Neuroscience for Kids

http://faculty.washington.edu/chudler/neurok.html

TEACHER GUIDE

Our Sense of Touch

<u>EXPERIMENTS</u>: two-point discrimination, masking the sense of touch, replacing sight with touch, and sensory interference

Featuring a "Class Experiment" and "Try Your Own Experiment"

WHAT STUDENTS WILL DO

- PREDICT and then MEASURE a person's ability to discriminate one versus two points touching various places on the skin
- RECORD and GRAPH their data
- DISCUSS the implications of having different sensitivities in different skin areas
- DESCRIBE the "sensory homunculus" and how it helps us understand sensory information processing in the brain
- DESIGN and CONDUCT experiments to extend the study of the sense of touch, for example:
    - TEST two-point discrimination while stimulating other sensory systems for interference
    - TEST two-point discrimination when skin receptors are partly blocked
    - FIND OUT if you can accomplish a task using only touch when you usually use vision
    - TEST the ability of fingertips to put grades of sandpaper in order

<u>SUGGESTED TIMES</u>

**45 minutes* for introducing and discussing the activities

**45 minutes* for the "Class Experiment"

**45 minutes* for Explore Time and "Try Your Own Experiment"

SETTING UP THE LAB

Supplies

For the Class Experiment

Toothpicks
Corks of various sizes, up to 6 or 8 centimeters (cm) in at least one dimension (available in hardware stores)
Rulers (metric)
Optional: blindfolds. If used, do not share.

To make the probes, choose either a set of cork/toothpick devices that are left intact, or choose one cork and vary the distance between the toothpicks stuck into it. For a set of probes, you will probably need 6 to 8 corks, with inter-toothpick distances of about 2, 5, 10, 20, 30, 40, and 50 cm.

For "Try Your Own Experiment"

Lego bricks of different sizes
Small matching nuts and bolts
Keyboard; e.g., from classroom computer
Ice cubes
Gloves, preferably cotton or ski liner gloves, not too thick
Pieces of cotton or wool, or any fabric
Vials with strong but harmless odors: ripe banana, cinnamon, perfume
(Be sure to check for allergies to these)
Tape player, tape (some teen-interest song), earphones
Several timers or stopwatches
Six to ten grades of sandpaper
Several children's puzzles with just four to six pieces. These should have raised edges and if possible, should have pieces that go into separate cavities in the board.
Optional: blindfolds. If used, do not share.

Other Preparations

For both experiments: Copies of the Data Recording Sheet and the histogram template are included at the end of the Teacher Guide and also at the end of the Student Guide.

Construct a chart on the board where all data can be entered for class discussion.

Decide the size of the student groups; for example, groups of three would each have a tester, a subject, and a data recorder. If people switch roles for the "Try Your Own Experiment" section, the new subject must have a baseline two-point discrimination test for the skin areas to be used in the new experiment.

Consider assigning students to the roles listed above, to ensure gender equality and to eliminate student bias.

Modifications for exceptional students: Students with severe diabetes may have diminished tactile abilities; students with impaired vision will not be able to read measurements. Assign students roles that take their capabilities into account.

INTRODUCTORY ACTIVITIES

Give students initial information

Introduce **Our Sense of Touch** to the class according to your teaching practices; for example, with reading, lecture, discussion, models, and handouts, before the lab work (the **Teacher Resource** accompanying this unit gives background material). In addition to covering the anatomy and physiology of the touch system, for these experiments you will want to introduce the concepts of sensory receptor density, receptive fields, and sensory interference. Add any other topics you think might come up in the "Try Your Own Experiment" section.

Introduce lab activities with a demonstration

The Class Experiment will be most successful if the teacher **demonstrates** the two-point discrimination test. Here is a suggested test:

Prepare a cork with two toothpicks stuck into it, as described under **Supplies**. You can use either one cork and vary the distance between toothpicks, or use a set of corks/toothpicks with preset distances. Describe what you are about to do, and ask the students to make some predictions about how far apart the toothpicks must be for someone to feel two separate points. Gently touch two toothpicks to the forearm of a student volunteer. Ask the student, who should close his/her eyes, whether he/she can feel one point or two. Depending on the answer, move the points closer to or farther from each other, asking how many points are felt, until the threshold for distinguishing two points is found. Measure this distance and write it on the board. Demonstrate only this one area. This is the procedure students will follow in the Class Experiment for other skin areas.

