Lesson 3: How does the environment affect perception?

I. Overview
Students continue to explore factors that affect perception, moving from biological factors to social and physical environments. Students view and discuss a video clip about scientists investigating the effects of language on color perception. Next, in a hands-on activity, students collect and analyze data on how different colored lights affect perception and behaviors like the selection of red candies. Students practice visualizing and analyzing their data in graphs as part of the activity, and collect evidence for revising their model throughout the lesson.

Connections to the driving question
In Lesson 1, students built a model of color perception and subsequent lessons explore light and sight in order to gain evidence with which to revise their models. This lesson includes evidence such as research on how language affects color perception and data and graphs from the colorful candy activity. Throughout the lesson, students collect this evidence on environmental influences of color perception, which they include in their revised model in Lesson 5.

II. Standards

National Science Education Standards
- Abilities necessary to do scientific inquiry. Design and conduct scientific investigations (9-12 A: 2/1)
- Abilities necessary to do scientific inquiry. Use technology and mathematics to improve investigations and communications (9-12 A: 3/1)
- Understandings about scientific inquiry. Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results. (9-12 A: 4/2)

Benchmarks for Science Literacy
- Cultural Effects on Behavior: Differences in the behavior of individuals arise from the interaction of heredity, culture, and experience—the effect of each depends on the other. (7A/H4)
- Scientific Inquiry: Bias attributable to the investigator, the sample, the method, or the instrument may not be completely avoidable in every instance, but scientists want to know the possible sources of bias and how bias is likely to influence evidence. (1B/H10)
- Mathematics, Science, and Technology: Mathematics is useful in business, industry, music, historical scholarship, politics, sports, medicine, agriculture, engineering, and the social and natural sciences. (2B/H6)
- Mathematical Inquiry: To be able to use and interpret mathematics well, it is necessary to be concerned with more than the mathematical validity of abstract operations and to take into account how well they correspond to the properties of the things represented. (2C/H3)

### III. Learning Objectives

<table>
<thead>
<tr>
<th>Learning Goals</th>
<th>Assessment Criteria</th>
<th>Location in Lesson</th>
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<tbody>
<tr>
<td>Experience how the environment affects visual perception</td>
<td>Students can describe their experiences and use evidence from the data (graphs). Viewing colors under non-white light changes how colors are perceived.</td>
<td>Colorful Candies student sheet</td>
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<td>Think critically about data analysis and measurement</td>
<td>Students can describe specific examples of how other scientists (in BBC Horizon video clip) or they themselves measured changes in “perception” (i.e. through behavior)</td>
<td>Language and color video discussion, Colorful Candies student sheet</td>
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<tr>
<td>Demonstrate the ability to accurately record data in a table</td>
<td>Students fill out their tables completely and clearly, and their data is consistent within and across groups.</td>
<td>During Colorful Candies activity, student sheet</td>
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<tr>
<td>Use mathematical and computational thinking to analyze raw data</td>
<td>Students accurately complete the calculations of percent accuracies and averages. Furthermore, they can accurately interpret the mathematical equations (Pre-Data Collection Questions).</td>
<td>Colorful Candies student sheet</td>
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<tr>
<td>Gain skills in representing data as graphs</td>
<td>Students make complete graphs with clear titles, axes, and labels with accurate data</td>
<td>Colorful Candies student sheet</td>
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<tr>
<td>Practice collecting evidence</td>
<td>Students collect and describe several pieces of evidence related to the perception of color</td>
<td>Throughout lesson, lab notebooks</td>
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### IV. Adaptations/Accommodations

Encourage students who find it difficult to quickly perform tasks such as sorting candies to participate in this activity. One adaptation is to allow additional time for students who may need it. The learning goal is to allow students to test how their own perceptions impact their behavior. Place enough cups of candies at each station for every student to have a fair chance at participating in the activity. Similarly, each student could be assigned a different task for each station (e.g. data recorder, timer, sorter, etc.) so experience with each component is gained across the lesson.

To encourage advanced practicing of mathematical practices, the Student Sheet can be modified so that instead of just using the equations as they are given, students must propose their own calculations and justify their reasons for using averages, etc.
Safety
Remind students to handle the lamps and bulbs carefully. The bulbs are fragile (like all glass objects) and become hot after being on for a length of time. Fluorescent light bulbs also contain trace amounts of mercury and should be disposed of properly.

