

Michael Balam
Neuro 430
Kids Judge Neuroscience Fair 2006 Exhibit
(with: Joseph Haynes, Russell Hyslop, and Crystal Philes)
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Kids Judge! Neuroscience Fair: Why Does My Mouth Feel Numb?

ABSTRACT: Local anesthetics have been used as long ago as 2500 B.C by the Egyptians, early Assyrians, aborigines of South America, and by the Incas as well. Although their methods of local anesthesia varied from applied pressure and ether spray to derivatives from cocoa leaf, local anesthesia has always been used to alleviate human pain and suffering. Local anesthetics are classified by their ability to hydrogen bond to the internal pore of sodium channels to inhibit depolarization of the neural membrane. Their action reversibly blocks voltage-gated sodium channels and delayer-rectifier potassium channels in a dose-dependant manner. To convey this information to an individual with no scientific background, a successful explanation poses a challenge to both teacher and student. The objective of the Kids Judge! Neuroscience Fair was to address these problems in a competition including Neurophysiology students and young individuals with minimal scientific knowledge. Our group constructed a model demonstrating two sodium channels spanning a cellular membrane to actively depict sodium entering a cell, transmitting pain signals to the brain. Interactive explanations and demonstrations were included to successfully deliver the major components of local anesthetic action. Evaluations declared second place for our group with two average ratings scoring highest among all groups. The most difficult aspect of the Kids Judge! Neuroscience Fair was the effective delivery of complex scientific topics to individuals with minimal scientific background. Analogies and representations of neuroscience topics allowed miscommunication between teacher and student but are necessary tools for effective explanations.

INTRODUCTION

The fundamental aim of medical science has always been the alleviation of human pain and suffering. It is remarkable that, historically, the first attempts to alleviate surgical pain were achieved through use of local anesthesia, and today is still of great scientific interest. Local anesthesia serves great surgical importance because it is recognized by patients as the satisfactory type of anesthesia which boosts patient confidence and cooperation regarding surgical procedures (Leake 1925). The development of local anesthetics from an empirical basis into a firm foundation is considered one of the greatest achievements in science (Leake 1925).

As long ago as 2500 B.C., Egyptian carvings illustrated the use of applied pressure to effectively reduce blood flow in order to reduce surgical pain and even the early Assyrians used

this method to perform customary circumcisions. Sir Benjamin Ward Richardson (1828-1900) noted the effects of low temperatures as possessing anesthetic effects which enabled him to produce an acceptable local anesthetic for its time; the ether spray. Later, derivatives from cocoa leaf were discovered for the relief of pain by aboriginal inhabitants of the highlands of South America which were used by the Incas as well. The Incas chewed up cocoa leaves and dripped the juice upon severe wounds if the pain became too great for the injured to endure (Leake 1925). Today, researchers are studying these past discoveries to determine the methods by which local anesthetics operate, as well as to identify their targets of action.

Local anesthetic agents prevent depolarization of the nerve membrane. As former methods of local anesthesia utilized reduced blood flow, cold temperatures and derivatives from cocoa leaf, their actions all possess a common goal; the alleviation of pain. The act of reducing blood flow to an injured location successfully depletes oxygen to cells in that region which slow metabolic processes just as cold temperatures do. Slower metabolic rates produce less energy for the cell and thus slow nerve conduction. Derivatives from cocoa leaf imitate what we use today as local anesthetics and act on receptors in the neural membrane to prevent depolarization.

As the concentration of anesthetic increases, the amplitude of the action potential is reduced over time, the firing threshold is elevated, the spread of impulse conduction is slowed, the refractory period lengthened, and finally, nerve conduction is fully blocked. Local anesthetic drugs exert their effect by bonding on the inside of the sodium channel to prevent its function. In a myelinated nerve, the site of action is the node of Ranvier in which two or three adjacent nodes must be affected to prevent conduction (Upadya and Upadya, 2005).

Voltage-gated sodium channels are reversibly blocked while A-type potassium channels and delayed-rectifier potassium channels are blocked in a dose dependant manner by meperidine (Wolff *et al.*, 2004). Since cellular excitability is largely determined by internal calcium availability, intracellular calcium stores are one of the targets of local anesthetics. The potency of these drugs appears to be modulated by intracellular calcium stores and according to Xu *et al.* (2003), when a cell is pre-stimulated to deplete intracellular calcium stores, the half maximum inhibiting concentration (IC_{50}) increases, thus making ropivacaine, mepivacaine, and lidocaine less potent. The potency of local anesthetics is also determined by their ability to hydrogen bond. To decrease cell excitability, local anesthetics replace calcium ions with a more stable electrostatic complex (hydrogen bonds) with the channels in the neural membrane (Sax and Pletcher, 1969).

The objective of the Kids Judge! Neuroscience Fair is to teach basic concepts in neuroscience to individuals with little scientific background, and to strike up interest in this expanding field. Due to the complex actions of local anesthetics, a model representing the basic concepts must consider only the major information to be successful in teaching novice individuals these intricate scientific topics. The model must only demonstrate the action of local anesthetics on sodium channels to prevent nerve conduction.