Use Explore Time to engage students

Because the Class Experiment requires a teacher demonstration, the teacher can give students Explore Time first, allowing students to come up with ideas, and then perform the demonstration. Alternatively, the class can have Explore Time before Try Your Own Experiment.

CLASS EXPERIMENT
How sensitive is my skin?

The sections below match those in the Student Guide. The comments guide teachers in preparing and teaching the labs.

LAB QUESTION

After the Introductory Activities, help students write the following Lab Question or one that closely matches it:

> **How far apart on the skin must two pointed objects be in order for a person to tell that there are two objects rather than one?**

PLANS AND PREDICTIONS

- Encourage students to add their own knowledge and experiences in order to make predictions after you have provided background information.

- Ask students whether they think the minimum distance measured on the fingertip will be the same as on other areas of the body. Possible questions:
  Will the measurement on the fingertip be the same as on the arm?
  Will the measurement on the palm of the hand be the same as on the back of the leg?
  Why do you think the measurements may or may not differ in each case?

PROCEDURE

1. **Introduce safety precautions**

- General: follow all standard lab safety guidelines for preparing and teaching the activity; e.g., take precautions to avoid germ spread, wash hands, dispose of chemicals properly, use equipment properly.
- Specific:
  - make sure students are comfortable being subjects, data recorders, or testers
  - use fresh toothpicks or other testing objects for each student
  - be sure students apply the points *gently*
  - if blindfolds are used, they should not be shared, to avoid spread of germs; students can elect to close their eyes

2. Establish the number of students in each group; each group should have at least a subject, tester, and data recorder. The group may have more, and people can take turns.
3. **Hand out** corks and toothpicks. Have students make their own sets of probes, or give each group a pre-assembled set, as described under Supplies in the Background section. It is important to try to touch the two points to the skin simultaneously.
4. **Hand out** metric rulers.
5. **Briefly explain** the steps in the experiment: these are listed in the Student Guide. Tell students that they will measure the two-point discrimination distances for the skin areas

listed on their data sheets; record their data; then graph the data. They will then compare results with others, discuss results, and answer the questions in the Analysis and the Conclusions sections.

DATA AND OBSERVATIONS

- Check to see that all students find the data collection sheets at the end of the Student Guide.

- Monitor the experiments to see that students understand the process.

- After the groups have collected their raw data, ask students to use the graph templates from the Student Guide to make histograms of their results.

- Have the data recorders from each group list their results on the prepared chart on the board.

ANALYSIS: THINK ABOUT IT!

The following questions can encourage thinking about the activity; add your own thoughts. ***(See also the specific questions in the Analysis section of the Student Guide.)***

- How do your results compare with those of other groups?

- Can you explain differences you see among the observations? (Differences in individual physiology; use of different probes; variations in accuracy of measurements; differences in number and size of increments in distance made.)

- Do you have any **direct** evidence from your experiment to show that sensory receptors exist? (There is no direct evidence; this would require microscopic investigation to identify possible receptors, and recording from neurons with special electrodes.) This is a good time to point out how scientists work without having a source of "correct" answers, and because of this, experiments must be questioned and repeated for accuracy.

- Discuss what the results mean in terms of the concepts covered in the introduction of touch sensory systems to the class; for example, receptors or the somatosensory cortex.

CONCLUSIONS

Students should:

- State how the Lab Question was answered in their experiments.

- List three things (or a number you choose) they think are important about today's experiments. Focus students by asking such questions as: How are our senses important to us? What do our brains do with sensory information? Can you experiment on some things at home, or is it best to wait until you are at school? Do scientists now know everything there is to know about the sense of touch?

- List ways to improve this experiment.

TRY YOUR OWN EXPERIMENT

LAB QUESTION

After students have completed the Class Experiment, indicate the lab bench or table where additional materials are available for "Try Your Own Experiment," and let them **explore** the items. Brainstorm with them for ideas such as **masking or altering the sense of touch** as measured by two-point discrimination. Questions can help them formulate plans: Can heavy input into another sense (hearing, sight, smell, taste) interfere with attention devoted to touch? What about changing the temperature of the skin?

