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Interactive Teaching Activities for Introductory Biopsychology

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Overview

The field of biopsychology is becoming increasingly relevant to the field of psychology as a whole (Stanovich, 2010). The American Psychological Association (APA) now specifies that understanding “the biological bases of behavior” is one of the core learning outcomes covered by undergraduate programs in the APA guidelines for the undergraduate psychology major (APA, 2007). However, teaching a biopsychology (neuroscience, physiological) course to undergraduates can often be challenging, particularly at institutions where resources are limited. Traditionally, biopsychology courses tend to be structured as lecture courses with several integrated lab components, such as the dissection of sheep brains by students (Lloyd, 2008). Although it may be assumed that students taking biopsychology will have an opportunity to be involved in activities such as examining stained cells on slides through powerful microscopes or collecting physiological data, not all departments have the resources to invest in these types of labs.

Lack of lab resources does not need to pose as severe a limit as might be expected as long as students have the opportunity to be involved in interactive ways of learning what many of them perceive as dry material. Simple, clear, and interactive activities can replace or supplement the traditional labs that are often associated with a biopsychology course. Furthermore, a large body of literature suggests that games, interactive activities, and simulations in the classroom promote student retention and learning (e.g., Kumar & Lightner, 2007).

As a neuroscience instructor in a department with limited resources, I have created a handbook of 11 simple, clear, and, most importantly, interactive activities that engage students and illuminate core neurophysiological concepts. Each activity requires little or no outlay of resources. Most activities can be implemented in the classroom and will take only 10-15 min of class time. Instructors can easily prepare all while adding an engaging and necessary interactive element to learning biopsychology. Some of these activities are unique to this book and others are unique interpretations of well-known demonstrations (e.g., the demonstration on touch receptor densities was adapted from two-point threshold demonstrations such as can be found here:

<http://frontiersofsci.org/?q=node/296>). Because each activity stands alone, users of this resource can select whichever best fit their classes. Each description include instructions for how to prepare and implement the activity.

References

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1. Conducting Self-Phrenology

Principle Demonstrated:

Not every commonly practiced scientific theory and principle is based in scientific fact. This activity is a way to engage students in the history of neuroscience and remind them that scientific theory and principles must always be tested. Because the history and background of the field are usual topics early in the semester, this activity can also serve as an ice breaker.

Equipment and Preparation:

Necessary resources include one copy of a simple phrenology chart for each member of the class. Phrenology charts are often available in introductory or biopsychology textbooks in the history chapter or are fairly easy to find online. I prefer to use a chart that is simple and has clear areas labeled with very common faculties or traits that students will understand and be able to interpret. One image I like to use can be found at the following link: <http://www.penelopeironstone.com/phrenology.gif>. Another suggestion is <http://www.cerebromente.org.br/n01/frenolog/frenmap.htm>.

Procedure:

This activity takes roughly 5-10 min. After a lecture on the history of biopsychology but before passing out the phrenology charts, have students write down five basic personality traits or skills that apply to themselves. Students can do this in groups, sharing their lists with their group members, or individually.

Next, pass out the phrenology charts and ask students to feel their own heads. Because some students might feel silly doing this, I suggest participating with them. Have them start with the front of their scalp and circle on the chart any bumps or depressions on the left or right side. Then have them work their fingers back, covering the middle, down by the ears, at the back of their head, and so on. If the chart shows only one side of the skull, they can generalize to the other side. If they are working in groups, students can have their group members circle the areas on the chart where they report feeling bumps or depressions.

Then, ask students to write down the traits that the phrenology chart suggests they ought to possess (areas of bumps) or not possess (depressions). Finally, they should compare the list to the one they made originally about themselves. This is also a good point to discuss the misuse of science, how easily prejudice can masquerade as science (e.g., phrenology upholding prejudicial standards about personality traits of races and sexes), and how important it is to systematically verify what sounds like a good scientific theory before assuming it has validity.