V. Timeframe for lesson

Opening of Lesson
• Introduce investigation by referring to models – 5 minutes

Main Part of Lesson
• Activity 1: Language and color (BBC Horizon) video – 10 minutes
• Activity 2: Colorful candy sorting – 45 minutes (allow students to complete the graphing questions as homework if necessary)

Conclusion of Lesson
• Discuss/collection evidence for revising model of color perception – 5 minutes

VI. Advance prep and materials

Activity 1: BBC Horizon video

Materials
• If needed, a transcript of the video is available (U1_L1_Resource_LanguageAndColorVideoTranscript.docx)
• BBC Horizon clip from episode “Do you see what I see?” (2011)
  o http://www.bbc.co.uk/programmes/b013c8tb

Preparations
• Print the transcript for students who may need it
• If planning to play the video in class, ensure the necessary technology is working

Activity 2: Colorful candies

Materials
• Large bag of colorful candies
• Four white paper plates
• Four paper cups at each light station
• ½ cup measuring cup
• Four desk lamps
• Four different colored light bulbs (green, red, blue, standard white)
  o Compact Fluorescent bulbs work best for this activity
Use normal overhead lighting in place of a station with white light if another color light (yellow, orange, black) is being used at a station.

If normal overhead lighting is being used for white light, have all the stations perform the candy sorting using white light at the start of the activity.

- Four stopwatches
- Four flashlights
- Student sheets (U1_L3_StudentSheet_ColorfulCandies.docx)

**Preparation**

Setup four stations each with:

- One desk lamp (each station with a different colored bulb installed)
- One paper plate placed so that the desk lamp shines directly onto it
- Four paper cups labeled A, B, C, and D, each with ~1/2 cup of candies inside
- Stopwatch and flashlight

**Homework and Assessment**

- Completing the Student Sheet, if necessary
- “Light Video (Part 1): What are Color and Light?” video From Lesson 4

**VII. Resources and references**

**Resources**

- The materials for this lesson can be downloaded for free from the Project NEURON website: http://neuron.illinois.edu/do-you-see-what-i-see/lesson-3

**References**
VIII. Lesson Implementation:

Opening of the lesson:
If student color perception models are visible in the classroom, point out some factors of the environment that may have been included. If students generated questions related to color perception and the environment, culture, language, society, etc., revisit them now and tell students they will be continuing their investigation of what affects color perception.

Main part of the lesson:

Activity 1: Language and color (BBC Horizon) video clip
If students did not watch the video as homework, show the video in class. The video clip, extracted from the BBC Horizon episode “Do you see what I see?” is about 7 minutes in length.

The clip discusses how scientists have found evidence that language and culture may affect how the brain processes and interprets color. It includes references to research on children before and after language acquisition and color perception in cultural groups such as the Himba tribe in Northern Namibia in Africa.

Some questions for discussion include

- Would you consider language as part of our environment? Why or why not?
- What problems may the scientists have come across while studying language and color perception? How did the scientists work around this?
  - Anna used eye-tracking software to try to understand how a child processed color categories before language acquisition. The scientist in Namibia used a translator to talk with tribe members about language. It may be difficult to know if these tools are actually accurate in what they are measuring or portraying.
- How did the scientists measure “color perception?”
  - Since there is no way (yet?) to actually observe what someone else is seeing, the scientists measured particular behaviors or time spent doing a task. This is an important consideration, since students may struggle with this is the Colorful candies activity.

Tell students they will be doing their own investigation of environment and color perception, except investigating the physical environment instead of the social environment.

Activity 2: Colorful candies
Tell the students that during the activity, they will move between four stations where they will sort candies under different colored light sources in an otherwise dark room. Hand out the student worksheet that describes the process and provides additional questions for students to answer (U1_L3_StudentSheet_ColorfulCandies.docx).

Give students some time to complete the pre-data collection questions, so they can think critically about the activity before beginning. (As a teacher guide, suggested answers are included in the Answer Sheet.)
After students are finished, assign them to groups of four for each of the four stations. (In larger classes, duplicate stations to maintain group sizes). Turn off ceiling lights or draw blinds to minimize additional light in the room.

Demonstrate the following protocol to students:

Each station has several cups of candies, a light source (white, red, green, or blue), timer, flashlight and a plate. At each station, one student will pour a cup of candies onto the plate at the same time another student starts the stopwatch. The first student will attempt to remove all of the red candies as quickly as possible. Stop the stopwatch when the sorter believes that all of the red candies have been identified. The timer will be responsible for recording the time that the sorter takes. (Sorting and timing should begin immediately after the candies are poured out so that the candies cannot be studied beforehand).