Experiments need not rely on the two-point tests. Students can test the ability of different areas of skin to discern surface features or can investigate the importance of sensory information for performance of motor tasks, for example.

Make sure that each group defines a Lab Question, as they did for the Class Experiment.

PLANS AND PREDICTIONS

SUGGESTIONS FOR EXPERIMENTS

(Add your own ideas to this list. The Student Guide also suggests some of these experiments but does not contain all details given here. Give hints and encourage students to come up with ideas.)

1. Measure two-point discrimination in two places (e.g., one fingertip and the forearm) under the following conditions:

    a. rubbing an ice cube over the area for 7 or 8 seconds before testing (it may be painful to do it any longer!)
    b. smelling a vial of cinnamon, banana, or perfume during testing
    c. lightly rubbing the opposite arm with a piece of fabric during testing
    d. listening to a music tape via headphones during testing

Note that this experiment should be performed on someone who has already been a subject for the Class Experiment, so that the group has baseline data on this subject and will be able to easily calculate any differences discovered in the new experiment.

2. Count the number of "bumps" on five Lego bricks with and without thin cotton gloves. (eyes closed)

3. Combine a motor task with the sense of touch, and measure time required to complete the task with and without gloves.
    a. stack 10 Lego bricks

b. put nuts on five small bolts

4. Count the number of mistakes made while typing a sentence on a computer keyboard with and without gloves.

5. Find out if any athletes or guitar players have calluses on their fingertips and see how this affects their sense of touch.

6. This experiment on puzzles is from the Neuroscience for Kids Web site Experiments and Activities page: http://faculty.washington.edu/chudler/chtouch.html

   Jigsaw puzzles are fun, but did you ever try to put one together without looking at it? Get a simple children's puzzle with only 4 to 6 pieces. The best ones are those with a raised rim around the border. Some have pieces that each fit into a separate cavity—try this kind first. Empty the puzzle and try to put it together using only your sense of touch and use a blindfold.

   To make this an **experiment**, students should predict the time it will take a subject to perform the activity, and then time it with a stopwatch. Variables can be the type of puzzle and number of pieces. For a control, time the puzzle-solving while using eyes.

7. Here is another activity adapted from the same URL at the Neuroscience for Kids Web site: Sand Paper Rankings

   To demonstrate the sensitivity of fingertips, use 5 to 10 different grades (roughness) of sandpaper from the hardware store. A number indicating roughness should be printed on the back. Cut the sandpaper into pieces about two or three inches square: write the grade of roughness on the back of each cut piece of sandpaper. Mix up the pieces of sandpaper and place them rough side up. Have a subject use fingertips to feel and line up the pieces of sandpaper in order **without looking**, from the smoothest to the roughest. Where do subjects tend to make mistakes?

   Students can predict the number of mistakes that will be made. To make this activity a control **experiment**, use another part of the body to try the same activity. For example, have the subject rub the pieces of sandpaper GENTLY on the elbow, palm, arm, or knee and try to line them up in order using this sensory information. Again, subjects cannot look at the sandpaper while doing the experiment. After gathering the results, students can create a diagram for each skin area tested, showing how large the differences in grades of paper must be in order for a difference in roughness to be detected.

HOW TO DESIGN A GOOD EXPERIMENT

In designing experiments to ask and answer questions like these, keep in mind what a successful investigator must do:

- Ask a **very specific question**: not, for example, “Does the sense of touch sometimes change?” but rather, “Does the two-point discrimination distance on the forearm change

when I rub the arm with an ice cube for several seconds right before testing?" It's good to have the general question in mind, but ask a narrow question for each experiment.

- Be sure you understand the **control condition** for your experiment, and then **change only one thing, or variable,** in the experiment. Some examples follow:

  - ✓ If you decide to interfere with two-point discrimination ability, the control experiment is the one the entire class did, measuring two-point discrimination under normal conditions. If you decide, for example, to change the temperature of your subject's skin with ice, temperature is your variable and you should not change anything else. If you also change the person who is the subject, you will not know if the different measurements you gather are a result of the new person's touch receptors or the change in temperature.