MATERIALS AND METHODS

Model Construction. A 20" x 20" square piece of 3/8" plywood was used as the base board for the model and 1.5" borders were nailed to its edges to encompass the base board. Before attachment of the borders, a 3" x 3" square was cut out of the base board on the lower right corner (figure 1). The cellular membranes were constructed to demonstrate two sodium channels spanning the cellular membrane. The cellular membranes were made by gluing two pieces of wood together, (for increased thickness), cut to proportionality then attached to the base board seen in figure 1 below. The materials used to construct the representation of the local anesthetic were two pieces of wood glued together and cut to accurately fit the sodium channel's pore. We constructed a stand to elevate the model to a 50 degree angle, in order to allow marbles (representing sodium) to roll through the sodium channels. To keep the marbles suspended above the sodium channel's pore, two wood blockers 1.5" in height were constructed and stood on edge to act as a barrier between the channels pore and the marbles. To keep these blockers standing on their edge, two 1/2" slits were cut out of the border on each side to allow the blockers to be pulled through them, allowing passage of the marbles demonstrating "activation" of the cell. A ramp 1.5" in height was constructed and glued on its edge to the base board of the intracellular space to reroute the marbles into a collection bowl sitting in the 3" by 3" space cut out of the base board.

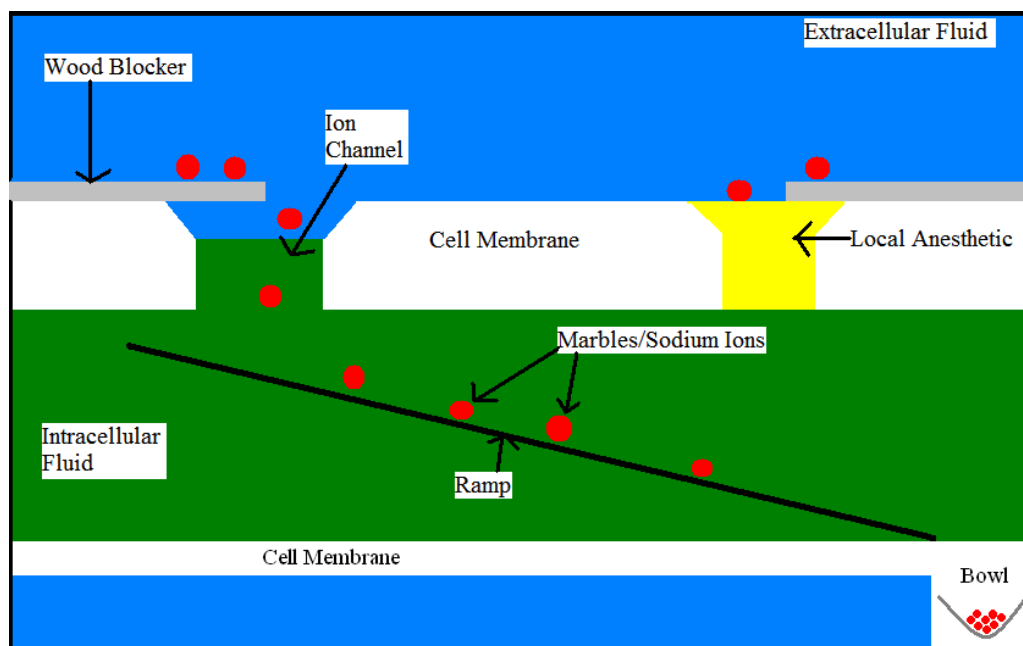


Figure 1. Model layout. The color blue represents the extracellular space, green – intracellular space, white – cellular membrane, red – marbles/sodium, black – model borders/ramp, yellow – local anesthetic, gray – sodium blocker.

Poster construction. We prepared a 43" by 60" poster using Microsoft PowerPoint then printed in color with title, group member's names and illustrations relevant to local anesthetic

action. Progressive focus onto sodium channels was developed in order to visualize exactly where in the human body anesthetics work. A photograph of a man's face was followed by a picture of his mouth, followed by a single nerve innervating a single tooth, then onto the neural membrane which included two sodium channels.

Presentation. We allotted eighteen minutes for the model presentation which was divided up into 5 phases. Phase 1 included an introduction to local anesthetics with emphasis on Novocain used by dentists during dental surgery. A lemon battery was utilized to demonstrate the flow of atomic particles through a system to create an electric current. Phase 2 included orientation to the model which explained what the model represented in reference to the poster, during which a sample of table salt was provided in order to put the many uses of sodium into perspective. Phase 3 was a working demonstration of how sodium ions enter the cell through sodium channels and how local anesthetics occlude the channels pore thus inhibiting sodium entry. Phase 4 included an interactive activity which involved three kids holding hands to form a small circle representing a single sodium channel. One kid stood in the center and held an umbrella open above the channel, inhibiting Wiffle balls (representing sodium) from being thrown into the channel. Phase 5 was a question and answer session as well as time for kids to fill out their evaluations.

Scoring. Presentations were graded on a one to five scale (five being the highest) evaluating how well the concepts were understood, how friendly the presenters were, how fun it was and if they would like to learn more in the future.

