

Tiffany Ludka
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Model Draft

Synaptic Tag

Abstract

Synaptic Tag is a game that was designed as a means to teach neuroscience to fifth graders. Its focus is the mechanism of transmitter action in the synapse. By modifying the basics of the child's game of tag, we were able to create a model of the synapse that taught about the roles of neurotransmitters and enzymes, and the impact of drugs on normal functioning. The structure of the synapse has been understood since it was first visualized in 1957. Subsequent studies have effectively shown the mechanism of action within the synapse. Based on this information, we were able to represent the more basic essential parts of synaptic transmission in our model. The kids were part of our model. They played the role of either a neurotransmitter or an enzyme. The object of the game was for the neurotransmitters to run from the pre-synaptic to the post-synaptic side of the course without being tagged by the enzymes. When drugs were introduced into the game, the enzymes were not allowed to move their feet, effectively reducing their efficacy. The understanding of the students was tested at the end of each trial run. We asked them what the significance regarding the strength of action potential transmission was. They had to make their decision based on the number neurotransmitters successful at completing the task during the trial. The students came away from the game with a pretty clear and thorough understanding of synaptic transmission. Our model was ranked second place in our group. It was consistently ranked highly in all four rating categories. Our model was an effective tool for teaching neuroscience to kids because it was both educational and fun.

Introduction

The purpose of this model was to demonstrate the action of neurotransmitters and enzymes in the synapse. The synapse was first visualized via electron microscopy by Trujillo-Cenoz around 1957 (Duncan). There were many discoveries that eventually led to the current understanding of synaptic action. In 1961, Davis proposed that the general mechanism of synaptic transmission is as follows: "stimulation (of a sense receptor) produces a receptor potential which causes the liberation of a transmitter. On its arrival at the post-synaptic side, this transmitter produces a generator potential which initiates the action potential in the (post-synaptic) neurone" (Davis). This elementary understanding of the travel of the action potential across the synapse became the accepted model of transmission. This was only a very basic understanding, however. There have been many research theses and discoveries that have led to our current understanding of the synapse. Once the method of basic transmission became common knowledge, many people began to assume that the differences in potentials in different cells were due to the release of different transmitters. There has been significant research in the area of neurotransmitters. Many chemicals such as acetylcholine, sodium, potassium and - amino butyric acid have been researched to determine if they are neurotransmitters.

Inhibitory post-synaptic potentials have been studied to determine why they are different from excitatory potentials (Tauc). Analysis of potentials from damaged cells has also proven to be a valuable research tool (Vera). Due to the abundance of research in these areas, the mechanisms of synaptic transmission have been well characterized.

Methods

Our project was a model of the neural synapse. To create the space, we put tape on the floor in the shape of a rectangle. It was approximately ten feet wide by fifteen feet long. The short sides were representative of the pre-synaptic and post-synaptic cell membranes. The kids were themselves part of the model. The typical size of the groups was six kids. Two were given signs to put around their necks labeling them as enzymes. They stood in the synapse facing the pre-synaptic side. The remaining four kids were given signs indicating that they were neurotransmitters. The tape was blue in color to facilitate ease of discrimination from the floor. This was important because the neurotransmitters were not allowed to go out of the bounds of the synapse. There were two X's taped on the ground in the middle of the synapse, one in front of the other when looking at the pre-synaptic cell. They were spaced about an arm's length from each other. This was the location where the enzymes started in the first set of trials and also served as the drug holding the enzymes in place during the second set of trials. Also important was the candy at the post-synaptic side of the synapse. When the neurotransmitters reached the post-synaptic cell, the way that we demonstrated the result of the transmission of the signal was the movement of the neurotransmitter's arm reaching for candy.