  - ✓ If you measure the time it takes to count the number of "bumps" on a set of Lego bricks with and without gloves on, you would **define the control condition** as the one without gloves.

- To make your activity a real experiment, ask a question, make a **prediction**, **test** the prediction, **analyze** the results, and draft **conclusions**.

  - ✓ For example, if you decide to try to interfere with the sense of touch by rubbing an ice cube on a Subject's arm, **predict** exactly how this will change their two-point discrimination ability. Use the Class Experiment results as your control, and **analyze** your results. Can you draw any **conclusions**, or do you need to do more experiments?

- Use the pages of the Student Guide to write down your new lab question, your predictions, and the steps in your procedure. Follow the general plan of the Class Experiment, and keep good records of everything you do.

PROCEDURE

- Follow all standard lab **safety guidelines** for preparing and teaching the activities; e.g., take precautions to avoid germ spread and use equipment properly.

- Note that the student subject for one of the "interference" activities must be the same person as for the Class Experiment. Or, the new person must have a <u>baseline</u> two-point test done for the area that will be tested for interference.

- To save time, instruct groups to choose just two skin areas, such as one fingertip and one arm area, if they are working further on two-point discrimination distances.

- Have each group write a simple plan, including a **question,** a **prediction,** and the **steps** they will take to answer the question.

- **Check and approve** each group's experiment.

- Students should **clean up** the lab when they finish.

DATA AND OBSERVATIONS

- Make supplies available to students. Check to see if anyone is allergic to substances with strong odors for the "olfactory interference" test, if you include it.

- Suggest that students create any data sheets and graphs they need.

ANALYSIS: THINK ABOUT IT!

The following questions can encourage thinking through the activity; add your own ideas. ***(See also the specific questions in the Analysis section of the Student Guide.)***

Have each group present its findings in a quick oral presentation (two to three minutes each).

What was the control experiment today, and what did you change or add for your own experiment?

Did you make sure to change only one variable?

If you did another two-point experiment, do you think the interference you saw in the ability to discriminate points was in the skin or in the brain?

CONCLUSIONS

(See also the questions on the student handout.)

Ask students how certain they are of their conclusions. Would they need more evidence to make their conclusions more secure?

Each group should write a final conclusion, making sure it addresses their Lab Question.

MORE *SENSE OF TOUCH* ACTIVITIES

- Draw a one-centimeter per side square and make 100 dots with a pencil inside it. There are **2500 receptors** in a square centimeter of fingertip skin! Of course, they are much smaller than pencil dots.

- Do other animals sense things with their skin the way we do? What about animals that are very different from us, such as insects? Do some library or Intenet research and report

back to your class. How do researchers know what animals are feeling with their skin if the animals can't talk?

- Make a "distorted" map of your neighborhood, like the brain sensory homunculus, to reflect the relative importance of home, video store, school, climbing gym, etc. Or, make distorted maps of the country, emphasizing places you like or know.

- Find out more about abnormalities or diseases of the touch sensory system, using your library or the Internet.

Here are some good Web sites to visit for touch or somatosensory information.

http://vm.uconn.edu/~advance/00050111.htm changes in the sense of touch with aging

http://thalamus.wustl.edu/course/bassens.html pathways for touch information in the brain

http://www.sfn.org/briefings/pain.html receptors that detect pain

http://faculty.washington.edu/chudler/chtouch.html
http://faculty.washington.edu/chudler/receptor.html lots of information and activities related to the sense of touch, right here at Neurosciences for Kids

http://www.apa.org/monitor/jun98/touch.html a young man loses his sense of touch

Name_____

DATA RECORDING SHEET

SKIN AREA FOR TESTING	**MINIMUM DISTANCE FOR TWO POINT DISCRIMINATION** in millimeters (mm)
FOREHEAD	
CHEEK	
FOREARM	
PALM OF HAND	
TIP OF THUMB	
TIP OF INDEX FINGER	
BACK OF LOWER LEG	

Name_____

DATA GRAPHING SHEET