The human salt bridge

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ABSTRACT

The Human Salt Bridge model was presented during the Washington State Universities Brain Awareness week; Kids Judge, March 13, 2003. The Human Salt Bridge Model was ranked last out of four other models in a six-question evaluation by forth grade kids. The model attempted to demonstrate resistance and amplification in an axon. Approximately 6 to 7 children were used to create a human salt bridge completing a circuit from 9-volt battery to a copper wand on a foam core picture of Harry Potter. The current from the 9-volt battery traveled across each child's skin as they hold hands to create a salt bridge. The current decrease through each child because of the resistance in their skin. A small amount of current did transfer to Harry Potter' s wand and was amplified to create a enough voltage to light up the LED' s in Harry Potter' s scar. In this model the kids represented resistance to the change in ionic current that traveled down the dendrite. The action potential of the axon was represented by the amplification of the voltage through an amplifier on a 9-volt circuit board.

Introduction

In the model created we wanted to show how a very weak signal gets amplified through an action potentials to send a clear message to the brain. The concepts we wanted to get across to the kids were that axons usually specialize in carrying signals faithfully over long distances like a relay line, or telephone line. Propagation of signals down the dendrites was thought to be purely passive. However dendrites like axons contain voltage-gated Na^+, K^+ and Ca^{2+} channels their concentrations determines the efficiency of signal conduction. The voltage- gate Na^+ and Ca^{2+} channels in the dendrites help amplify small EPSP. Although signals can be quite small they can be amplified in the dendrites and again in the axon hillock trigger zone of the neuron. In the neuron's trigger zone, large concentrations of Na^+ channels create a positive feed back mechanism that along with action potentials amplify the signal even more (Kandel, Schwartz, and Jessell, 2000).

In our model we used the kids to represent the resistance that builds up as the signal travels down the dendrite. Approximately 6 to 7 children were used to create a human salt bridge completing a circuit from 9-volt battery to a copper wand on a foam core picture of Harry Potter. The current from the 9-volt battery traveled across each child's skin as they hold hands to create a salt bridge. The current decreased through each child because of the resistance in their skin. The conductance of the voltage across each child' s skin is similar but unique to that individual.

Skin impedance is the most difficult to characterize. It is non-linear, time-variable and depends on environmental and physiological factors that are usually difficult to control in an experimental setting. The resistance in skin is often the primary factor that limits current flow in the body, particularly where the applied voltage is moderately low (<200 V) and where the skin is undamaged. (Rielly, 1998).

Biegelmeier, (1985) summarize skin conduction as a function of the sweat gland activity and the skin's pore size. An individual's baseline skin conductance will vary for many reasons, including gender, diet, skin type and situation. Sweat gland activity is controlled in part by the sympathetic nervous system. When a subject is startled or experiences anxiety, there will be a fast increase in the skin's conductance due to increased activity in the sweat glands. Sweat glad activity increases the skins capacity to conduct the current passing through it.

Sweat is chiefly a 0.1 to 0.4% saline solution of sodium chloride, with a resistively of 140 cm at 37°C (for a 0.3% solution). The density of sweet ducts (per cm^2) is approximately 370 on the palmar and platar surfaces of the hands and feet (Reilly, 1998).

In our demonstration we had the kids hold hands to create a human salt bridge that carried the current from a 9-volt battery to a set of LEDs. As the current pass across each child's skin, the current decreased because of the resitivity of the skin. In neuro-biological systems, even when the ionic current changes are very small the system has a way of amplifying that change through a positive feedback cycle. When a membrane of an axon for example, depolarizes sufficiently to open some of the voltage-gated NA^+ channels, the flow of Na^+ current inward causes more channels to open further depolarizing the membrane. The positive feedback cycle eventually drives the membrane potential to the peak of the action potential (Fozzard,1979). In our model we used a small electronic circuit amplifier to represent the action potential. Electronic amplifiers are used to increase the amplitude of an electronic signal. A circuit designed to convert a low voltage to a higher voltage is called a voltage amplifier.

we wanted the kids to take home several things; the first was that their bodies are very conductive as demonstrated by the creation of the salt bridge. The second thing was that some nerve signals are decreased significantly because they travel along paths that are full of resistance. Although the signal may be decreased to a very small signal, that signal can be amplified into action potentials. This was demonstrated as we over came the resistance in the salt bridge and amplified the signal enough to light up Harry Potters scar.

Methods

Subjects

Our subjects were kids from forth grade, approximately 8-10 year olds, a mixture of females and males.

