

The Incredible Edible Excitable Neuron

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ABSTRACT:

To understand any concept in neuroscience, one must have a solid understanding of the structure of the functional unit of the nervous system. In this project we constructed interactive models to help teach young students the important structural features of neurons. A large poster along with a large model neuron was used as examples to display the basic structure of a neuron. To reinforce this information, the students were asked to build model neurons out of food products, including marshmallows and fruit by the foot. As these models were built the students were taught the name and function of each of the individual parts of a neuron. This project proved successful when presented to students, with our group receiving a rank of second overall in a student judged competition. More importantly, the students seemed to learn and retain this new information.

INTRODUCTION:

One of the most fundamental concepts in all of neuroscience is an understanding of the structure of the neuron. For much of the early history of neuroscience, the

neuronal structure was unknown due to a lack of technology. With the invention of the compound microscope a new field of tissue study developed known as histology.

However, it was found that observing thinly sliced brain tissue under a compound microscope elucidated little about the structure of cells within the tissue. Thinly sliced brain tissue appeared as an even, flesh colored tissue, with no way to discern individual cells (Jones 1988).

In order to visualize individual cells in a slice of brain tissue, staining methods were created, in which individual neurons absorb specific dyes. One such stain, which is still in use today, was discovered by Franz Nissl. This method known as the Nissl stain, uses Cresyl violet, a basic dye to stain the nuclei of all cells (Jones 1988). In addition, material surrounding neuronal nuclei is also stained. This stain became very useful in that it was able to distinguish neurons from other supporting cells, the glial cells.

Although this was a useful histological method, the Nissl stain was limited to visualizing only the nuclei of cells and showed nothing of neuronal structure other than the nuclei. However, in 1873, Camillo Golgi discovered that by soaking a slice of brain tissue in silver chromate, a small number of neurons became stained in their entirety (Golgi 1906). This stain, known as the Golgi stain, revealed that neurons are in fact composed of a central region, from which many projections radiate.

Using this stain, along with the Nissl stain, the parts of the neuron were named. The central region as seen in the Golgi stain was named the soma, or cell body. This region corresponds to the part of the neuron visualized by the Nissl stain (Golgi 1906). The thin projections leaving the soma were labeled as neurites. Neurites were found to

be of two types, a single axon of constant diameter projects from the soma, as do several dendrites, which have tapering ends (Golgi 1906).

Using the Golgi stain, a Spanish scientist named Santiago Ramon y Cajal studied many different regions of the brain, examining the circuitry found in each. Cajal was able to stain individual neurons, showing that brain tissue was not continuous; rather neurons were distinct cells (Ramon y Cajal 1908). This finding was important historically because it led to the formation of the neuronal doctrine, which states that individual neurons are the elementary signaling elements of the nervous system.

Further study of the nervous tissue revealed that some axons are surrounded by multiple membrane layers called myelin. Myelin originates from two different types of cells depending on their place within the nervous system. Oligodendrocytes, found in the central nervous system, wrap their membranous projections around approximately 15 axons. In contrast, Schwann cells, which are found in the peripheral nervous system, only surround a single axon (Jones 1988).

In both cases, myelin insulates the axon and allows for greatly increased transmission speed of action potentials. The myelin does not wrap around the axon continuously down the length of the axon, but is interrupted at somewhat regular intervals. These breaks in myelin are known as Nodes of Ranvier (Jones 1988).

It is at these points where ions cross the membrane to generate action potentials. Action potentials initiated in the axon hillock are able to travel down the axon by skipping from node to node. This leads to greatly increased speed, since the action potential only has to travel from node to node, not down the entire length of the axon.

This idea is known as salutatory conduction and is responsible for the extremely fast transfer of information within the nervous system (Jones 1988).