After the time is recorded, the group will use the flashlight to check if the sorter accurately performed the task. Alternatively, turn on the overhead lights after each attempt to allow students to record their data without the need for flashlights; however, this requires that every group be finished with the task. Data on the number of different candy counted need to be recorded in the table provided (see student sheet, U1_L3_StudentSheet_ColorfulCandies.docx).

The next student in the group will then do the same procedure, except they will sort a different cup of candies. After each student has performed the candy activity at the station with cups A–D, the groups rotate to the next station.

Students will record their data on the accompanying sheet. After rotating through the stations, the students will analyze how the different colored lights (or the environment) impacted their ability to perform the task in this activity in comparison to the control group (white light).

**Procedure in brief:**

1. Pick up cup #1 and pour the contents onto the paper plate positioned underneath the lamp.
2. Immediately start the stopwatch and begin removing all of the red candies, placing them back into the cup (refrain from looking at the candies in the cup at this time).
3. After you believe you have removed all the red candies, stop the stopwatch.
4. Pour the removed candies onto the table.
5. Use the flashlight to check the color of the candies (or wait for overhead lights to come on).
6. Record the time, # of red removed, # of non-red removed, total removed, and total red in the tables below for each station. (Be sure to record data in the table matching the station).
7. Repeat steps 1-6 for cups 2, 3, and 4 with a different group member for each cup.
8. Follow directions below the table and answer any questions.
9. Move on to the next station and repeat all steps.

Note: It is important that the data collected be recorded in the correct row as data will be compared
across groups and each group will use the same cups of candies. Because of this, it is also important that candies not be eaten!—the same number and color distribution of candies needs to be in the cups for each group otherwise the data collected will be inconsistent.

Allow students to move to the stations and start the activity, recording data in their sheets as they go. Allow enough time in class for students to finish recording their data during class. If time remains, students can work on the data visualization sections for the remainder of class or continue working on it at home.

Before the class is over, it may be helpful to bring the class together to share general observations as they start their data analysis. Ask the students to consider these questions while completing the worksheet:

- Which station posed the most/least difficulty?
- Did you notice any patterns in the time it took to complete the task between stations?
- Did they notice any patterns or trends within each station?
- Did you progressively get better at each station?
- Did you have to adjust your behavior to perform the task accurately? How?

Scientific Practices: Analyzing and interpreting data
Once data is collected, scientists must organize, interpret, and analyze the data through tools such as graphing, tabulating, and statistical analysis. They must then present and explain their findings. After their investigation and data collection, students will be guided through this process of analysis and explanation as they are prompted to graph the data and explain and answer questions about their findings.

When students have completed collecting data and have started, or attempted to, analyze their data, bring the class together for a discussion about their results and conclusions. Data analysis can be difficult and tricky, and encouraging students to learn from each other and compare results can benefit their learning. Allow students time and space to wrestle with the data themselves, instead of providing answers.

Reviewing the student sheet and the driving questions will be beneficial for making meaning from their investigation of the colorful candies:

- What is the effect of the environment on color perception?
- How do colored lights affect the average selection accuracy and average completion accuracy?
- Do colored lights affect the average time spent in separating red candies from other candies?
- Did cup order affect the results?
**Conclusion of Lesson**

Conclude the lesson by revisiting what students did to investigate the eye and how biology can affect color perception. Ask students to suggest pieces of evidence they can include in their models later when they are revised, or give students time to record these pieces of evidence in their lab notebooks.

Tell students that they will continue their investigations in the next lesson by investigating the mechanisms behind light and how it interacts with the environment. For homework, students may watch “Light Video (Part 1): What are Color and Light?” (see Lesson 4), unless it will be watched in class as the opening for Lesson 4.

<table>
<thead>
<tr>
<th>Scientific Practice: Using mathematics and computational thinking</th>
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<tbody>
<tr>
<td>Mathematics and computational tools are an integral part of science. In this activity students’ attention is drawn to this concept as they make process the raw data they collect during the Colorful Candies activity. Students are prompted to calculate averages and percent accuracies. Advanced students can be expected to propose their own calculations and justify their reasons for doing so (see Section IV Adaptations and Accommodations).</td>
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**Assessment**

Assessments of learning goals is achieved through class discussion, completion of the student sheet for the Colorful Candies activity, and evidence collected for students’ perception of color model.