Equipment and Materials

Our model consisted of a 24X30 foam core picture of Harry Potter, a very popular children's book and movie character. Harry Potter's scar on his forehead had been cut out and lined with red cellophane. In back of the cellophane was a set of 4 LEDs in series that were rated at ~ 0.2 volts each. One end of LEDs was wired to a copper wand on the front of the Harry Potter picture. The other end of the LEDs had a positive lead that was clamped to the end of a 1000-OHM resistor on a circuit board and a negatives end that attached to a negative lead from the battery, (see figure 2).

We used an ARCHER EXPERIMENTER SOCKET Circuit board made for Radio Shack. The board was approximately 2x6 inches with a pattern series of perforated holes.

The main components that snapped into the holes on the circuit board were; the amplifier (Dual BiFET OP Amp with absolute maximum ratings of supply voltage (V+): 36VDC or $\pm$18VDC), two 1000 OHM resistors, one 300M OHM resistor and a nine volt battery. Clamped to the 300M

OHM resistor was a lead with a copper tube used as a handle by one child to connect them to the circuit (see figure 2).

Procedure

We always started demonstration by modeling resistance using a Hospital Intravenous flow bag filled with water. Letting the water flow, clamping, or partially clamping the tubing we attempted to simulate the flow of electrical ions through an axons. We tried to show how pressure (voltage) and resistance could affect the flow of that signal.

We explained to the children the concept of how the electrical current flows over their skin but the longer the distance the current had to travel the more resistance it met through each person. It was explained that the person at the end of the line had the least amount of current and that the electrical current was small but could be amplified by an action potential, which would amplify the electrical signal enough to send a clear message, (example light the LEDs). In our model we lined the Kids up in a semicircle, asked them to all hold hands (created a salt bridge), the person at the beginning held the copper tube connected to the circuit board and the person at the end touched Harry Potters wand. The wand was connected to the circuit board that fed the weak signal through amplified and up to the LEDs in Harry Potter scar. The LEDs lit up with the completion of the circuit. We had the kids drop hands and move apart and it broke the circuit. If the kids were close together but not holding hands we could also complete the circuit because of static electricity.

RESULTS

The Results were based on quantitative evaluation forms with a scale of one to five; one being the lowest and five being the highest. Each child was asked to fill out a form. The categories included; understanding what the presenters were trying to tell you, were the presenters friendly, was the exhibit fun, and would you like to learn more about this topic. Two questions were comments; what was your favorite part of this exhibit, and what did you learn from this exhibit, (see figure 2). Over half of the children said that their favorite part of the exhibit was lighting up Harry Potter' s Scar. Although there were about 8 children that loved the idea of holding hands, one little boy thought it was awful he had to hold a little girls hand. Out of 36 children 17 had no comments about what they learned and16 said that they learned the body conducts, two said they learned we can overcome resistance and only one said that signals get amplified. It would be hard to say what these kids learned, their evaluation forms are not a true indication because they were filled out in such a hurried fashion.

The presenters were divided up into two sections (A & B). Each section was judged by a different group of kids. We were in section B, group four. In the B section our group came in last in the judging of best model. The correlation between the best model and individual judgment sheets for section B were far below 1. This would indicate that there was no correlation. (see figure 3).

The kids received the model with an interest and excitement. The explanation of the model was simplistic and the kids said they understood. We did not go into deep explanations of the circuit board except to say that the amplifier worked like an action potential.

DISCUSSION

The model we created, the Human Salt Bridge using the Harry Potter poster was creative. Using the title, Human Salt Bridge, more frequently in our explanation would have reinforced our concept better. We instructed the children on the concept of how current travels over the skin. I believe it was hard for the children to conceptualize our project as being related to the brain. We were constantly improving our demonstration as we received new groups of children. We started asking the kids questions to find out if they grasped the concept.

In preparing for the event we worked very hard on getting our model to work and not enough time on our presentation. In the very beginning my partner had a terrible time with stage freight and would stand behind me. Neither of us knew much about electrical circuitry and had to rely heavily on other people for help. If I had to do this all over again I would work harder at relating the model to the human brain functions. The wonderful thing is I learned about electrical circuitry and resistance.

As with most project of this nature, experience presenting our model demonstrated the things that could have improved. We compromised accuracy for simplicity by not bringing an Ohm meter to demonstrate our principal. One thing that we could have done to make the model better was to measure the voltage going to the first child and measure the voltage at the last kid that touch the wand. Having a voltage meter might have help the kids see the voltage drop on the meter. We also could have measured the resistance that built up between the kids.

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Figure Caption

Figure 1. Human Salt Bridge Model with circuit board lay-out

Figure 2. Individual results from Kids Judge evaluation forms.

Figure 3. Section and Group results from Kids Judge evaluation forms.