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Neuro 430
KidsJudge! Neuroscience Fair 2007 Exhibit
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Neuron Gossip

Abstract

We used a model to demonstrate the concept of chemical synaptic transmission and receptor specificity. We wanted a group of 5th grade judges to learn what synapses and neurotransmitters were, and how they play a role in neurons sending messages to one another. We compared receptor specificity to language, by talking about how someone must be able to understand the words a person is using in order to do something they are being told. In this same way, neurons send molecules that are like specific words and only certain receptors on a second neuron can "understand" those words. To experiment with this concept, the judges participated in an activity where they had to discover which neurotransmitter (objects of different size and shape) fit into their receptor (receptical with different sites to put the objects). More than half of the judges answered questions that demonstrated that they had learned the concepts, but we could improve their learning by increasing the fun they experience and decrease the amount of time we spend talking. This would hold the attention of more students.

Introduction

At one time, people thought that the nervous system was one large unit that had intricate branching instead of discrete cells. As research progressed, better stains and microscopic imagery emerged and showed this assumption to be false. Neurons can be connected so that the action potential can travel directly from one neuron to the next (electrical synapses), but there is also a second type of synapse that allowed neurons to communicate and transmit signals to a neighboring neuron without the neurons actually being connected physically (Bloom 1988). These connections are made at chemical synapses, when the first neuron (presynaptic) releases chemical substances called neurotransmitters. These neurotransmitters are held in vesicles until they fuse with membrane of the presynaptic neuron and release the neurotransmitter through exocytosis. This process is triggered when the arrival of an action potential caused the influx of calcium (Llinas, et al, 1986). The next neuron (postsynaptic) has sites (receptors) where the neurotransmitters can bind, but not just any neurotransmitter will bind to any site. A conduction of the signal will only occur if a neurotransmitter is bound to its corresponding receptor, upon which the cell can translate this binding into an excitatory or inhibitory signal. These signals can be triggered in the postsynaptic cell by direct opening/closing of channels or second messenger systems (Nicoll, et al, 1990). The type of neurotransmitter and receptor will determine the form of trigger that is used.

The difference in neurotransmitters and receptors lend to the diversity of the ways a neuron can react. There are many classes of neurotransmitters. Some of these classes include serotonin, epinephrine, norepinephrine, acetylcholine and dopamine (Nicoll, et al, 1990). Each of these neurotransmitters is chemically different and will only fit into a certain type of receptor (Dani 2001). This difference is important when considering the communication of one neuron to the next and when classifying a molecule as a neurotransmitter. The signal released must be recognized by the neighboring neuron in order for the neurotransmitter to have any effect.

A single neurotransmitter does not have only one action. As mentioned previously, the subtype of receptor also plays a role in the action of a neurotransmitter. One subtype of receptor could be connected to a channel and binding of a neurotransmitter opens the channel (i.e.; potassium channel). Another subtype could be a G-protein coupled receptor that initiates a second messenger cascade (Lopez-Ilasaca, et al, 1997). Also, these different receptor signaling pathways do not always have the same effect on the postsynaptic neuron. For example, depending on the subtype of receptor, acetylcholine can be excitatory or inhibitory. Two completely different results can come from the binding of the same neurotransmitter (Nicoll, et al, 1990).

The purpose of our model was to demonstrate the idea of neurotransmitter selectivity to groups of fifth graders. We used a game that lead them to discover which type of neurotransmitter will work in their receptor. At the end we asked the students questions to encourage further thought and retention of the information. The most important thing we wanted the students to learn from this model is that in order for one neuron to communicate to the next neuron, the first neuron must release the correct signal. It must be a signal that is recognized by the second neuron or the signal will not be transmitted.

Methods

We started by pairing the judges up and having them stand across from one another. We gave judges on one side an egg which had a note with a message inside. We told the judges that they had to get that message to their partner without reading it to them. The idea is to get them to throw the egg to their partner, who reads it and does the action (i.e. do a jumping jack). We explained that there are gaps between neurons (synapses) and that neurons cannot use verbal communication in order to communicate. We told them that the neurons send special signals in the form of neurotransmitters. We used a poster to show the students a pathway (brain to the leg) that the nervous system utilizes. The pictures focused on the synapses and gave a basic explanation of how the neurotransmitters are released and travel to the next neuron. Next we began speaking phrases to the judges in different languages (French, Russian, German), and switched back to English. We asked the judges what was easier to understand. We pointed out that even though neurotransmitters cannot speak, they send signals (neurotransmitters) that act like words. These signals are specific and have to be understood by both neurons in order for the signal to be sent. After this discussion, we separated the students into three groups to play a game. We constructed three "receptor sites." Each team had a different receptor. Through trial and error they had to discern which neurotransmitters (objects of different size and shape) would fit into their receptor. They had to correctly bind a neurotransmitter to their site three times in order to complete the relay.