This may also be a good time for you to discuss the concepts of face versus convergent validity. For instance, coincidentally one or two students might find agreement on one or two traits, and they may think at first that the map has face validity. However, on the whole the class should find no correspondence between the phrenological map and their actual traits and skills. You may even wish to have the face

versus convergent validity discussion both before and after conducting the activity. You can discuss other personality assessment tools introduced in personality or social or abnormal introductory classes that might be utilized to measure convergent validity (or lack thereof) between the phrenological map and other validated assessments.

Note: Students do not like to touch one another, so I found that typical versions of this kind of activity that require students to exam each other's scalps, even through a swim-cap, are unsuccessful. This activity still demonstrates the problems with early cognitive/neuropsychological theory without asking the students to put themselves in an uncomfortable position.

2. Building a Neuron Model

Principle Demonstrated:

This activity will assist students in learning the parts of a neuron, including its structural elements and organelles, in detail.

Equipment and Preparation:

Students can perform this activity in class, as homework, or as an extra credit assignment. If you opt to do the entire activity in class, you will need to supply a variety of materials, including construction paper, pipe cleaners, Styrofoam™, Play-Doh™ or clay, paint, markers, crayons, scissors, and glue. You may also include other craft items such as candy, puff balls, and cotton.

Procedure:

The students will be building a three-dimensional model of a neuron. You may specify what structures to include or assign a minimum number of labeled structures, such as:

- The Soma
 - Cell nucleus
 - Rough endoplasmic reticulum
 - Ribosomes
 - Golgi body
 - Mitochondria
- Dendrites
- At least one Axon
 - Axon proper
 - Axon terminal
- Myelin
- Nodes of Ranvier

Encourage students to be creative, accurate, and detailed. If you opt to have the students do this on their own time, remind them they will have to transport their neurons to class. The in-class version of this activity will probably take nearly an entire class period, or approximately 45-60 min to complete.

Whether students build their models at home or in the classroom, take 15 min of class time for students to display their neurons to one another. You can have the students vote on the best neuron in specific categories (e.g., most creative, strangest material, most detailed, weirdest looking).

Alternative/Advanced Task Version: An alternative or more advanced version of this task would be to assign different types of neurons to students (e.g., 5 students all build a multipolar cell; another 5 complete a pyramidal cell, etc.). You could include bipolar neurons, unipolar neurons, stellar neurons, pyramidal neurons, granule neurons, Purkinje neurons, and so on. When students complete their models or bring them to class, you

might ask for brief presentations on the differences in function in each cell, or you might contribute this information as students present each cell. You might wish to highlight, or have the students highlight, information on how neurons differ from other cells in the body and why and how neurons with different structures might serve different specific functions.

3. Acting Out the Human Action Potential

Principles Demonstrated:

Students act out how the action potential is initiated and propagates down the axon and the roles of specific ions, ion gates, and the principle of diffusion.

Equipment and Preparation:

Necessary resources include colored construction paper, tape, and individually wrapped candies (Starbursts™ work well and are inexpensive). In advance, cut construction paper into large rectangles and choose a color to represent each “character” in the action potential. For a class of approximately 35-40 students, I prepare

- 6-8 rectangles labeled “K+” for potassium (pink)
- 10 rectangles labeled “Na+” for sodium (red)
- 10 rectangles labeled “anion” for negative ions (blue)
- 2 rectangles labeled the “NA+/K+ Pump” (brown)
- 2 rectangles labeled “Na+ Channels” (brown with a red patch)
- 2 rectangles labeled “K+ Channels” (brown with a pink patch)
- 4-6 rectangles labeled “Axon” for nonpermeable axon (green)
- 1 rectangle for the cell body labeled “Soma” (yellow)

Note:

For a larger class, either double the number of cards for each character, except “Soma,” or repeat the demonstration with the remaining students. Also, you will need a space long enough for all the “Soma,” “Axon,” and “Gate” students to stand in a line and wide enough for three lines (“Ions” on each side of the “Soma-Axon-Gate” line).