Using these basic concepts as a background, it was the goal of our project to present a model to children explaining the basic structure of a neuron in an interactive way. It was our thought that by relating the different parts of a neuron to some commonly used items, the children would learn to remember the basic structure of a neuron. Therefore, we had the children build their own neuron out of food products including marshmallows and fruit by the foot; all while teaching what each type of food represented and the function of each structure. Our project was then judged by children, and compared to other projects. These projects were then ranked by the students with our group receiving a rank of second overall.

METHODS:

Three forms of media were used to aid in teaching the structure of neurons. First, a large poster was constructed. Images out of a Biopsychology text book were scanned and then enlarged, after which they were glued to a large piece of poster board (Pinel 2000). These images included an animation of a neuron with all of its units labeled, including myelin. Also a smaller, non labeled picture of a neuron was used. A picture of an action potential was also used.

Next, a Styrofoam ball was cut in half and attached to the poster to represent the cell body of a neuron. Different types of candy were then glued to the inside half of the ball to represent the different organelles found within the cell body. Jelly beans were used to represent mitochondria, a malted milk ball was used to represent the nucleus,

gummy worms were used to represent the endoplasmic reticulum and small pieces of licorice were used to represent the Golgi complex.

On the poster, dendrites were drawn out from the cell body, as was a large axon. Along the length of the axon, half roles of toilet paper were glued to the poster to represent myelin. A Styrofoam cone was cut in half, and glued to the poster at the end of the axon to represent the axon terminal. M and M's were glued to the inside of this cone to represent the synaptic vesicles.

In addition to the poster, a large, free standing model of a neuron was constructed. A large Styrofoam ball was again used, this time in whole. The ball was painted red and several thin, bent wires were placed into this ball to represent dendrites. Next, a cardboard tube from paper towels was cut, and a small section was placed into the side of the ball opposite the dendrites. This tube represented the start of the axon.

At the end of this short tube of cardboard, half a role of toilet paper was placed over the top of the cardboard tube. The toilet paper again was used to represent myelin. Three roles of toilet paper were used along the length of the axon and each was separated by a short piece of clear plastic tubing. This tubing was used to represent the Nodes of Ranvier.

After the last role of toilet paper, another short section of cardboard tubing was used. Running inside of this long tube like axon was a piece of red string, representing information traveling down the axon. This string was attached to the Styrofoam ball at one end and a cone shaped piece of Styrofoam at the other, representing the axon terminal.

Because this red string could only be seen through the clear plastic pieces, this provided an accurate model by which to demonstrate how an action potential propagates itself down the length of a myelinated axon. The children were able to see the red string “activity” at the clear Nodes of Ranvier, thus demonstrating salutatory conduction.

The final teaching aid in this project involved having the children build their own neurons. When the group came to our station, each child was given a marshmallow and was told that it represented the cell body of a neuron. Cell bodies were also pointed out on each of the other two visual aids and the children were told that the cell body is the “brain of the cell,” helping to maintain normal cell function.

Next, the children were given approximately four toothpicks and instructed to place them into the marshmallows. The children were told that these toothpicks represented the dendrites and that dendrites functioned to receive information from other cells in the nervous system and send this information to the cell body. Dendrites on the poster and on the model were pointed out to reinforce this concept. Next each child was given half of a straw and instructed to lace the straw in the marshmallow on the opposite side as the dendrites. The children were told that the straw represented the axon and that the axon functioned to pass information out to other cells in the nervous system. Again, axons were shown on the other models so that every child understood the structure.

Next, each child was given a small strip of Fruit by the Foot and instructed to wrap this strip around the straw at three different places along the straw. They were told that the fruit by the foot represented myelin and that myelin functioned to speed the transmission of an action potential down an axon. The roles of toilet paper on both the poster and model were shown to help explain the wrapping of myelin around the axon.

Also, the large model neuron was used to show how information jumps from one node to another, thus speeding information transfer along the axon.

After their edible model neurons were complete, the children were not allowed to eat their neurons until they had reviewed each of the parts of the neuron and the function of each. Students from the group were randomly selected and asked what each of the different parts of the model represented in a real neuron. Students were then asked the function of these parts. This was done to get each student involved in the project and further reinforce the information presented in this project.