To make our receptor sites, we started by constructing the tubing that the neurotransmitter would travel through. We decided that we wanted the tubes to allow the passage of marbles, bouncy balls and plastic Easter eggs. For the marble tube we used poster board. Because this was the smallest object we would be placing in the sites, we were just able to make a simple tube. We used cut up aluminum cans to make sturdy tubing for the two larger objects. With these tubes we had to cut slits at the base of the tubes that would allow any object smaller than the correct object to fall through. If the object was the correct size, it would go the full length of the tube and drop into a box that could be seen though a window. In addition to the three objects that were correct for one of the sites, we also had tennis balls and wooden blocks to give the students a wider variety of items to choose from. The slits had to be large enough so the blocks would fall out also.

We set up the receptor sites in a large cardboard box. We cut the windows in the box so that if the students picked the correct neurotransmitter then they would be able to see it in the window. We placed funnels of poster board at the top of each receptor site so the students would not be able to tell which neurotransmitter was the correct one by just looking at the hole they were placing the objects in during the game. We covered the box in green and white paper and had pictures of appendages with a neuron to demonstrate where the signals might be going once the neuron receives the neurotransmitter. See figure 1 for a diagram of the receptor box.

After the judges finished the game we discussed why certain neurotransmitters would not work in certain receptor sites (i.e. size and shape). We asked question in order to gauge how much they learned.

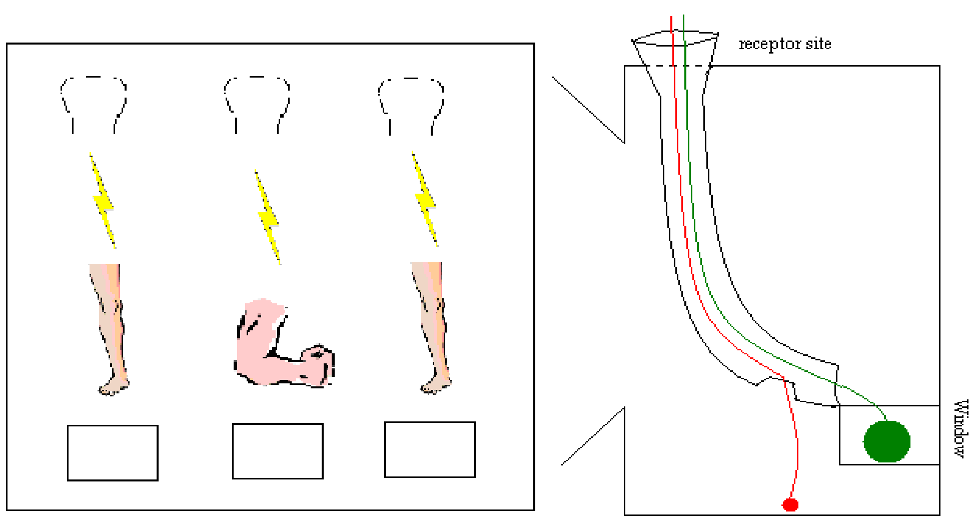

Figure 1. The diagram on the left is a view of the front of the receptor box. The diagram on the left is a view of the side of the box through to the inside.

Results

We found that a majority of the judges seemed to understand the basic idea of a synapse and neurotransmitters. By the end of the session most of the judges answered "synapse" in response to the question, "what is the gap between neurons?" and "what do the neurotransmitters have to pass through to get to the second neuron?" They could also respond with neurotransmitter to the question, "What is the name of the messages that the first neuron sends to the second neuron?" In the evaluation sheets, nine out of the twenty-eight children used the word synapse. Five of the children used the word neurotransmitter. Six of the children talked about the concept of the neurons sending messages to on another. In drawings received back from schools, there were two that showed a picture of neurotransmitters floating across the synapse. When the judges were asked on the evaluation sheet whether they understood what we were trying to tell them, we received an average score of 4.32 (5 being all and 1 being nothing) (Figure 2). This score is lower than those in the other three exhibits in our group. At least one child in three of the four groups was able to answer a question that required taking what they learned and applying it. We asked them, "if someone wanted to make their leg move and that person thought about it and nothing happened, why?" We had many different answers pertaining to what we had taught them: the first neuron is not sending the correct message; the first neuron is damaged so the message is not being sent; or the neurotransmitters are floating away and not making it to the second neuron.

