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Welcome to the Bio-Coding Club curriculum. The goal of this curriculum is to give educators all the tools needed to run successful student-driven coding projects related to biology – and to boost student interest in STEM by making science fun.

The Broad Institute created the Bio-Coding Club, in collaboration with Putnam Avenue Upper School in Cambridge, Massachusetts, as an after-school program for students in grades 6-8. The club met weekly for 75 minutes. A team of professional scientists, all volunteers from the Broad Institute, served as mentors. Club meetings generally started with a snack and a discussion of a biology topic. Students then took part in a hands-on activity before moving on to practice coding with Scratch (scratch.mit.edu).

This module, curated by the Broad Institute’s Office of STEM Engagement and Inclusion, consists of 7+ lessons about neuroscience. The lessons you’ll find here are suggestions; they can be modified to fit your program’s resources and students.

To download additional Bio-Coding Club modules, visit broad.io/biocodingcurriculum.

The following table shows the suggested curriculum order, but sticking to this order is not strictly necessary.

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Middle school students love learning about themselves, and the Bio-Coding Club’s Neuroscience Unit gladly taps into that enthusiasm. This unit stimulates interest in how the human brain works through seven fun, hands-on activities and the Scratch projects linked to them. Students will learn about neurons, explore the link between vision and taste, use their “sixth” sense, practice categorizing personalities along the “Big 5” dimensions, test their memory, and tease their brains with optical illusions.

Each week’s hands-on topic is paired with a Scratch project that can be personalized and made more complex as time or interest allows. The suggested projects come with a printable Scratch card that allows students to work independently on their projects or take things in an entirely new direction. By the end of the Neuroscience Unit, students will reach a deeper understanding of the quirks of their brains, and be able to share some of those quirks with friends and family through the Scratch projects they have created.

NEXT GENERATION SCIENCE STANDARDS

- **MS-LS1-1**: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- **MS-LS1-2**: Develop and use a model to describe the function of a cell as a whole and ways the 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.
- **MS-LS1-8**: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
Objective

SWBAT build a model of a neuron and identify its major components.

SWBAT make sprites of neurons in Scratch and code movement and costume changes into them.

Vocabulary

- **Neurons**: nerve cells that receive, interpret, and pass on information. Five parts of the neuron are:
  - **Cell body**: contains the nucleus and much of the cell’s cytoplasm
  - **Nucleus**: the structure that contains the cell’s chromosomes and controls the cell’s activities
  - **Cytoplasm**: the jelly-like liquid that fills cells
  - **Dendrites**: receive signals from other neurons and carry them to the cell body
  - **Axon**: the long fiber that takes information away from the cell body
- **Neurotransmitters**: chemical messengers used for signaling between neurons

Framing Question

What would physical and digital models of a neuron look like?

Materials

- Supplies to build a model of a neuron. If time allows, you can pre-sort all the materials onto individual plates that students can use at the appropriate time. There are many possible ways to do this activity (using edible and non-edible materials); one possibility (illustrated in Fig. 1 below) includes:
  - Sugar cookie (cell body)
  - Frosting (cytoplasm)
  - Solid chocolate (nucleus)
  - Twizzlers Pull-N-Peel (full-size for axon and cut pieces/snack-size for dendrites)
  - Candy conversation hearts (neurotransmitters)
- Neuroscience 1 Scratch card (p. 7)
- Computer for each student
Plan/Activities

1. Preview
   • If you are starting a new semester of the Club, describe the format of the Club and make introductions. Segue into the theme of the unit by waving to any new students. You can then explain:
     “When I wave at you, and you wave back at me, we are using neurons. Neurons are found in our brains and spinal cords. When I want my hand to wave, neurons transmit a signal from my brain to my fingers. Neurons have a unique shape that makes them excellent at sending and receiving messages. We’re now going to model a neuron’s shape out of candy.”
   • Pass out the supplies for the activity.

2. Assemble the Neuron Cookie Model
   • If your group is small enough, you can build a model along with the students. Or, you can take pictures beforehand as you build a prototype, and then create a how-to slide presentation. As the students build, explain that:
     1. The cookie is the **cell body**, the main part of the cell.
     2. The frosting is the **cytoplasm**, the jelly-like substance that fills cells.
     3. The chocolate candy is the **nucleus**, where the DNA of the cell is stored. Instructions for how to build and operate a cell are written in each cell’s DNA.
     4. The large twisted licorice piece is the cell’s **axon**. The axon is a long cable that carries messages from the neuron to other neurons or cells such as the muscle cells in your waving hand.
     5. The partially unwound ends of the licorice are the **axon terminals**. These axon terminals connect with other cells to communicate with them.
     6. The smaller licorice pieces are the **dendrites**. They receive messages from the other cells.
     7. The conversation hearts are the **neurotransmitters**, the chemical messages that neurons send to each other. You can put them around the dendrites and axon terminals.