RESULTS

During our presentation, the kids seemed to receive what we were teaching them very well. At times during the presentation, the kids were leaning in closely to see what we were demonstrating. When they were given the opportunity to operate the model themselves, a lot of hands reached in all at once, which informed us that the level of excitement for our model and what we were teaching them was at a sufficient level. When we asked questions to the group, they answered correctly which allowed us to properly assess and maintain the appropriate level of communication with them. When given opportunities, there were few questions about the material we presented.

When the kids were asked to write down what they learned from the exhibit, one of the responses was, "when a dentist injects numbing [agent into your mouth], it blocks sodium channels". Other comments relating to what they learned included the role of the cell membrane in a neuron, how local anesthetics block signals, why your mouth feels numb, and how medicine can help reduce pain. Additional comments regarding what they enjoyed about our model were the marbles, table salt, lemon battery, Wiffle balls and operating the model themselves.

The average scores for "Why Does My Mouth Feel Numb" range from 3.84 to 4.80 with overall group averages ranging from 3.24 to 4.90 (table 1). "My Oh Myelin" came in first place

with 10 votes and “Why Does My Mouth Feel Numb?” came in second place with 9 votes. “VAWBAM” and “The Brain Under The Microscope” came in third and fourth place, respectively. Our presentation scored highest among the four groups in two of four categories, and second highest in the remaining two categories. Our highest scoring areas were how easily the concept was understood and if they would like to learn more. We scored second highest in how friendly our presenters were and how fun our presentation was.

Table 1. Average scores obtained on a one to five scale (five = highest) in each of the four evaluated categories. 1. How easily the concept was understood. 2. How friendly the presenters were. 3. How fun the presentation was. 4. Would you like to learn more? Also, the number of votes obtained by each individual group to reveal their appropriate placement.

Project	# of Votes	Placement	Understand	Friendly	Fun	Learn More
My Oh Myelin	10	1	4.45	4.9	4.6	3.86
Why Does My Mouth Feel Numb?	9	2	4.56	4.8	4.52	3.84
VAWBAM	4	3	4.24	4.68	4.26	3.56
The Brain Under The Microscope	2	4	3.6	4.16	3.44	3.24

DISCUSSION AND CONCLUSION

The objective of the Kids Judge! Neuroscience Fair was to educate and motivate young individuals to explore the expanding field of neuroscience, in hope that they will pursue a career in the field. The effective delivery of neuroscience concepts to children is a necessary tool that not only develops us as teachers, but builds the children’s knowledge and excitement for neuroscience as well. Teaching children neuroscience today is an effective strategy for improving neuroscience tomorrow. Events such as the Kids Judge! Neuroscience Fair enabled us to recruit individuals for neuroscience research for the future in order to increase the knowledge about how the brain really works. After presenting a neuroscience concept to young individuals, a personal assessment of how enthusiastic and willing these young people are in regard to neuroscience, presents a positive outlook for the future.

The interest I saw from the kids made me certain that some of them would go on to pursue more information about neuroscience. Our topic was chosen based on what we decided to be relatively easily understood, because we do not expect kids to pursue further information in an area of study that frustrates them. The ability to relate a neuroscience topic to something kids have experienced themselves demonstrates great significance and makes teaching the topic more effective.

The number of questions asked by the kids was relatively small. This could be attributed to a clear understanding of the concepts presented to them, or to an overall misunderstanding of the concepts presented. The evaluation forms enabled us to assess what they learned and

understood, and therefore we can confidently conclude that they grasped the neuroscience concepts we presented. The fact that they were actively listening demonstrated that they were interested and willing to learn what information we were offering.

It is challenging to verbally communicate a scientific concept to a group of people who have minimal scientific background and experience, which was the most difficult part of the presentation. My presentation was limited to analogies and representations of biological processes. These analogies and representations allowed listeners to make their own assumptions about what is technically happening in the biological system. In this fact, it becomes very difficult to explain the facts without using scientific language. A single biological term can define and explain what is occurring, but an explanation to a novice individual would take many analogies to explain, which increases the probability for miscommunication.

To be successful in our teaching and learning, we must leave out information that does not pose great importance to understanding complex topics. Much information must be compromised when teaching and learning in order to be a successful teacher or student. Details must be spared so students do not become overwhelmed with information, which would likely result in trouble grasping the main concept. Our model compromised a description of the action potential and what brain centers respond when we perceive an aversive stimulus. Many facts about local anesthetics were not included due to confusing terminology and relative insignificance to the major concepts.

Our model could have been enhanced if we utilized more teaching aids to secure the students learning and understanding of our topic. A demonstration of what a local anesthetic feels like in your mouth would be a great benefit and would really secure what they learned. To circumvent the difficulty of access to a pharmacological local anesthetic, Fire-Ball candy was given to them to slightly numb their mouths. Spicy candy contains capsaicin which is derived from hot peppers and has a numbing effect. Also, a short video presentation showing a dentist injecting a local anesthetic into a patient's mouth would help the kids apply what they were about to learn, and would prompt an explanation of why we are teaching them about local anesthetics.

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