Results

Our model was very successful at teaching fifth graders about the neural synapse. This fact is shown by the high grades our model received in both the rating of individual aspects of our model and its overall ranking of second place. We placed above the average of the group we were placed in for all four categories. There was anecdotal evidence to go along with the numbers that showed that the students learned and also enjoyed themselves. After running through the game once, we would ask the kids to explain what happened and what the results of the neurotransmission (or lack thereof) would be. They were able to accurately reveal the correct outcomes resulting from the transmissions. A few of the students told us that our model was the best because it was the most fun. On the grading sheets, many students commented that the game was fun and that they liked running. Also on the comment sheets, the students were able to write an example of something they learned from our model. Very few were left blank, and only one wrote that nothing was learned. Most wrote that they learned about neurotransmitters, enzymes, or how drugs can interfere with the normal system.

	Understand	Friendly	Fun	Learn More	Average	Place Vote
Synaptic Tag	4.79	4.75	4.75	4.25	4.635	2

Discussion

In our model, we demonstrated to fifth graders the basic mechanism of synaptic transmission. We started the model by explaining the basics of synaptic transmission. We wanted to promote the interest of the students by having them become one of the

essential transmission elements. We taped off a rectangle on the floor approximately fifteen feet long by ten feet wide. This was the synaptic cleft. To keep the concept simple for easier understanding, we limited the initial trial to only neurotransmitters and enzymes. The purpose of the game was for the neurotransmitters to run across the long length of the synapse to “trigger” the potential in the post-synaptic cell. However, we did not want the task to be too simple, so to add difficulty and fun, two students were enzymes in the synapse. Their job was to catch as many neurotransmitters as possible to prevent them from triggering a signal in the post-synaptic neuron. The students wore signs around their necks to help them remember the words “neurotransmitter” and “enzyme.” We ran the trial several times to allow different students to play the role of enzyme. The enzymes were only able to tag one neurotransmitter at a time. If the neurotransmitters ran outside the boundaries of the synapse, they were recycled back to the pre-synaptic cell and did not induce cell firing. The second set of trials was in the presence of a drug. The drug ended up increasing the strength of potential in the post-synaptic cell by preventing the enzymes from moving their feet. Therefore, this impaired the enzymes’ abilities to regulate the potential. There was discussion after the game to informally test the understanding gained by the students. Although the ways in which transmission was modeled were not entirely accurate, we feel that the inaccuracies we allowed dramatically increased the ease of understanding.

We would talk with the kids about how much neurotransmitter got to the post-synaptic cell and they would tell us how strong of a response there should be in the post-synaptic cell. In our pre-play discussion, we used the example of a cell in the brain telling a cell leading to the arm to move. The purpose of the movement was to grab something. To further illustrate this point, when the neurotransmitters reached the post-synaptic cell, they were allowed to do the action and use their arm to grab a piece of candy. They told us that when many neurotransmitters got across the synapse, there would be a strong signal and the arm would be able to move (just like when many of them got candy). But when only one or two would make it across, the signal to the arm would not be very strong, and maybe the arm would not be able to move far enough to get the candy (just like how only a few students got candy when that happened). Our model was an effective teacher because the students had fun while they participated. It is very important for the students to have fun because they will be more likely to remember the important details of the game if they enjoyed playing it. Toward the end of the day the students who did not have a chance to visit the models in our group were invited to look at them. We had many students approach us about how our model worked and what it taught. Most importantly, as more and more students were interested in playing during the break, we began asking the students who were already playing to explain to the newcomers. They did wonderful jobs of explaining the synapse, neurotransmitters, and enzymes. I was very impressed with their depth of understanding. The students who came to play during the break were not given candy and our model was still very popular. That shows that the kids were having fun playing the game, not just hoping to get candy.

Although our model served its purpose very well, there were some limitations. For example, to make the model reach the level of understanding of a fifth grader, we had to simplify the process considerably. The neurotransmitter does not enter into the post-synaptic cell. Having the enzyme touch the neurotransmitter does not accurately

represent the mechanism of inactivation. Drugs do not immobilize the enzymes like in our representation. The acts of the neurotransmitters running toward the postsynaptic cell and the enzymes actively seeking the neurotransmitters do not accurately model the diffusion and random collisions in a real synapse. There is no “boundary” to the synapse, whereas our play-field had boundaries. As set up, our model was also limited to the number of students who could participate. Overall, I feel that our model was a very effective tool for teaching the complex topic of neuroscience to fifth grade students.

Works Cited

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