![Image of neuron model](image1.png)

**Figure 1. Examples of edible neuron models.**

• Yes! Students may eat the cookies after they’re done and pictures have been taken.
Scratch Activity: Neuron Blaster Game Part 1

• Students will be building the first part of a two-part game with neurons and neurotransmitters. The example program for today is here: https://scratch.mit.edu/projects/557599443/. The completed game is here: https://scratch.mit.edu/projects/557599496/.

• Show students what the game will look like when completed next week. The game requires students to draw or import a simple neuron and neurotransmitters. They can then code the main neuron to follow the mouse and code costume changes into other neurons.

• Have each student grab a computer and sign into Scratch. Instructions for logging in new students can be found on p. 6.

• Pass out the Neuroscience 1 Scratch card to each student.

• Check in with students on their progress as they code.

How will you determine if students met the objective?

Students should successfully make a neuron cookie, and make a neuron sprite in Scratch that points towards their mouse.

Facilitator Tips

• Before making the cookie neuron, double-check to make sure students don’t have an allergy to any of the products. Some types of candy have gelatin, which many students don’t eat.

• Remind students that they should not eat their cookie until they have completed their model.

• Students may want to take a long time to draw their neurons in Scratch. Remind them that they can always add details later.
At least two days before the lesson:
Sign up for a Scratch teacher account at https://scratch.mit.edu/educators/register. With a teacher account, you can easily reset student passwords and collate student projects. Pick a short username that is easy to type, because your username will be the default password for your students.

Select My Classes near the top of the screen and then + New Class to add a class for your students. You can also create specific studios for students to share their work in.

Sign Up a New Student (when students want to pick their own usernames)
1. Sign into your teacher account and select My Classes. (More than one person can sign into the teacher account at the same time, so using multiple facilitators can speed this process.)
2. Under your chosen class, click the blue Students (n). The number (n) will show the number of students signed up so far.
3. Click + New Student.
4. Add the student’s new username to the class. The username should be unique (it will be rejected if it isn’t), and it shouldn’t be the student’s actual name or have other identifying info.
5. The student should then go to https://scratch.mit.edu/ and sign in with their username. Their default password will be your teacher account name. (Note: Your account name, not your password.) They will be asked to choose a new password and answer some basic questions as they register. (You can reset their password to your teacher account name anytime they need it.)
6. Once registered, the student should click the My Stuff file in the blue bar.
7. The student can click + New Project to start their first activity.
8. Once done, they should give their project a title in the light blue box at top, click Save Now, and click Share.
9. If you have created a studio, the student can click the blue + Add to Studio button at the bottom to add their project.
10. The student can then click the desired studio and Okay.

That’s it! The student’s work is now shared with the class in the studio.
1. Draw a neuron in the costumes tab...

2. Position and size it.
   - when clicked
   - go to x: 0 y: -180
   - get size to 60 %

3. Make it point towards the mouse.
   - forever
   - point towards mouse pointer

Do you have to change its center or the direction it's facing?
4 Draw some other neurons for the main neuron to target.

You can have active and resting costumes for the neurons.

5 Add code to switch between the costumes at random.
Objective
SWBAT define their sixth sense, known as proprioception.
SWBAT code and clone neurotransmitter sprites in Scratch to complete a game.

Vocabulary
• Proprioception: awareness of the position and movement of our bodies (pronounced “pro-pree-o-ception”)

Framing Question
How do I know where my hand is when my eyes are closed?

Materials
• Pencils and a Proprioception Activity handout (or lined paper) for each student (p. 12)
• Neuroscience 2 Scratch card — one per student (p. 13)
• Computer for each student
Plan/Activities

1. **Preview**
   - Remind students that the current topic of the Club is neuroscience, and they are learning about the brain and neurons.
   - Tell students that they are going to play a classic game and then learn about how their “sixth sense” made the game possible.

2. **Activity: Pin the Tail on the Donkey**
   - Ask for volunteers to play Pin the Tail on the Donkey. To make it more thematic, you can do “pin the tail on the Scratch cat” or “pin the neuron on the brain.” We’ve found that a quick set-up for this game involves simply projecting an image on a whiteboard and asking students to mark an X on the “tail” with a dry-erase marker while keeping their eyes closed. You can write their names next to their X’s to keep track of whose X is whose. The winner is the student who makes their mark closest to the tail.
   - Ask the students what senses they used to play the game. You can review the five senses with the students (touch, sight, hearing, smell, taste) and inform the students that they were most prominently using their sixth sense, *proprioception*.

3. **Explaining Proprioception**
   - Proprioception is the sense of where our body and our limbs are in the world. It allows us to move our bodies adeptly even when we can’t see them.

