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Neuro 430
Kids Judge Neuroscience Fair 2006 Exhibit
(with: Chelsey Stewart)
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Don't Smoke Your Muscles

Abstract:

The purpose of our project was to demonstrate the signaling of pharmaceutical drugs at the nerve-muscle synapse through ion channels. This should relay a functional model of how the drug nicotine affects the ACh receptor-channel and its effects on functional system of the skeletal muscle. Our project was in two parts an interactive game, and a model to demonstrate the concepts of the game.

Introduction:

Nicotinic acetylcholine receptors used in our model demonstrate the effects of pharmaceutical drugs at the nerve-muscle synapse. Five Nicotinic Acetylcholine receptor subtypes mediate synaptic transmission at the neuromuscular junction in the peripheral autonomic ganglia and the central nervous system (Watanabe, Zoli, and Changeux, 1998). Our functional model taught how nicotine affects the Acetylcholine receptor sites and its synaptic transmission on skeletal muscle.

The skeletal muscle in our body is activated after the initial binding of the agonist Acetylcholine. This activation produces a conformational change in the ion channel subunits, producing an allosteric transition of an open pore, creating a higher permeability to specific ions. An influx of ions such as Sodium produces a higher conductance at the endplate of the cell membrane causing recurrent action potentials at the post synaptic membrane (Colquhoun and Sakmann 1998). If, in addition to Acetylcholine, the agonist Nicotine also binds to these receptor sites, the channel underwent a blockage of receptor sites so that more Ach cannot bind. Blockage of these sites causes an open channel to have a longer duration than normal opening (15-20 μ s) (Colquhoun 2006). However, if too much agonist (Nicotine) is present the channel goes through a desensitized state where Acetylcholine is bound tightly but the channel becomes non-conducting (Salamone and Zhou 2000). In the case of drugs of abuse, such as Nicotine, it may seem that your body is relaxed, but an excessive production of action potentials causes internal excitability of your skeletal muscle. However, as Salamone and Zhou have explained, an excess of Nicotine can also lead to a blockade of non-conductance and signs of illness such as headaches and vomiting.

The functional division of the receptor sites are comprised of a pentameric class of ligand-gated channels (Salamone and Zhou 2000). The Nicotinic receptor channel is comprised of five subunits that span the lipid bilayer and come together to form a pore through the cell membrane. The pore plays an important role as it configures after binding to allow for a higher permeability to such ions as Ca^{++} , K^+ , and Na^+ . The nicotinic receptors in the brain can be identified by two types. The first type is able to bind H-labeled agonists such as Acetylcholine and nicotine, while the second type are I-Labeled sites that bind Bungarotoxin (Salamone and Zhou 2000). In the brain, the Nicotinic acetylcholine receptors are responsible for the transmission of nerve impulses from motor nerves to muscle fibers (Coloquhoun, Unwin, Shelley, Hatton, and Sivilotti 2003). After the initial neurotransmitter release of ACh at the nerve-muscle synapse, the ion channels of the postsynaptic membrane in the muscle cell opens, and the initial electrochemical driving force was maintained (Coloquhoun, Unwin, Shelley, Hatton, and Sivilotti 2003). The initial release of neurotransmitter onto the receptor sites was what caused the synaptic transmission in the ganglia and the movement of skeletal muscle.

Our project demonstrated the signaling of pharmaceutical drugs at the nerve- muscle synapse through ion channels. The demonstration was in two parts, an interactive game and a model to demonstrate the concepts of the game. To help the kids understand how Nicotine effects the nerve muscle interactions, the children will partake in a game, allowing them to become an axon and nerve muscle. In the second portion of our demonstration we will have an interactive model showing the ion channels and the binding of the nicotine to its receptors. Both of these concepts should illustrate the effect of Nicotine and it's active signal on the nerve muscle synapse.

The concepts in the model have been simplified so that younger children can conceptualize the effect of Nicotine on the neuromuscular junction. We expected to show the children what defines a neuromuscular junction, ion channel, and the effects of Nicotine on skeletal muscle. It is important that they take away a basic idea that an agonist such as Nicotine with Acetylcholine produces a fast release of Na^+ ions causing an excitation on skeletal muscle.

Materials:

Plexi-glass, Gumballs of different colors, plastic tubing, paint (pink and green), two plastic funnels, plastic glue. Paper for labels, and a ball labeled Acetylcholine.

Methods:

The children were split into three groups representing an axon, Nicotine, and nerve muscle. The first group of children (arranged in a line) act as signaling down an axon by a "high five" action. Group two will consist of one child labeled Nicotine. Finally, Group three was arranged to form a circle connecting their hands representing a nerve muscle. For the first run

through of the game, the children will see how the normal axon/ nerve stimulation occurs without Nicotine. Group one began by their high five action down the axon until the last child in the line tosses the “Ach” ball to the nerve muscle group producing a high five action at normal speed. Next, we demonstrated the actual effects of Nicotine on the nerve muscle response, we placed a child with the Nicotine label between the two groups. This action is the nicotine binding to the receptor sites at the axonal level. The high five process will continue again, however, this time we will have “Nicotine” intercept “Ach” and carry it to group three where they will proceed to high five at a more rapid pace. This interactive game demonstrated that the neurotransmitter Nicotine along with Acetylcholine increases the stimulation in the nerve muscle system.