Procedure:

This activity takes about 10-15 min of class time, including set up and organization. Start class by reviewing the action potential. Then tell students they are going to act it out. Ask for volunteers (Who wants to be a sodium ion? A segment of axon? The soma?) and encourage every student to participate. Have the students tape their construction paper label to their shirts. Place the “Axon” students in a line and insert the “Channel” students in between the “Axon” students, alternating one “K+ Channel” between two “Axon” sections followed by one “Na+ Channel” ion between the next two “Axon” sections, so it alternates “Axon,” “Channel,” “Axon,” “Channel.” The “Soma” stands at the head of the line. Now place the “K+ ion” and “anion” students “inside” the cell (keeping it relatively negative in comparison to the extracellular membrane) behind the membrane line and the “Na+” students on the outside or extracellular side of the line.

Step 1. Once the students are placed, tell the “Soma” student to stretch out both hands and keep count of the Starbursts as you or another student drops them into and removes them from her or his hands until the count reaches 10. These simulate the postsynaptic potentials. Drop Starbursts into the outstretched “Soma” hands, quickly removing some and dropping more, so the “Soma” really has to keep count.

Step 2. When 10 Starbursts are in hand, the “Soma” turns and gives a high-five to the “Axon” student next in line. See Panel 1, Figure 1.

Step 3. The “Axon” high-fives the “Na⁺ Channel” next in line.

Step 4. The “Channel” then ushers about 5 “Na⁺ Ion” students waiting outside the cell to the other side and then high-fives the next “Axon” student in line. See Panel 2.

Step 5. The “Na⁺ ions” diffuse (i.e., move) down the line.

Step 6. Meanwhile, the current “Axon” high-fives the “K⁺ Channel” student.

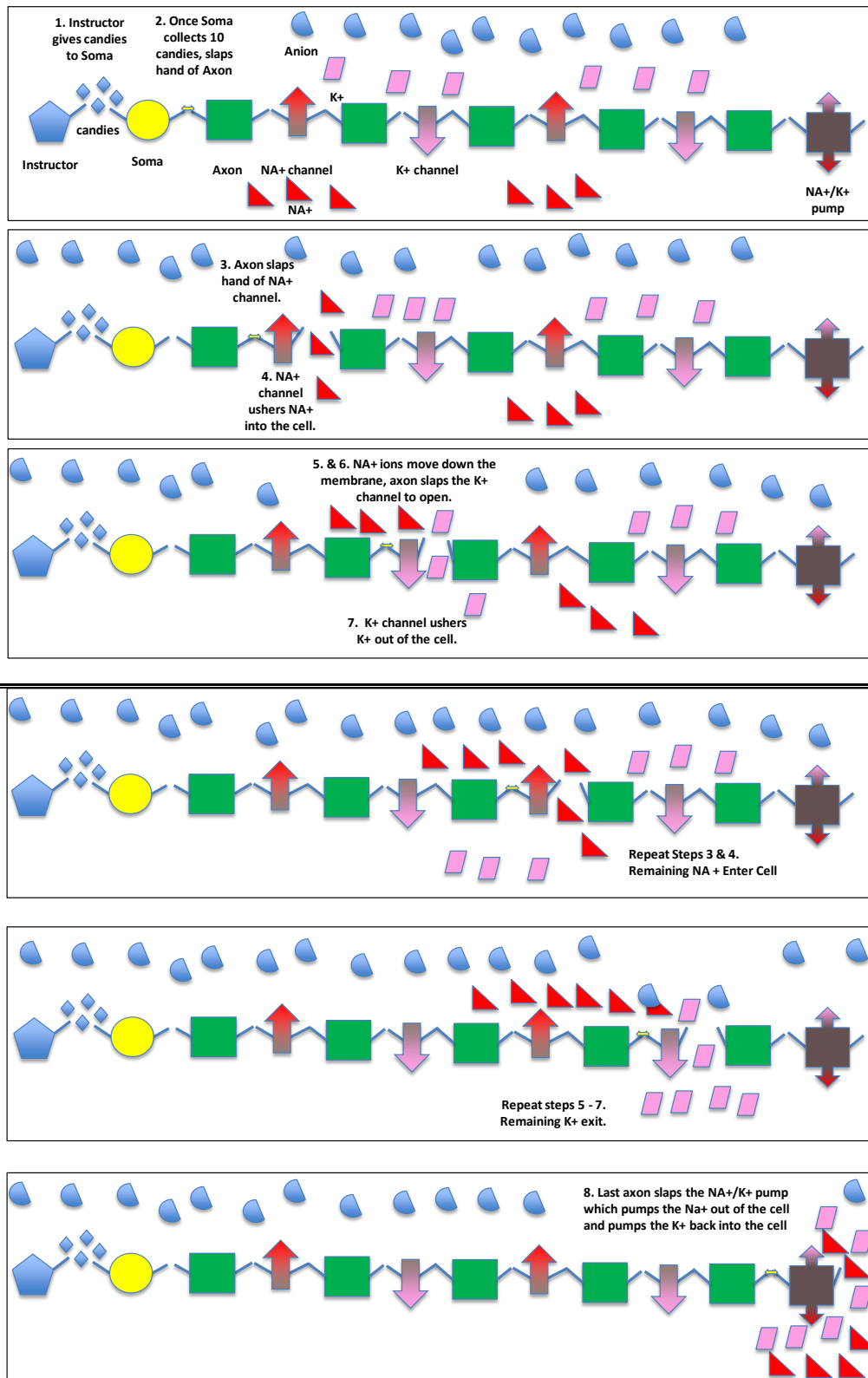
Step 7. The “K⁺ Channel” lets out about half of the now crowded “K⁺ Ion” students who were inside the cell. See Panel 3.