4. **Optional Proprioception Activities**
   - To further illustrate proprioception if time allows, try the activities found on the Exploratorium’s website and outlined here:
     1. **Find your fingertips**
        1. Stretch out both arms straight above your head and close your eyes.
        2. With the pointer finger on your right hand, quickly touch your nose, then touch the thumb of your left hand above your head. Don’t move your left hand.
        3. Repeat with the rest of the fingers on your left hand, touching your nose in between each.
        4. Try again. This time, wiggle the fingers of your raised hand between each touch.
     2. **X marks the spot**
        1. Grab the proprioception handout (p. 12) and a pencil.
        2. Put the handout on a table. Raise your pencil above your head, close your eyes, and then lower the pencil and make a dot on the paper as close to the X as possible.
        3. Check where your pencil landed. Try a few more times with your eyes closed. Can you get closer?
        4. Try with your eyes open.

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3. Handwriting analysis
   1. Write the word *proprioception* on one of the lines on your handout.
   2. Place your pencil on the same line next to the word, close your eyes, and write it again. Is there a large difference between the words?

5. Debrief
   • In all of these activities, your sense of proprioception allows you to move your hands to the desired spot, even when you can’t see your hands. Wiggling your fingers in the first activity gives your brain added information, and should have made the task easier.
   • We still rely on vision a lot, which is why you probably got closer to the second activity’s X each time, as you gathered more visual information between each attempt.
   • Looking at your paper before you tried the third activity probably didn’t help much, as we rely on the “feel” we have gained through proprioception to write words.

Scratch Activity: Neuron Blaster Game Part 2
   • Students will work to complete the neuron blaster game begun last week. Once again, preview the example program: https://scratch.mit.edu/projects/557599496/
   • Have each student grab a computer and sign into Scratch.
   • Students can finish the neuron blaster activity that they started last week. Pass out the Neuroscience 2 Scratch card to each student. This week they will work on adding neurotransmitters and scoring to their game. Students can modify the code as they wish.
   • Check in with students on their progress as they code.

How will you determine if students met the objective?

Students will be able to describe how their “sixth sense” helps them, and will have completed a working neuron blaster game.

Facilitator Tips

Print out copies of the *Proprioception Activity* handout beforehand. Students can also use their own paper if you wish.
Neuron Blaster 2

1. Create a neurotransmitter sprite. Code some clones of it to appear when you click the mouse.

   - When clicked, go to x: 0, y: -175.
   - Forever, if mouse down? then create clone of myself.

2. Shoot the clones in the direction of the mouse.

   - When I start as a clone, show.
   - Point towards mouse-pointer.
   - Forever, move 10 steps.
   - If touching edge then delete this clone.

3. Make a Score variable.

   - Code
   - Costumes
   - Variables
     - Motion
     - Looks
     - Sound
     - Make a Variable
     - my variable
     - Score
Neuron Blaster 2

4. When the target neuron is in the right costume and is hit by a neurotransmitter, the player scores.

Challenge!
Can you make a countdown clock?

1. When the target neuron is in the right costume and is hit by a neurotransmitter, the player scores.

2. If touching color is 2, then change Score by and wait 1 seconds.

3. Forever.

4. Set Timer to 0.

5. Wait 1 seconds.


7. Repeat until Timer equals 0.

8. Stop all.
Objective

SWBAT try out some optical illusions and understand that the brain does not always interpret correctly what the eyes see.

SWBAT create a Scratch program that showcases optical illusions.

Framing Question

Can my eyes deceive me?

Materials

- Computer for each student
- Finding Your Blind Spot handout (p. 17)
- A selection of optical illusions to show the students
Plan/Activities

1. Preview
   • Begin by explaining: We humans rely on our vision more than any other sense. Our eyes are pretty good at gathering information from our surroundings, but it’s up to our brains to interpret that information. Sometimes our brains do a great job, and sometimes they fail. Let’s start with one place where our brains do a great job: filling in our blind spots.

2. Blind Spot Activity
   • Pass out the Finding Your Blind Spot handout (p. 17). (If you can’t print the handout, it will also work on the students’ laptops, but that’s a bit harder for the students.) Ask students to do the following:
     1. Cover your left eye with your left hand. Hold the handout a couple feet from your face and focus on the plus sign. The dot should be off to the right. Looking directly at the plus sign, slowly move the paper closer to your face. When it’s about 10 inches away, the black dot should disappear. Try it a few times, moving it a bit left or right if it doesn’t work the first time.
   • Ask the students if they had known they had a blind spot. The blind spot is where the optic nerve starts in the eye. The optic nerve sends visual information to the brain. No rods or cones are there, so the human eye can’t see anything in that spot. The brain uses the surrounding information to fill in what’s missing.

3. Optical Illusions
   • Pick your favorite optical illusions to show the students. Some are provided in the sample slides.

Scratch Activity: Presenting Optical Illusions

   • Show the students the sample Scratch program: https://scratch.mit.edu/projects/557602534/
   • Pass out the Neuroscience 3 Scratch card (p. 18) to students. It shows how to code the simple optical illusions shown.
   • Encourage the students to create a program that highlights some optical illusions they find fun.

