Reflexes and You!

Final Model Assignment
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Abstract

Reflexes are essential for everyday movement, as well as protection. Without reflexes, we wouldn't be able to walk, blink fast enough to prevent eye damage, or pull our hands away from hot substances at a speed fast enough to prevent serious damage. Since reflexes are central to our functioning, we decided to present reflexes at the Kid's Judge exhibition. We were able to discuss the importance of reflexes, how reflexes work, and the central concepts of reflexes to the students. The students were able to learn, through the eye blink demonstration, that there is no cortical involvement in reflexes. They were also able to understand that it is the small number of neurons involved that allow reflexes to so be fast. Through the use of our simple Rube Goldberg model, we were able to show, with a gumball, two funnels, two sections of pipe, and a leg carved out of foam, the path that the reflex signal takes in the knee jerk response. The students generally enjoyed the model, and watched the different paths that the gumball would take to eventually make the leg jerk.

Introduction

Reflexes are a necessary part of the nervous system's ability to function. Walking, swallowing, and standing would not be possible without reflexes working in our favor. There are many different reflexes, but our investigation was focused on the knee jerk reflex.

The knee jerk reflex is also known as a myotatic reflex. A myotatic reflex is a simple reflex, requiring only one synapse to function. In the case of the knee jerk reflex, a stretch receptor detects the tap of the mallet on the tendon, and generates action potentials to relay the information afferently toward the dorsal root ganglion, where the cell body of the sensory neuron lies. The signal is transmitted to the spinal cord, where the sensory neuron chemically synapses on a motor neuron lying in the ventral horn of the spinal cord. The motor neuron projects to the extensor muscles in the quadriceps of the leg, that causes the lower leg to jerk forward (Purves 2004). This is the essential circuit for the reflex, but there are additional synapses made onto inhibitory interneurons made in the spinal cord that inhibit the flexor muscles. The inhibition allows the extensor muscles to jerk the knee forward, without being restricted by antagonist muscles, such as the hamstring. In many cases with leg reflexes, interneurons project to the contralateral leg to stabilize the body while the weight is lifted off the ispilateral leg. This is the simplest neural circuit in the nervous system, and requires no input from the higher brain structures (Risien Russell 1893).

There are many ways the knee jerk reflex can be altered. The simplest method is to increase the strength of the stimuli. The knee jerk increases in intensity as the stimulus increases in intensity, causing the leg to kick farther. While the strength of the stretch contributes to the response, the speed of the stretch does not. A stretch will trigger the response once the threshold of the receptors is reached, regardless of the stretch duration or velocity (Liddle 1924). The reflex requires a certain threshold of pressure before the stretch receptors will fire, but this does not have to happen quickly.

Sir Charles Sherrington discovered that leg position, at the time the reflex was triggered, had an influence on the intensity of the response. He found that when the knee was at a right angle, the hamstring was most relaxed, and that the reflex was stronger from this position. The hamstring is an antagonistic muscle to the reflex, thus allowing the hamstring to counter the response of the reflex. By relaxing the antagonist muscle, the reflex response was larger.

We hypothesized that creating an active visual representation of the knee jerk reflex would help the fifth graders understand the basic mechanisms of reflexes. To represent the reflex, we set up a simple Rube Goldberg system of pipes and funnels. We made a leg of foam that caught our signal, which was represented by a gumball. The students triggered the signal and watched the gumball fall through the piping and funnels, to finally cause the leg to jerk.

This set up was designed to help the students understand that reflexes occur independently of the brain, and are able to happen at rapid speeds. We wanted the students to understand how useful reflexes are in survival because they occur so quickly, such as in the example of the eye blink reflex when objects approach the eye. We had other examples of reflexes to give students multiple responses to examine.

Methods

We began the demonstration with a basic explanation of what reflexes are, and how they work. We had a schematic drawing of the reflex arc of the knee jerk reflex displayed, which allowed us to visually show the students the locations and pathways of the two neurons involved. After explaining the diagram, we then asked the students to identify what each part of the model represented, based on what they had just learned. We asked for student participation so that we knew that the students understood and were paying attention.

Our model was designed to illustrate the path that the signal took when responding to stretch. The first step was the mechanoreceptor, which was modeled by a short inclined piece of piping cut in half lengthwise. Inside the pipe, we had a circular cardboard cutout that rotated when the attached string was gently pulled, allowing our signal to fall into the first funnel. The signal was represented by a gumball. The gumball rolled out of the mechanoreceptor, into a funnel attached to a section of flexible pipe, representing the axon of the sensory neuron. The ball jumped from the first pipe through the air, representing the synaptic cleft, into the second funnel, or post-synaptic membrane. This funnel was also attached to a section of piping, representing the motor neuron axon, from where the gumball fell out of into our manufactured leg (see figures 1 &2). The leg is made of florist foam, and is balanced on a horizontal bar, so that the leg kicked forward when the gumball fell into the end of the leg.