Repeat Steps 3 through 7. As the “Na⁺ Ion” students move down the cell, the “Axon” high-fives the next “Na⁺ Gate” and it opens and lets more “Na⁺” in, and the next “K⁺ Gate” lets more “K⁺” out. See Panels 4 and 5.

Step 8. Now tell the “Na⁺/K⁺ Pump” to start ushering Na⁺ out and K⁺ back in until all the ions are back where they started. See Panel 6.

As the instructor, you move up and down the line and direct the students to move where they need to go and when. You can repeat the demonstration to both practice and clarify the principals of the action potential. When the activity is complete, everyone gets a piece of candy.

Figure 1. Acting Out the Human Action Potential



4. Acting Out Saltatory Conduction

Principles Demonstrated:

This activity will clarify for students the function of the myelin sheath and the importance of saltatory conduction.

Equipment and Preparation:

This activity requires no equipment or preparation. It will take approximately 5 min of class time.

Procedure:

Ask for 15 student volunteers to come to the front of the class. Have 10 students stand in one line (representing an unmyelinated neuron) while the other 5 are in a second line (representing a myelinated neuron). Have the first line of students stand close to one another and hold hands. Have the second line stretch out so their line lengths are the same as the first line and have them hold hands. Tell students they are playing the “pulse game.” When you say “go,” the first student in each line will squeeze the next person’s hand, who will then squeeze the next person’s hand. When the student at the end of each line feels the pulse, she or he raises a hand.

What the students will find is the line with more students closer together takes twice as long to conduct the pulse signal as the line with fewer students standing farther apart. You can then explain that saltatory conduction works in this fashion – myelin allows for fewer points of re-initiation for the action potential and thus the signal can travel much faster down the neuron. Meanwhile, the neuron line without myelin has to keep reinitiating the signal constantly as it travels down the axon, and this takes much longer.

As long as the unmyelinated line is twice as long as the myelinated one, the activity can be modified for different class sizes.

If your class is more advanced, you could have students use a stopwatch or their cell phones to time the difference between the two lines as they finish the conduction game. These data could be compared statistically, thus giving students experience working with primary data. You might also lead the students into a discussion of why the myelinated axon is faster than the unmyelinated axon to complete conduction, incorporating ideas such as the purpose of insulation and time requirements for active propagation due to the opening and closing of ion gates.

5. Visualizing Exocytosis

Principles Demonstrated:

This activity will assist students in visualizing the process of exocytosis in the axon terminal button. Specifically, it will aid in understanding the form and function of vesicles and how they bind with the presynaptic membrane at the active zones to release neurotransmitter.

Equipment and Preparation:

You may either do this as a demonstration at the front of the class or have students perform the demonstration in small groups. You or each group will need a wide, shallow container, such as a disposable aluminum pie tin, into which you have poured some bubble soap; a large bubble wand; and a small bubble wand.

Note: Although this activity is basic, the act of visualizing the process of exocytosis may assist students remembering how the process works.