How will you determine if students met the objective?

Students can create a Scratch program that showcases an optical illusion of their choice.

Facilitator Tips

Wikipedia and other websites are a great source for optical illusions.
Optical Illusions

1. Draw your optical illusions. Use different sprites for each part.

2. Create a different backdrop for each illusion.

3. Use different backdrops to signal the illusion sprites to show and hide.

   when a backdrop switches to backdrop 2
   go to x: 39 y: 113
   show

   when a backdrop switches to backdrop 3
   hide

4. Make the parts of the illusion movable.

   set the drag mode draggable

5. Create a button sprite to cycle through the backdrops.

   when this sprite is clicked
   next backdrop
Challenge!!!

Can you code a sprite that introduces each optical illusion?

- When clicked:
  - Say: "Your brain can play tricks on you!" for 2 seconds
  - Say: "Want to see?" for 2 seconds

- When a backdrop switches to `backdrop3`:
  - Say: for 2 seconds
Objective

SWBAT test their memory by playing a memory game and, if time allows, learn some memorization strategies.

SWBAT create their own memory game in Scratch.

Vocabulary

• **Long-term memory**: a memory that lasts from a few minutes to decades
• **Short-term memory**: a memory the brain stores temporarily, from milliseconds to a few minutes
• **Working memory**: a type of short-term memory process that involves temporarily storing and manipulating information

Framing Question

How does memory work, and can I create a memory test program in Scratch?

Materials

• Computer for each student
• Two sets of *Memory Game* cards for every 3-4 students
  • Sample cards are found starting on p. 24 and are formatted for 2-sided printing
• Neuroscience 4 Scratch card (p. 32)
Plan/Activities

1. Introduction:
   • Get the students thinking about the types of memory. They may already know about short- and long-term memory.
     1. Long-term memory: This is where you store memories that last a long time, like ones of your first day of kindergarten, or the fact that Mexico is south of the US.
     2. Short-term memory: This is where you store memories you don’t keep for a long time, like words at the start of this sentence.
   • Let the students know that today they’ll be focusing on one type of short-term memory: working memory.
   • What is working memory?
     If I asked you to add 5 + 4 and then subtract 3, those numbers would be stored in your working memory, so you could “work” through the math problem. You probably won't remember that math problem in a few minutes. Working memory allows you to hold a conversation with someone and remember what they said a minute ago.
   • Tell students that they’re going to play one kind of brain game called “Memory.”

2. Memory Card Game
   • Group students into threes or fours. Each group gets two sets of Memory Game cards (p. 24 or use your own). Students should shuffle the cards and place them in several rows, picture-side down.
   • Play starts by having one player turn over two cards.
   • If the two cards are identical, the player picks up these two cards and turns over two more.
   • If the two cards are not the same, the cards are turned back face down in the same place they were and it is the next player's turn.
   • The object of the game is to remember where identical cards are located and to pick up as many pairs as possible.
   • The winner is the one who has the most pairs at the end of the game.

3. Review
   • Ask the students how they did in the game. Do they have a good working memory, or a bad one? Do they think they could improve their memory?
4. Optional Activities (if time allows)

- Chunking activity
  1. Hand out folded slips of paper to the students, and tell them you are going to give them 10 seconds to memorize the numbers on their slips of the paper.
  2. Half the students have the numbers written as 1945149220211776. Half the students have the numbers written as 1945 1492 2021 1776.
  3. Take an informal poll. Who was able to remember more of the numbers? Everyone had the same numbers, but some had the numbers broken up into “chunks” that were famous years. It was probably easier to remember years rather than numbers. Chunking is when we take individual things and bin them into chunks that are easier to remember. The most frequent use of this is phone numbers, where we divide a number up into a 3-digit area code, a 3-digit number, and then a 4-digit number. It’s hard to keep ten numbers in our working memory. It’s a lot easier to keep three numbers.

- Spatial memory or “memory palace”
  1. Give the students a list of five things to remember, such as: flower, tomato, hen, book, stapler.
  2. Distract them for a moment. For example, ask, “What’s 21 times 4? Touch your head, shoulders, knees, and toes. Now recite the last five letters of the English alphabet backwards.”
  3. Ask the students how many of the five things they can now remember.
  4. Explain that it’s hard to remember random items on a list. We’re a lot better at remembering where things are (using our spatial memory), but we can use our spatial memory when trying to memorize anything. You might have heard this technique referred to as a “memory palace.” Go back to those five things I had you memorize. Close your eyes. Now imagine you are at the front door of your house or apartment. You look down. There is a flower on the welcome mat, and you are squishing it. The door opens, and it is a giant tomato opening the door. You walk into your kitchen. Sitting on top of the refrigerator is squawking hen. You open the refrigerator, which is full of books. You look over at the sink and see a dancing, singing stapler in it.
  5. Get feedback on the students on whether it is now easier for them to remember the five items.