The second portion of our demonstration supports the game concept, but will be in the form of a model consisting of a “pinball” like appearance. The main chutes and ion channels will be constructed from plexi-glass with plastic tubes to go into the functional system. Two kids will insert the initial Acetylcholine and Nicotine (represented by gumballs) into a set of funnels. The system with both Acetylcholine and Nicotine will have a quicker release compared to the system with only Acetylcholine. Tubes representing ion channels will contain Na⁺ ions that can be released by a trap door by the kids. The effect of the drug is demonstrated by the fast release of Na⁺ ions to produce recurrent action potential and movement of skeletal muscle. The demonstration should illustrate the effect of Nicotine and it’s active signal on the nerve muscle synapse.

Results:

After presenting our model during the ‘Neuroscience Kids Judge Fair’ it seemed that the 5th graders made a good connection between the actions of the drug Nicotine and it’s excitation on skeletal muscle. Their understanding was represented by the number of questions asked and the accurate evaluations that they made. Some children stated responses of “nicotine is bad, and it impairs your senses and body” although this was a simplified explanation, overall they understood what the drug was and how it effected the body and specifically skeletal muscle.

The model helped the children to understand what an ion channel was composed of and how agonists of Nicotine and Acetylcholine conformed the channel. The kids loved to watch the gumballs fall down the shoots, through the ion channels, to meet the skeletal muscle. At the end of the model we incorporated a quiz section supported by a reward of candy to see if they understood the main explanation and to clarify any foggy points. Some kids had a difficult time understanding the complexity of the ion channel and how Nicotine and Acetylcholine bound to it, but we were glad that the kids were willing to ask questions. However, most kids were anxious to respond to questions during the fast paced quiz section and raised there hands to contribute to the discussion.

The game of our model allowed the kids to become actively involved, and it helped them to understand neuromuscular junctions in relation to the speed of adding Nicotine into your body. The kids responded well to the game and they felt ‘special’ in their own roles of a ‘Neurotransmitter’ ‘Acetylcholine’ and ‘Nicotine’. I felt this was a different and successful approach to teach the kids how neuromuscular junctions and its connections cause the effect of increased communication between junctions by the addition of Nicotine.

Overall, the kids enjoyed the entire project with most responses stating “my favorite part of the exhibit was the game, model, quiz, and candy.” I was surprised at their level of understanding, and their interest on our topic. Unfortunately, our score of fourth in our division, did not reflect the kid’s judged evaluations. Below is a table that describes the kid’s scores and the standard deviations of those scores. The results show higher values (about 4) for each section.

Questions	Scores of 1	Scores of 2	Scores of 3	Scores of 4	Scores of 5	Average & standard deviation
Number 1	0	1	1	11	12	4.36 ± .75
Number 2	0	0	0	1	24	4.96 ± .2
Number 3	1	0	1	9	14	4.40 ± .91
Number 4	1	2	5	10	7	3.80 ± 1.08

Question

Number 1: Could you understand what the presenters were trying to tell you?

Number 2: Were the presenters friendly?

Number 3: Was the exhibit fun?

Number 4: Would you like to learn more about this topic?

Discussion:

The kids general response to our project was positive and successful, however I would suspect we placed fourth place, because our topic was somewhat complex and overwhelming. We intended to give the children a basic understanding of ion channels, neuromuscular junctions, and Nicotine’s effects on skeletal muscle. I feel that my team accomplished this by interactively involving the kids, and providing some basic background, but limitations of their understanding were present when trying to learn the more complex information. To help the kids understand the effects of Nicotine on skeletal muscle, we compromised some of the in-depth details of the system in order to present a more simplified basic model. Therefore, our discussion did not cover the electrochemical driving forces, the chemical principals behind the binding of the agonists to the ion channel, or the intracellular connections made by the gap junctions. Although

some details were removed from the presentation, I do not feel the accuracy of the project was jeopardized.

The evaluations recorded during the kids judge fair showed scores of high responses in all answered sections. This gives me a good impression that the kids understood the basics of the project and enjoyed the demonstration. Our 'kids' evaluations were very high as an individual project, but I think that our topic was too complex to be placed any higher against the other groups. The lowest score recorded averaged at a 3.80 in the section of having further interest in the topic. I suspect that this was because too much information was presented over such a short duration of time, and therefore we took home fourth place.

Overall, if I were to do this project again, I would reduce the demonstration into either a game or model to represent the topic. In our presentation we attempted to explain the mechanisms of ion channels related to agonists such as Nicotine on skeletal muscle by a game *and* model. Although the kids had a great time playing the game, and watching the gumballs fall down the chutes, I think that they could not understand all of information presented. Therefore, I would use one method of explaining the idea to the kids by only using a game to keep the model simplified, allow for better understanding of the topic, and intrigue the kids to want to learn more about the nerve-muscle synapses of skeletal muscle.

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