Procedure:

This activity will take between 5-10 min of class time. Perform this demonstration after lecturing about the process of exocytosis and the role of calcium and the SNARE proteins in vesicle binding to the presynaptic membrane. Explain to students that vesicles are like pockets or bubbles of protein, which is similar to actual bubbles.

Blow a bubble (make it as big as possible) using your larger wand and catch it on the base of the wand (you may wish to practice this at home before coming to class!). You can carefully rest this in the tray if you're concerned about losing it, or you may have a student hold it for you. Then blow one or more smaller bubbles with your smaller wand. Catch one of those as well. Now ask students to picture that the larger bubble is the presynaptic membrane with the inside of the bubble as the synapse. Explain to them that neurotransmitter packets will need to escape the vesicle (the smaller bubble) and diffuse into the synapse. When calcium floods the cell, it causes a reaction that allows the vesicle to bind with the presynaptic membrane wall. To demonstrate this fusion process, carefully tilt the smaller bubble onto the bigger bubble so that now it has joined with the larger bubble. You should be able to remove your wand and have the smaller bubble now on top of the larger bubble. Explain that in this way a neurotransmitter inside the vesicle is now free to dump into the synapse. Note that because the proteins forming the various membranes are similar in material, like the bubble soap, it allows for the fusion of the membranes and proteins when necessary (as in exocytosis).

6. Sampling Tastes on the Tongue

Principles Demonstrated:

This activity clarifies for students the role of the taste buds, the process of taste transduction for salt and sour, as well as dispels the urban myth that taste buds are localized to different regions of the tongue.

Equipment and Preparation:

Resources include small paper plates or napkins, unsalted unflavored tortilla chips or bland bread, enough lemon or lime wedges (or unsweetened lemon or lime juice) for all students in the class, small paper cups containing water, several shakers or containers of salt that can be passed around the class, and a pump-bottle of hand sanitizer.

Procedure:

This demonstration will take approximately 10 min of class time. It should follow lectures introducing the cell anatomy of the tongue, types of taste, and taste transduction. Before passing out the lime or lemon wedges or the salt shakers, re-introduce the idea of taste transduction by clarifying how sodium passes straight through the sodium ion channels on the taste buds and is the most simple form of transduction we know. Thus, salt is innately a taste enhancer because the influx of sodium automatically excites taste cells and makes them more likely to fire in the presence of other tastants. Remind students that sour works in a similar way to salt. Sour acids dissolve in water and release hydrogen ions. These protons are able to flow through the same sodium channels that enable our taste of salt, thus exciting the cell. You may also wish to note that unlike sodium ions, hydrogen ions also block potassium channels, decreasing the membrane's permeability to potassium and making it more likely to fire, which scientists believe leads to a different perceptual experience of sour from salty. Because of their ability to move through sodium channels, however, both sour and salty items should act to enhance flavor.

To those students who wish to participate, pass out the food items so that each student receives several chips or small pieces of plain bread and a lime or lemon wedge (alternatively, use paper cups containing a small amount of lime or lemon juice). Instruct students to taste a plain chip or piece of bread and rate its taste from 1 (*bland*) to 5 (*flavorful*). Students should then cleanse their palate with a sip of water. Now have students squeeze or sprinkle a small amount of lime or lemon juice on the chip or bread. Ask them to rerate the flavor – is the flavor stronger? Finally, pass around the salt containers and have students sprinkle salt on a chip or bread piece and rate it again. Why do they think people add lemon juice to water and salt to bland food?

The second part of this activity demonstrates how there are not separate compartments or areas on the tongue for each type of taste bud. Have students place a small amount of salt on the very back of their tongue. Are they able to taste it? Now have them clear their mouths and place some salt at the tip of the tongue. Can they still taste it? You may have them continue to place salt in various locations on the tongue, having a sip of water or a bite of the bland chip in between each trial to cleanse the

palate. They should conclude that all taste buds are equally distributed around the tongue, such that the different parts of the tongue are equally capable of responding to different tastants. You will want to mention the blind spot at the very center of the tongue, where no receptors are located – you may suggest that students try to find this spot, although they may find they have limited success due to the chemical nature of the tastants and how they spread upon contact with saliva.