5. Conclusions

- Ask the students what techniques they use to memorize things. Some they may come up with include:
  1. Saying things aloud repeatedly.
  2. Making a mnemonic.
     1. Musical mnemonic = ABC song
     2. HOMES acronym for the great lakes
     3. Counting your knuckle bumps to remember the number of days in each month
  3. Quizzing yourself: When you use flash cards or other ways of testing yourself, you activate neurons used in the retrieval of information. That makes it easier to access the data when you need it later.

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3 This activity and more information can be found at Doolittle, P. (2013, June) “How your ‘working memory’ makes sense of the world” [Video]. TED Conferences. https://www.ted.com/talks/peter_doolittle_how_your_working_memory_makes_sense_of_the_world?
Scratch Activity: Make a Memory Test

• Preview the Scratch program for today: https://scratch.mit.edu/projects/557605204/
• Have each student grab a computer and sign into Scratch.
• Pass out Neuroscience 4 Scratch card (p. 32) to each student.
• Students can code a simple memory test as the example shows, or they may prefer something more complex like a Simon game.
• Check in with students on their progress as they code.

How will you determine if students met the objective?

Students will complete a memory game in Scratch.

Facilitator Tips

• For the memory game, make sure to cut out the cards ahead of time. You can laminate for future uses.
• To play one game as a whole group, print out larger cards, laminate them, and use adhesive magnet squares to play the game on the whiteboard.
1. Create some sprites made of random letters for the memory tests. The cat sprite will ask the questions.

   ![Sprites](image1)

2. Create a new variable to keep track of your memory score. Set it to zero to start.

   ![Variable](image2)

3. Broadcast a signal to start your first memory test.

   ![Broadcast](image3)


   ![Broadcast](image4)

5. The cat asks for an answer and checks if it is correct.

   ![Check](image5)
Memory Test

6. Repeat for the rest of the memory test sprites.

7. After the last test, tell the player how they did.

Challenge!
Can you give partial credit?

Memory Score

Broadcast start 6

Say seconds

Get ready for round three!

Broadcast start 6

Broadcast end 4

Broadcast and wait

When I receive

Ask What were the letters?

If answer = rymb then

Change Memory Score by 4

Say Get ready for round three!

Wait seconds

Show R Y M B

Hide R Y M B

End 4

ask and wait

What were the letters?

If Memory Score > 20 then

Say Your memory is excellent! for 2 seconds

Else

Say Your memory is terrible! for 2 seconds

When I receive

End 4

Broadcast

Start 4

R Y M B
Objective
SWBAT categorize fictional characters along the “The Big 5” personality axes.
SWBAT create a personality test or other sorting program in Scratch.

Vocabulary
• Personality: the idea that people will behave predictably and consistently in various situations

Framing Question
How can personality be quantified?

Materials
• Computer for each student
• Big 5 Personality Slides
• Neuroscience 5 Scratch card (p. 38)
Plan/Activities

1. Preview the Day’s Topic
   - **Personality** is the idea that people will behave predictably and consistently in a given situation. For example, some students have a personality where they always get nervous before any kind of test. Other students never get nervous. There are a lot of personality traits out there. Can you think of some? [Students will probably hit on Introversion/Extraversion right away.] Scientists have determined that there are five different areas of personality that everyone can be ranked on. They call them the "Big 5," and they are: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (acronym OCEAN). You can measure these five traits in anyone. In fact, even animals like fish and insects have been evaluated and shown to have consistent personalities.

2. Explore the Big 5
   - Pick some fictional characters well known to your students (see examples in Table 2, p. 37) to illustrate the extremes of each of the five factors. Placing images of your chosen characters on the slides provided can make the Big 5 approachable to students.
   - Encourage students to suggest additional characters who would fit each extreme of the Big 5 or who would be in the middle.
   - Pick a well-known character and rank it on all of the Big 5. The five-part ranking is that character’s personality. For example, *Shrek*'s Donkey is high in Openness, Extraversion, and Agreeableness, and low in Conscientiousness and Neuroticism.
   - Close the activity with a discussion on whether students think a person can change where they fall on each of the Big 5 personality traits.

**Scratch Activity: Personality Test Part 1**

- Tell the students that they’ll be coding their own personality quiz over this week and next. They can use the Big 5 or develop their own personality categories.
- Preview a sample personality quiz in Scratch. Here’s a sample program: https://scratch.mit.edu/projects/557609907/. You may also want to preview some Buzzfeed quizzes or *Harry Potter* house sorters.
- Have each student grab a computer and sign into Scratch.
- Pass out the Neuroscience 5 Scratch card to each student who wants to use that format for their personality quiz.
- Check in with students on their progress and provide feedback as they code this week and next.
NEUROSCIENCE 5: Personality

How will you determine if students met the objective?

Students will have started a sorting program in Scratch.