In addition to understanding, the judges evaluated presenter friendliness, exhibit fun and whether they would like to learn more about the topic (5-high to 1-low). For each of these categories we received 4.68, 4.25 and 3.6, respectively. We were also ranked 4th overall (Figure 2). In all categories we scored slightly lower than the other exhibits in our group. When the judges were asked about what part of the exhibit they enjoyed, eighteen of the judges talked about the games and two said they enjoyed learning.

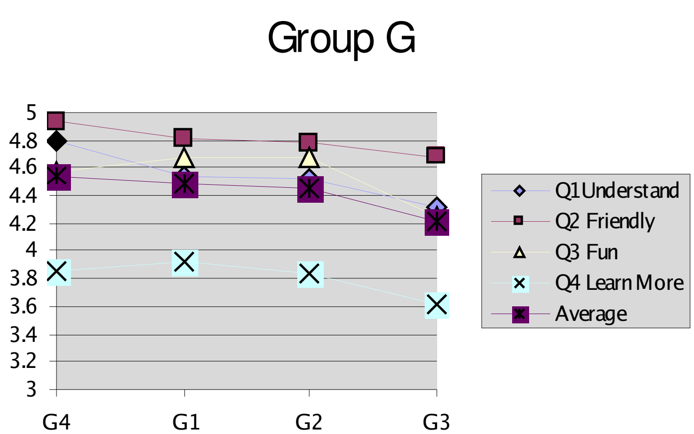

Figure 2. This is a graph of the average scores of the exhibits in ours group on the 4 categories of the evaluation sheet and the average score. Our group is represented by column G3.

Discussion

Our model was set up to demonstrate the concept of receptor specificity. We wanted the kids to take away the concepts of synapse, neurotransmitters and the fact that the neurons send specific messages. In order to make the subject easier for the kids to understand, we did have to omit some details. We discussed size and shape as a way a neuron codes that message, but we did not discuss charges. We also avoided discussing that there is not always a one to one relationship between the type of neurotransmitter and the receptor. We wanted to make sure the kids could just get the main idea.

We feel that many of the kids learned the basic idea. Their ratings were low for this area compared to the other groups, but more than half of the kids were able to answer the questions at the end of the session, and they were able to write coherent comments about what learned. One way we may be able to improve their learning is by keeping their attention. Our rate of fun was significantly lower than the other groups and I believe this affected how some of the kids took in the information. We had two activities, but they were short compared to the talking. By the end of the discussion, after the last game, the kids had a hard time focusing on what we were saying and asking. I think if we could integrate the explanation into the games more the kids would be more engaged. The children that have a shorter attention span would have learned more. We do need a balance between fun and learning, though. It is important to note that our exhibit was close to the "What's in Your Nose besides Boogers" exhibit, which was very active and attention drawing to student125s who were not even participation in that exhibit. We often had to compete to gain the students attention.

The judges did enjoy the model, but we could make improvements on it to make the experience better. It was not very durable. We had to do some minor fixes before the judging started and by the end of the last group, one of the tubes was coming away from the window. The box should also catch the eye of the judges more. We could use brighter colors and more professional looking finish and pictures. We did have a few problems with the game that did not pertain to the box itself. The kids had a hard time communicating with their partners, so they would try multiple items more than once. I also believe the idea that the small items would fall out of the back of the box was a little vague. It would be good if the box had a way to shoot the small object back to the front and out of the box. If we did this again we would try and find a way to explain the parameters of the game better. We just did not want to spend too much time talking, so we cut this explanation shorter than maybe we should have.

Overall, I believe a majority of the judges came away with an idea of how neurons communicate across a synapse using neurotransmitters that code specific messages. The judges did comment that they enjoyed our games, but we would do better to increase the level of activity of the project to increase the fun, so we can engage more students. We did find that asking questions helped them retain information and helped us discern how much they understood the concepts. A great benefit of the model project was that it has helped me to better articulate science concept to those who have less background in it than me.

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