In order to clarify that this is not true just of salty tastants, suggest that students attempt this same activity at home with different types of tastants (e.g., sugar for sweet, a small piece of meat for umami). Use the hand-sanitizer at the end of the activity to clean hands.

You may also use this demonstration as an opportunity to discuss individual differences in perception of taste, the role of the frontal and orbitofrontal cortex in taste perception, and the potential confounds in the task such as procedural difficulties and construct validity (e.g., rating tastes).

7. Emulating Labeled Lines and Population Coding

Principles Demonstrated:

This demonstration will help students to understand the function of labeled lines, how patterns of labeled lines lead to population coding, and how population coding leads to cohesive sensory perception.

Equipment and Preparation:

This demonstration requires at least one guitar or bass player with a guitar or bass; this can be a student or guest willing to bring in an instrument, or yourself. Alternately, you might download a single guitar string sound and chord sounds from the internet. One site that easily allows you to download guitar sounds is <http://archive.org/details/GuitarChord-A>

Procedure:

The activity takes approximately 5 min of class time. Begin by explaining the concept of labeled lines in taste and olfaction perception. Then, further explain how stimulating patterns of labeled lines leads to population coding of particular smells or tastes. Then you or the musician volunteer should play a single string or note. Explain that this is like a labeled line. A single note has no innate meaning to us but it does have a specific quality we can hear, just as a single tastant or odorant has a specific quality the neuron responds to individually. Now play or have the volunteer play a chord. Explain that this is like population coding. Now we suddenly have a holistic, integrated, beautiful sound that is unique – just as a pattern of neurons responding to a pattern of tastants or odorants now gives us a cohesive perception of that unique taste or smell. If you like, you can verbally extend this to an orchestra analogy for multisensory perception.

You may also wish to utilize this demonstration as an opportunity to give more detail regarding the gustatory and olfactory systems, the features of bottom-up and top-down perception, and some of the basic theory of sensation and perception such as parallel and hierarchical processing.

8. Experiencing Olfactory Adaptation

Principles Demonstrated:

This activity demonstrates the slow-acting nature of the unmyelinated olfactory nerves and also the process of olfactory sensory adaptation.

Equipment and Preparation:

You will need to be creative with your resources. Before the students arrive, you need to bring to class something that smells strongly/pungently (pleasant or unpleasant) such as heavily perfumed soap; pungent soap, herbs or flowers; or even garbage. If your classroom is very large, you may wish to bring in several such containers and set them around the perimeter of the classroom. Visually obscure or hide the items, so students cannot source the scent.

Procedure:

This demonstration will take place over an entire class period, but you should be able to conduct the class as usual while the demonstration occurs in the background. When students settle into the classroom, either ignore their comments on the smells or point out that their olfactory cells will habituate. Lecture on the transduction and process of olfaction and specifically point out the slow-acting nature of the unmyelinated olfactory nerves. Pause to ask students if they noticed a different odor in the class today. Ask them how long it took them to notice. It should be the case that it took them several moments to notice the scents after they walked into the door despite the strong smell, although students will report different experiences. Continue to lecture, including olfactory habituation as part of the topic for the day. By the time the class is over, students should by and large be less aware of the smell. Point this out to them at the end of the class (although this will make them re-aware of the scents – you can point this out too, if you want to give a quick nod to the role of attention). Explain that during the hour, they became much less sensitive to the scent, which allowed them to continue to operate in the classroom despite their initial response, and that this is part of the role of olfactory adaptation.

If you like, you can roll this demonstration into a discussion of the difference between the slow adapting olfactory system and other more rapidly adapting receptor systems (such as vision), the role of evolution on adaption and the systems involved in alerting to danger versus sensory adaptation to constant sensory stimuli and the purpose of both.

9. Acting Out Photoreceptor, Bipolar, and Ganglion Cells

Principles Demonstrated:

This activity will clarify when the photoreceptors are excited versus inhibited, the difference between the off and on bipolar cells, and when and how bipolar and ganglion cells respond to stimulation from the photoreceptors.