The two separate neurons and axons were different colors to illustrate to the kids which pipe represents which section of the reflex arc. The colors, red and blue, corresponded to our diagramed version of the reflex arc. The color coordination was done to increase the visual learning of the children, since they were able to see both the poster diagram and the model. The kids had a chance to put their own gumball through the system, using the string to start the sequence, and timing how long the gumball took to complete the system. We illustrated how the reflex is affected by stimulus intensity by demonstrating the system with more balls, which caused the leg to swing farther.

The other reflexes we demonstrated included the pupillary reflex and the eye blink reflex. Shining a light in the student's eyes exhibited the pupillary reflex, so that the other students could see the pupil constrict. To demonstrate the eye blink reflex, we had a sheet of plexi glass that one person would hold in front of their face, while students would take turns throwing a stuffed animal at their face, and watch them blink. These demonstrations allowed the students to see how reflexes are part of their everyday life.

Results

The students were able to understand the basic mechanisms of a reflex through the demonstration of our model. The students could see the correlation between the poster representation of the reflex, and the model itself. We determined the students' level of understanding by asking the students to identify the parts of the model. They were able to identify the various parts of the model, as well as remember the function of each piece. Students also reported on their evaluation forms that they understood the model presentation. The students were able to understand the lack of cortical involvement in reflexes when they tried to defeat the eye blink reflex themselves. Eventually, they realized that they would blink when something was thrown at them, despite their best efforts; it became clear that they had little conscious control over reflexes.

The students seemed to enjoy the model demonstration. The gumball never fell in the same path twice, many times missing the leg completely, which would be similar to having a spinal cord disorder that interfered with the neuronal signaling. The students enjoyed throwing the stuffed animal at the plexi glass to see if the demonstrator would blink. This generated the most student comments. The students were able to time the path of their gumball in the reflex, and seemed to enjoy the competition between them, to have the fastest gumball. While many of them thought that three or four seconds was fast, when we explained the actual speed of reflexes, most were impressed, though many of the students had difficulty comprehending milliseconds.

The answers to the questions on the survey the students filled out, were insightful. The answers indicated that our model served its purpose, and that the students learned what we wanted them to. The questions were out of a possible five points, and we scored 4.72 on their understanding of the model, 4.85 on how friendly we were, 4.46 on how fun the exhibit was, and a 3.72 on how interested the students were in learning more about reflexes. When asked about their favorite part, most students said they enjoyed the gumball reflex, but the next most common comment was how much they enjoyed throwing stuffed animals at the presenters. When the students were asked what they learned from the demonstration, almost all of them said that they had learned about reflexes. We placed third of the three demonstrations in group A.

Discussion

The Rube Goldberg design for the model was chosen for its simplicity, as well as the opportunity for the students to interact with the model. The myotatic reflex is a relatively simple reflex, but designing an interactive model for the students was difficult. With the design we chose, the students were able to start the reflex model by pulling the string, and were able to see the gumball flow through our model neurons and make the leg kick. Florist foam made the leg heavier than if we used a lighter material, like Styrofoam. Since the leg was heavy, the gumball was unable to cause the leg to kick much. If we were to recreate the model, it would have been nice to find larger funnels so that we could have a larger heavier ball to demonstrate with, as well as Styrofoam to make the leg out of.

The simple design allowed the students to fully understand how the knee jerk response worked. Allowing the students to watch each other blink as they threw objects at each other's faces, which were protected by the plexi glass, was both interesting to the students and enabled them to learn through trying to defeat their own reflexes. The model was able to show the students the lack of cortical involvement, how simple reflexes can be, as well as learning about the basic anatomy of the reflex. The materials we were able to find, since we did not have an elaborate way to demonstrate the signaling mechanisms at the stretch receptor, synapse, or neuromuscular junction, limited the model. The simplicity allowed the students to have ample time to run the model multiple times, since the reflex was diagrammed and modeled so clearly that only minimal time was necessary for explanation.

Our model ignored a few mechanisms of the reflex that are important. Aside from not discussing how the signaling mechanisms worked, we ignored the importance of the antagonist musculature. Even myotatic reflexes have interneurons that project to the antagonist muscles to allow the reflex to occur. In the knee jerk example, interneurons would project to the hamstring to inhibit its action. In many reflexes involved in walking, the interneurons must also project to the contralateral leg to prepare it to support the full weight of the body. These concepts were ignored because we had a limited amount of time to explain the reflex to the students.

We placed last in our group because our model was not near as interactive as the other models in our group. While the other groups incorporated games into their models, we only had the Rube Goldberg device for the students to interact with. Other than not placing well, the model was a success. The students were able to explain reflexes back to us, identify the parts and functions of the model, their importance, and they understood the basic anatomy of the knee jerk reflex. Overall, we did not score much lower than the other groups. The students found our model interesting, they found us to be friendly; they felt they understood the model, and most of the students were interested in learning more about the model.

Reflexes are important to our survival, and we were able to effectively portray that to the students. Decerebrate felines are able to walk on treadmills in studies done by Sherrington. The fact that animals can still be mobile, using only reflexive knowledge, is testament to the importance of reflexes in our lives. Without reflexes, we would not be able to walk, and we would not be able to prevent damage to our bodies.

References

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