Facilitator Tips

• The fifth personality trait is neuroticism. Because of negative associations with the word “neurotic,” you may choose to use the word “reactivity” in its place in this activity.
• Choose fictional characters that appeal to your demographics and student population.
• We found that the students were very interested in creating a personality quiz. This Scratch activity extends into the next week and can be extended even further based on student interest.
Table 2. Resource list of fictional characters at the extremes of the Big Five.

<table>
<thead>
<tr>
<th>Personality</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Openness</strong></td>
<td><strong>Curious, Imaginative, Inventive</strong></td>
<td><strong>Cautious, Consistent, Practical</strong></td>
</tr>
<tr>
<td>Ariel (The Little Mermaid)</td>
<td>Curious George Phineas and Ferb</td>
<td>C-3PO (Star Wars) Marlin (Finding Nemo) Bert (Sesame Street)</td>
</tr>
<tr>
<td><strong>Conscientiousness</strong></td>
<td><strong>Efficient, Organized, Self-Directed</strong></td>
<td><strong>Careless, Easy-Going, Spontaneous</strong></td>
</tr>
<tr>
<td>Hermione Granger (Harry Potter) Mary Poppins Twilight Sparkle (My Little Pony)</td>
<td>Ron (Harry Potter) Dory (Finding Nemo)</td>
<td>The Cat in the Hat</td>
</tr>
<tr>
<td><strong>Extroversion</strong></td>
<td><strong>Energetic, Enthusiastic, Outgoing</strong></td>
<td><strong>Aloof, Solitary, Reserved, Quiet</strong></td>
</tr>
<tr>
<td>Donkey (Shrek) Buzz Lightyear (Toy Story) Genie (Aladdin)</td>
<td>Shrek Elsa (Frozen) Carl (Up)</td>
<td></td>
</tr>
<tr>
<td><strong>Agreeableness</strong></td>
<td><strong>Compassionate, Friendly, Trusting</strong></td>
<td><strong>Challenging, Detached, Uncooperative</strong></td>
</tr>
<tr>
<td>Baloo (Jungle Book) Snow White Elmo (Sesame Street)</td>
<td>Shrek The Grinch Oscar the Grouch (Sesame Street)</td>
<td></td>
</tr>
<tr>
<td><strong>Neuroticism</strong></td>
<td><strong>Nervous, Sensitive, Stressed, Worried</strong></td>
<td><strong>Confident, Secure, Stable</strong></td>
</tr>
<tr>
<td>C-3PO (Star Wars) Fluttershy (My Little Pony) Rex (Toy Story)</td>
<td>R2-D2 (Star Wars) Timon and Pumbaa (The Jungle Book) Ms. Frizzle (The Magic School Bus)</td>
<td></td>
</tr>
</tbody>
</table>
1. Design your personality categories and make variables for them.

   ```
   when [Flag icon] clicked
   set Agreeableness to 0
   set Conscientiousness to 0
   set Extraversion to 0
   set Openness to 0
   set Neuroticism to 0
   switch backdrop to O1
   ```

2. Create your personality quiz questions as different backdrops.

3. Create agree and disagree sprite buttons that change the personality score for each question when clicked.

   ```
   when this sprite clicked
   wait 1 seconds
   if backdrop = O1
   name
   change Openness by 1
   wait 1 seconds
   next backdrop
   stop this script
   ```
Personality Quiz

4 Create sprites with different costumes for the different personality categories.

5 Tabulate your results. Show the costume at the end that corresponds to the score.

Challenge!

Can you add an introduction?  Can you include pictures?
Objective

SWBAT determine whether color influences taste by measuring their success in guessing a jelly bean's flavor both with and without knowing its color.

SWBAT finish working on their personality quiz Scratch project.

Framing Question

What is the relationship between vision and taste?

Materials

- Computer for each student
- Jelly beans: We used Brach’s for this activity, which is gelatin-free and has the flavors mentioned below
- Small cups or envelopes
- Does Color Affect Taste student handout (p. 43)
- Neuroscience 5 Scratch card (p. 38)
Plan/Activities

1. Set Up the Activity
   • This will be a blind taste test of jelly bean flavors. Set up six cups for each student. Label each set with the numbers 1-6. Place one jelly bean in each of the first five cups, making sure that you are consistent across all the sets. For example, every cup labeled #1 should have one purple bean. In the sixth cup, place one jelly bean of each color, for a total of five. A sample setup would have:
     1. 1 purple (grape)
     2. 1 yellow (lemon)
     3. 1 green (lime)
     4. 1 red (cherry)
     5. 1 orange (orange)
     6. All five colors

2. Probing Questions for Students
   • Have you ever gotten a cold and noticed that your food has less taste? Why is that?
   • Explain: “When your nose is congested, your sense of smell is not as strong. A large part of how something tastes is actually how something smells. How something looks can also affect how it tastes. How do you think your sense of vision affects your sense of taste? Today we're going to explore that question with blind taste tests.”