Equipment and Preparation:

This activity requires square or rectangular pieces of paper (one for each member of the class) and tape. The pieces of paper should be divided into four equal groups plus one group twice as large. For example, for a class of 36 have

- 6 rectangles labeled “Rod”
- 6 rectangles labeled “Cone”
- 6 rectangles labeled “On Bipolar Cell”
- 6 rectangles labeled “Off Bipolar Cell”
- 12 rectangles labeled “Ganglion Cell”

Procedure:

This activity takes approximately 15-20 min of class time. Start class by reviewing the principles of transduction in the eye and how photoreceptors synapse onto bipolar cells that then synapse onto ganglion cells. Students will probably need to be reminded that photoreceptors are excited in the dark and inhibited in the light, and that on and off bipolar cells respond differently to light.

Hand out the labeled paper and have students tape the labels to their shirts. Have the “Rods” and “Cones” come to the front of the class. Now pair half of the “On Bipolar Cells” with “Rods” and half with “Cones” and do the same with the “Off Bipolar Cells.” Then have a “Ganglion Cell” join each pair of students. You should now have 12 groups of three standing at the front of the class.

Begin the demonstration with the “Rods” and “Cones” and remind these students that they respond to light in the same way. Tell them that photoreceptors like to party at night and sleep all day. Because the classroom lights are on, it is day, so they should act sluggish, close their eyes, maybe sit down or lean against the wall to demonstrate inhibition.

Next, tell the “Off Bipolar Cells” that they are the best friends of the photoreceptors, so when photoreceptors are inactive, “Off Bipolar Cells” will also be sleepy and inactive. They want to do whatever their photoreceptor friends do. Have them mimic the photoreceptors.

Tell the “On Bipolar Cells” that they are like the gossip/not-nice friend of the photoreceptors. Whatever the photoreceptors do, the “On Bipolar Cells” will do the opposite. Thus, ask all of the “On Bipolar Cells” to immediately start acting up, jumping around, and gossiping to the “Ganglion Cells.” Therefore, when the lights are on, the “On Bipolar Cells” are active even while their photoreceptor companions are inactive.

The “Ganglion Cells” will be instructed to do whatever the “Bipolar Cell” they are paired with does. Thus, “Ganglion Cells” paired with “Off Bipolar Cells” should be sleepy and inactive; “Ganglion Cells” paired with “On Bipolar Cells” should be just as gossipy, talkative, and animated as the “On Bipolar Cells.”

The students should be able to look around the room and see two types of groups of three. Half the triplets will consist of three inactive people, whereas the other chains of three will consist of one inactive (the “photoreceptor”) and two active people. Whether the “photoreceptor” is a “Rod” or “Cone” will not influence the behavior, only whether the “Bipolar Cell” is labeled “On” or “Off.”

For phase two of the demonstration, dim or turn off the classroom lights. Now instruct the “photoreceptors” that because it is dark, they are awake and ready to party! Have them get all excited and talkative. Meanwhile, this will be the cue for the “Off Bipolar Cells” to get active as well, and thus so will their “Ganglion Cells.” Now the “On Bipolar Cells” and their paired “Ganglion Cells” should get lethargic and sleepy. Thus, the chains have reversed activity from what they did in the light.

You can run through this demonstration several times so that the students can understand that on bipolar cells are excited when the lights are on, regardless of what photoreceptors do, and off bipolar cells are excited when the lights are off, regardless of what the photoreceptors do.

10. Experiencing Touch Receptor Densities

Principles Demonstrated:

The difference in touch response on different areas of the skin depends on the density of touch receptor cells in that area. This activity clearly demonstrates the difference in the proportions of skin area represented in the somatosensory cortex and can directly be related, then, to the homunculus and its disproportional representations.

Equipment and Preparation:

This activity requires only that each student have a pencil, pen, or toothpick. It is also useful to project an image of the sensory homunculus.

Procedure:

This activity should take 5-10 min of class time. It is a fairly simple touch perception demonstration that should follow a lecture on mechanoreceptors and their various sizes of the receptive fields. Have students break into pairs or small groups, depending on the size of the class. Explain that we have different densities of skin receptors on different parts of our body depending on the level of use and the amount of detail we need from that body area. Refer to or show an image of the homunculus. You can point out that the hands and face are well represented but the arms and legs are barely represented and that this has to do with nerve density in these areas. More dense layers of nerves mean finer two-point threshold discrimination.

