask the mentees about how they feel. They will likely struggle to walk straight. That is because their vision is sending signals that conflict with their vestibular sense. More specifically, their vision thinks they are stationary while their vestibular system thinks they are still rotating.

Classroom Notes

Make sure to confirm that each mentee has sufficient space to do our activity.

Module 2: Sense of Time

This module introduces our time perception, which is our unique ability to determine the duration of a particular event. The mentees will be learning how this ability can be affected by external factors though an interactive demo.

Teaching Goals	**Materials**
1. **Time:** The ongoing sequence of events taking place, including the present, the past, and the future 2. **Time Perception:** A person's unique understanding of the duration of events based on their past experience and external factors. **MD Goals** *Hi MD!*	• None

Procedure

1. Introduce the concept of time. This is a very abstract topic and there is no wrong definition, so feel free to give your own take.
2. Explain our time perception, which is how fast a person thinks time is elapsing.
3. **Activity:** Display a stopwatch on the screen.
4. Tell the mentees to close their eyes and start the timer on the screen.
5. Ask the mentees to open their eyes when they think 60 seconds have elapsed and record the actual time. Make sure to not stop the timer at the 60 seconds mark because some mentees might underestimate instead.
6. Now, repeat the experiment, but ask the mentees to do something exciting or enjoyable (sing, play music, snack) for 60 seconds instead of closing their eyes.
7. Ask the mentees to compare the results from the two trials. Hopefully there will be a difference between the two recorded times.
8. Explain to the mentees that there are different factors that can influence a person's perception of time. For example, emotions, like excitement, can seemingly make time go faster.

Figure 6: a stopwatch

Module 3: Sense of Temperature

This module introduces our thermoception, which is the ability to detect a change in temperature. Mentees will be learning about how this ability is connected to heat through an interactive activity.

Teaching Goals	**Materials**
1. **Heat**: A form of energy arising from the random motion of the tiny molecules that make up an object 2. **Temperature**: A measure of hot and cold, or a measure of the amount of heat 3. **Thermoreceptors**: Specialized nerve cells that are able to detect differences in temperature. 4. **Thermal Conduction:** Transfer of heat via collisions of tiny molecules, either inside an object or between two touching objects 5. **Thermal Conductivity**: The rate at which heat passes through a specified material. **MD Goals** *Hi MD!*	• None

Procedure

1. Introduce the teaching goals of heat, temperature, and thermoreceptors.
2. Introduce the concept of heat conduction and conductivity.
3. **Activity:** Set a timer for 2 minutes, challenge the mentee to find the “coldest” object they can find in the house. The thing cannot be stored in the fridge and mentees should use their own **thermoception** to determine which thing is colder. Some examples include metal spoons, ceramic cups or glass vases. No Ice! If something is painful to touch, it is probably ineligible.
4. If there are mentors Zooming in live, invite the mentees to share the object they found.
5. **Important**: In reality, the heat fluxes inside an enclosed room should be well equilibrated, and all objects should therefore have the **same temperature**. What thermoception

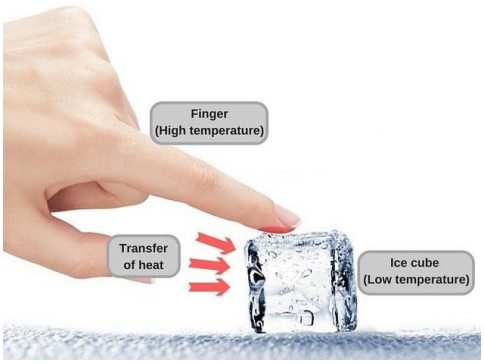

Figure 7: Heat Conduction between the finer (hot) and ice

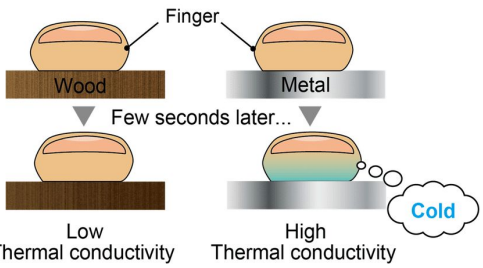

Figure 8: How your thermoception perceives object with high and low thermal conductivity

measures is not temperature itself, but is actually the **change** in temperature of your skin, which depends on the conductivity of the material. In short, **the "coldest" object is in fact the most conductive object.**

6. To further demonstrate this concept, ask the mentees to hold their object for at least 30 seconds. The object should begin to feel warmer because of two reasons. **1)** After the initial shock, the cold receptors on your finger are slowly adapting to the new temperature by sending less signals to the brain. **2)** Your finger is giving heat to the object, which warms it up over time.

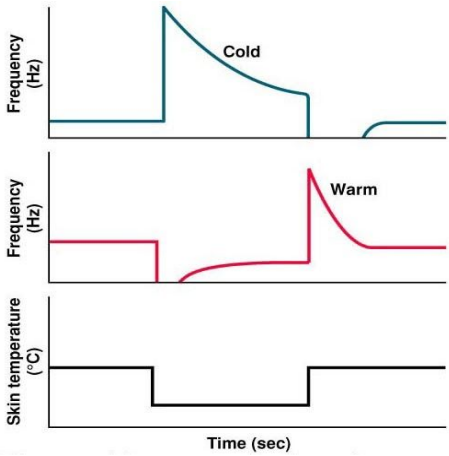

Figure 9: Response signals of hot and cold receptors when skin is placed in cold and warm water sequentially.

Classroom Notes

In general, household items are generally pretty safe to touch for an extended period of time. However, make sure to tell the mentees to let go of an object if they begin to sense pain.

Conclusion

To wrap up the lesson, have a discussion with the kids! Talk about the incredible things that our bodies are capable of doing, and ask them what new facts they learned about their body from the lesson. Feel free to briefly talk about other senses you find interesting, but make sure to explain how they benefit our daily lives.

References

- 2-Minute Neuroscience: Vestibular System, Neuroscientifically Challenged. https://www.youtube.com/watch?v=P3aYqxGesqs
- Temperature Perception Experiment, University of Minnesota. https://www.d.umn.edu/~jfitzake/Lectures/UndergradPharmacy/SensoryPhysiology/Somatosensation/TempPerceptionExp.html
- Time Perception, Wikipedia. https://en.wikipedia.org/wiki/Time_perception

Summary Materials Table

	Amount per Site	**Expected $$**	**Vendor (or online link)**
Clear Cup	1 per student	-	-
Water	-	-	-
(Food Dye)	1 per site	-	-