3. Jelly Bean Blind Taste Test
   • Part 1
     1. Give each student the Vision and Taste handout (two copies on p. 43) to record their experiment. Then give them the first five cups, each with a different color/flavor of jelly bean.
     2. Remind the students not to look at the color of the bean in the cup, but to taste it and write down what flavor they think it is.
   • Part 2
     1. Pass out cup six, which contains all five flavors of jelly bean.
     2. Students can keep their eyes open and taste each bean knowing its color. They should record, on the bottom section of their handout, what they think the flavor is for each bean.
   • Collect the results
     1. Take an informal poll of the whole class for both sets (color unknown and known) to see if students were better able to deduce the flavors when colors were visible.
     2. Students should identify more flavors correctly when they can see the colors.
   • Debrief
     1. Ask how they might use this brain trick. (For instance, adding color to medicine to make it taste better, making food more or less desirable.)
Scratch Activity: Personality Test, Part 2

- Have each student grab a computer and sign into Scratch.
- Give each student a Neuroscience 5 Scratch card from last week (if they still need it).
- Check in with students on their progress and provide feedback as they code.

How will you determine if students met the objective?

Students should complete a personality quiz in Scratch.

Facilitator Tips

- Make sure to prep the cups with jelly beans before the activity. If you don’t want to place the beans in cups or envelopes, you can wrap them in aluminum foil instead.
- This website was helpful in designing this activity and has a useful collection of research on color and taste experiments: Chudler, E.H. (2021, June 2) Neuroscience for Kids. https://faculty.washington.edu/chudler/neurok.html.
- We modeled this activity to parallel a food science experiment from the 1980s4 where test subjects were given flavored drinks both when they could and could not see the color. While they were largely successful at determining the flavor when they could see the color, they were much less successful when they could not. (Successful identification without seeing the color: grape = 70%, lemon-lime = 50%, cherry = 30%, orange = 20%.) You may wish to compare your jelly bean results to this previous research.
- Students don’t have to eat the whole jelly bean. You can also decrease the number of beans offered to students to shorten the activity.

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**Does color affect taste?**

**Directions:** Without looking at the jelly beans, taste each numbered bean, one at a time, and write the flavor you think the bean has.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>1:</td>
<td>2:</td>
<td>3:</td>
</tr>
<tr>
<td>4:</td>
<td>5:</td>
<td></td>
</tr>
</tbody>
</table>

Now, try to identify the flavors when you can see the colors.

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<table>
<thead>
<tr>
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<th></th>
</tr>
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<tbody>
<tr>
<td>Green:</td>
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</tr>
<tr>
<td>Purple:</td>
<td>Orange:</td>
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</tbody>
</table>
Objective

SWBAT think about the parts of the brain required to do a complex task.
SWBAT create a computer game that uses a mirror effect.

Vocabulary

- **Mirror Neuron**: a neuron that fires both when an individual does a specific action and when the individual sees the same action done by someone else
- **Empathy**: understanding and being sensitive to someone else’s feelings, thoughts and experiences

Framing Question

What parts of the brain are required to do a complex task?

Materials

- Printed *Tangram Cutouts* for each student. (Pre-cut them, or the students can cut them) (p. 47)
- Desk dividers (may use laptops, folders, or books)
- Printed copies of completed *Tangram Puzzle Examples*, with enough copies of each puzzle for half the class (p. 48)
- Computer for each student
- Neuroscience 7 Scratch card (p. 49)
Plan/Activities

1. Introduce the Day’s Topic
   • Tell students: “We’ve been talking a lot about the brain. Today, we are going to divide up in teams of two to do a really difficult task, and while you are doing it, I’d like you all to think about what parts of the brain you are using.”

2. Tangram Game
   • Divide the students into pairs and arrange them so that they are sitting at their desks across from each other. The students should set up a divider so their partners cannot see what is on their desk (e.g. students can open their laptops or place their bag on their desk). If needed, have each student cut out their own tan pieces (p. 47).
   • Pass out one of the provided tangram puzzles (p. 48) to the “Describer” in each pair.
   • Without showing it to their partner, the Describer should build the tangram with their pieces while describing their actions to their partner, the “Builder,” so that the Builder can also build it simultaneously. After the Builder is finished, the Builder can look at the printout and the Describer’s tangram. Partners should then switch jobs and try a different tangram.
   • Remind students who become frustrated that the task is supposed to be hard.