Ask students to roll up their sleeves. Students will shut their eyes in turn while their partner or group members lightly and briefly touch them on the arm (outer is better than inner) with the tip of the pencil, pen, or toothpick. The closed-eyed student must then try to approximate where the touch occurred once the pencil is removed – they can use a pencil tip to point to the location they believe was just touched so as not to obscure the distance between the actual touch location and their approximation. They should be several centimeters off. Have students try this with each other until everyone has had a turn attempting to localize the touch. Note: because the receptors in these areas are large, less specific information is being transmitted to the brain. Now have students perform this activity again, but the touch should occur on the palm of their hands. They should be able to exactly identify the location of the touch. Once they have all tried, point out that there are many small, densely packed receptors on the palm, thus giving it greater representation in the homunculus and allowing for more precise touch perception. You can also segue into a discussion regarding the type of mechanoreceptors on different areas of the skin and their response characteristics to different kinds of stimuli.

If you wish to further expand the demonstration, you might include different types of touch stimuli to activate different types of mechanoreceptors on the arm or palm. For instance, you can include the corner of a piece of paper and then vibrate the paper gently with your fingers to create a different vibration frequency for the touch. You might also include different types of stimuli, such as a feather, the tip of a piece of chalk, or the edge of a penny, and ask students to guess what the stimuli are depending on whether they touch the arm or the palm of the hand. This can lead into discussions of active and passive touch and top-down versus bottom-up processing in the role of perception.

11. Acting Out Synchronized Cell Oscillation

Principles Demonstrated:

This activity will aid students in understanding how populations of neurons synchronize their firing patterns with one another at a local and global level in the brain, and how this synchronized pattern is believed to be a neural correlate of awareness.

Equipment and Preparation:

This activity will require moving the classroom chairs against the walls or finding spaces where groups of students can march in place.

Procedure

This activity takes about 10-15 min of class time. After explaining that neurons fire in unity via synchronized cellular activity, divide students into three groups. Alternatively you can just divide the classroom into thirds and have students march next to their desks. Ask the students to stand up and make room for themselves to march in place (while standing in their three separate groups). From the front of the classroom, explain that you are a single neuron in the auditory system and you are firing in temporal unity with an external vocal pattern. Begin to march, slowly. Now ask the first group (Group 1) of students in the room to march with you (to the cadence: 1, 2, 3, 4; 1, 2, 3, 4). Explain to the class that Group 1 consists of sensory neurons in the auditory cortex and the neurons they synapse with in the inferior colliculus and other “early” midbrain sensory regions. Once Group 1 has the hang of marching, have them stop for a moment, but ask them to remember the rhythm. Now explain to Group 2 that they are receiving synaptic input from Group 1. While Group 1 begins again to march at their old rhythm (1, 2, 3, 4), Group 2 should start marching twice as fast but in time with Group 1 (1&, 2&, 3&, 4&; 1&, 2&, 3&, 4&). In other words, Group 2’s base rhythm should match the slow beat of Group 1, but they should be hitting the half-beats as well. Now pause both groups while you instruct Group 3 that they are higher-level systems in the temporal and parietal lobes that help to bind conscious information together. They fire at even faster rates but are still receiving input, and thus firing in rhythm with the first two groups. Ask Group 1 to start marching and Group 2 to join in. Now have (and assist by demonstrating) Group 3 start marching in rhythm but hitting the interim and half beats (1a&a, 2a&a, 3a&a, 4a&a) – note that they *must* hit the 1, 2, 3, 4 when Group 1 does, and the “&” beat when Group 2 does. Once the rhythm is well-established, you can point out that this is how neurons in the brain communicate and how information that is the focus of attention gets amplified and selected for further processing at a neuronal level. This is a fantastic opportunity to guide the class into a discussion about the neural underpinnings of consciousness and the predominant theory of how neural oscillatory synchrony and the phase-locking of neuronal patterns allow certain stimuli to be amplified to conscious processing.

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