RESULTS:

The students seemed to be very receptive of the concepts presented in this project. After they had built their neuron, they all seemed to have a grasp of the basic parts of the neuron and the function of each part. More importantly, they all seemed to enjoy participating in this project. Therefore, it was no surprise that our project was voted second overall for group B.

After review of the judging sheets, it was found that our scores were very similar to all other groups. Our highest score was in the fun category, with an average score of 4.67. Our lowest score was in the Learn More category, where we had an average score of 3.92. This is of no surprise, however, since every group seemed to receive their lowest score in this category.

There was an interesting discrepancy between our average score in each category and our overall rank. Although our group ranked second overall, our average scores for each category seemed to be lower than most of the other groups. This can be explained

in a number of ways. First, it is possible that when it was time for the students to make their final vote, they realized they had enjoyed our project more than the others. So, although they had already given us a low evaluation, we received more overall votes because our project was most enjoyable. Another possibility is that the students were voting on criteria not covered in the evaluation sheets. For example, if they were voting purely on their like, or dislike of the presenter, which was not an evaluation question, then there would be little correlation between scores on the evaluation sheet, and overall rank.

DISCUSSION:

Overall this project seems to have been a success. By combining the individual student's reactions with their input from the judging sheets, it seems as though they enjoyed themselves and felt as though they learned from the project as well. Although our score was low in the Learn More category, this should not be taken as a flaw in the project.

Comparing our scores with those of the other groups, it is clear that every group received low scores in this category. This is probably due to the age of the students and the complexity of the concepts in each of the projects. It is not surprising that children of this age would not be terribly excited to learn more about neuroscience, especially at a time in development when most children are more interested in being police officers or firefighters than scientists.

Examination of the mean scores for each category proved very interesting. Having a standard deviation of $\pm .5$, we see that these means are not very representative

of the population. The measurement of standard deviation was high compared to the difference in mean values, thus not statistically significant.

The presentation of this project seemed to get better as the day progressed. Although we knew the information we wished to convey, we were not given enough time to explain all of our details, like all of the organelles in the cell body, and each of their functions. We learned this lesson the hard way when our group was supposed to be finishing up before we had even started to build the edible neuron. With each subsequent group the information became more directed towards the neuron structure. We were then careful to teach the structural concepts, and make sure these concepts were reinforced several times, so as to ensure the students learned.

The first group of students did not seem to enjoy our project as well as later groups, which probably meant that we did not receive many overall votes from this group. This could have led to our ranking of second instead of first overall.

Our presentation was not perfectly scientifically accurate since it focused on a very simplified version of the neuron. Not all neurons are perfectly linear, as was our model, with a cell body in the middle, and its neurites projecting out in either direction. Here we sacrificed scientific accuracy in order to keep the concepts simple enough to be taught to the young students.

The idea of saltatory conduction was a difficult idea to express, however our large neuron model with clear nodes simplified this concept by allowing the students to visualize the information jumping from node to node. Of course this is a very simplified version of the actual propagation of signals; however, to effectively present this idea, simplicity was needed.

Neither our large model nor our edible models were created to scale. In most neurons the axon is much longer than the dendrites; however, it was not that much longer in our models. This is of little importance, since that degree of accuracy is not necessary for the concepts important to our presentation.

Other problems with the presentation relate to the space allocated to each group. We were limited to one table, which was insufficient for the large size of each of the student groups. Some students were unable to see or hear the presentation, although every effort was made to accommodate each student.

Further, since all projects were confined to such a small space, many students seemed distracted by the other projects around our table. In particular, projects that made loud noises seemed to steal our student's attention. Future presentations would run much smoother if the sizes of the groups were decreased and the projects were spaced further apart. Also, if a few more minutes were available, the depth of the topics covered could be increased.

It is our hope that this project educated students about the structure of the neuron. We hope that learning about these concepts sparked an interest in neuroscience that might one day lead these young students to a career in neuroscience.

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