3. Debrief
   1. Ask the students what areas of the brain they were using during this activity. Answers might include the parts of the brain responsible for hearing, moving, vision, language, planning, and memory. Remind students that a complex task like this requires a lot of parts of the brain.
   2. Ask students what they wanted to do when they were a Builder. Students probably wanted to see what the Describer was describing as they built their shape. Use this moment to introduce the concept of mirror neurons.
      • We have these special neurons called mirror neurons that activate when we see other people do things. They help us figure out how to do something ourselves by watching others! [You can get into more detail if you have time.]
   3. Have the students do at least one more round of tangram building. Ask the students if it was easier to do the activity the second time around. If it was, ask them why. Students may report that when they were the Describer, they were using the “planning” part of their brain a bit more. They might also have tried to put themselves into the shoes of the Builder to think about how to help them do the tangram. That’s empathy! One of the interesting ideas behind mirror neurons is that they help us imagine what it’s like to be someone else. Mirror neurons might be part of why humans can be empathetic! Isn’t that cool?

5 This activity is based on the activity “Tell Me About It” by BrainU.
6 More information can be found at Ramachandran, V. (2009, November) “The Neurons that shaped civilization” [Video]. Ted Conferences. https://www.ted.com/talks/vilayanur_ramachandran_the_neurons_that_shaped_civilization?
Scratch Activity: Mirror Game

- Students will build a game in which sprites mirror each other.
- Preview the game here: [https://scratch.mit.edu/projects/556472159/](https://scratch.mit.edu/projects/556472159/)
- Have each student grab a computer and sign into Scratch.
- Pass out the Neuroscience 7 Scratch card to each student.
- Check in with students on their progress and provide feedback as they code.

How will you determine if students met the objective?

Students will be able to describe some parts of the brain used for the tangram activity, and complete a Scratch program.

Facilitator Tips

- You may want to set a time limit when building each tangram. Some students rush through the task while others take a very long time.
- The activity can be made harder by printing the shapes without color.
Tangram Cutouts

7
Mirror Game

1. Divide the stage in half with two line sprites.

2. Make a sprite that follows your arrows.

3. Create a vertical obstacle.

- when clicked
  - go to x: -168 y: 44
  - forever
  - if key right arrow pressed? then move 10 steps
  - if key left arrow pressed? then move -10 steps
  - if key up arrow pressed? then change y by 6
  - if key down arrow pressed? then change y by -6
  - if touching Top Line then broadcast Game Over

- when backdrop switches to Blue Sky 2
  - show
  - go to x: -250 y: 180
  - forever
  - create clone of myself
  - wait pick random 1 to 2 seconds
  - when I start as a clone
    - go to x: pick random -220 to 220 y: 180
    - forever
    - change y by 6
    - if touching Top Line then delete this clone
    - if touching Cat Flying then broadcast Game Over

1. Divide the stage in half with two line sprites.
2. Make a sprite that follows your arrows.
3. Create a vertical obstacle.
Mirror Game

4. Create a horizontal obstacle.

- when clicked
- go to x: 260 y: 38
- repeat until touching Cat Flying
- show
- change x by -3
- if x position < -250 then
- hide
- go to x: 260 y: 38
- wait pick random 0 to 5 seconds
- if touching Cat Flying then
- broadcast Game Over

5. Create a BIG obstacle.

- when clicked
- go to x: -260 y: 0
- hide
- wait 5 seconds
- forever
- show
- change x by 6
- if x position > 250 then
- hide
- go to x: -260 y: 38
- wait pick random 0.5 to 5 seconds
- if touching Cat Flying then
- broadcast Game Over

6. Code sprites for the other side of the mirror!

- Cat Flying
- banana obstacle
- Falling Apple
- Cat Flying2
- banana obstacle
- Falling Apple

7. Draw a backdrop for Game Over.

GAME OVER
Objective
SWBAT create a project with Scratch to practice the coding skills that they’ve learned so far.

Framing Question
Can I create a project in Scratch?

Materials
- Computers
- Copies of all previously-used student Scratch cards
- *Scratch Student Planning* template (p. 53)
Plan/Activities:

1. Criteria for Success
   • Students will have the remaining weeks left in the club to work on their Scratch projects. They should create a project that relates to something they've learned during their time in the Club.
   • Possible topics include:
     • An extension of any of the projects they have been working on
     • Student choice — have students pitch you an idea of a code project they'd like to create

2. Scratch Projects
   • Once students have decided on a project topic, help them develop a plan using the Scratch Student Planning template.
   • When students are satisfied with their plan, they should begin to code their design in Scratch.

How will you determine if students met the objective?
Students will have completed a project in Scratch.

Facilitator Tips:
   • While this is an independent project, it is important to provide frequent check-in and feedback to students so they can finish up by the deadline.
   • The criteria are focused on projects related to neuroscience module, but you may add additional success criteria to fit your program and students.
Directions

Use this sheet to plan out your project

Student Name(s): ________________________________

Project Name: ________________________________

Project Description:
____________________________________________
____________________________________________
____________________________________________
____________________________________________
____________________________________________
____________________________________________

Sketch of Stage

Flow Chart of Design:

Description of Sprites, Costumes, and Code:

Sprite 1:  

Sprite 2:  

Sprite 3:  

Sprite 4:  
