

Blood Brain Barrier: The Mystic Portal into your Mind

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Abstract

The experiments leading to the concept of a blood-brain-barrier (BBB) date back more than 100 years. We now know that the BBB is important to keep out viruses and other foreign objects from getting into the brain, and to make sure the brain has a constant, well-maintained environment. The barrier accomplishes this task with a selective permeability characteristic, which allows certain things into the brain, but not others. The opportunity to make it possible for kids, (and adults), to understand the importance of the barrier was both exciting and educational. We had a liquid density model to demonstrate the properties of the BBB: Water on the bottom representing the brain, green olive oil in the middle representing the BBB itself, and rubbing alcohol, dyed red, on top representing blood. Using candy Skittles to represent glucose, green marshmallows to represent viruses, and denture cleaners to represent severe head trauma, we demonstrated how glucose (Skittles) could easily pass through the BBB and viruses (marshmallows) cannot. We also taught them the importance of wearing a helmet by showing how head trauma (denture cleaner) ruptures the BBB (oil) and makes a mess throughout all three layers. A standardized form was used to judge the exhibit. The form asked the kids to rate the demonstration based on a scale from one to five, (five being the highest, or best, and one being the lowest, or worst). Also on these forms were questions

that asked for comments from the kids. Looking at the numerical results from all the rated questions, the written responses, along with the additional comments found on the judging forms, we determined that our model was a success by being both educational and fun for the kids.

Introduction

The concept of a vascular barrier arose in the early 1900's. Experiments with pharmacologically active compounds and with dyes showed that in many cases these did not enter brain from blood. The barrier had to be a vascular one since the same substances would readily get into the brain when injected directly onto the Cerebral Spinal Fluid (CSF). The hypothesis that arose later from further observations on uptake of dyes that the barrier is impermeable to anions but permits cations to pass is not generally tenable. Later observations noted the barrier has properties like a cell membrane, in particular, its permeability depending very strongly on the lipid solubility of the compound presented. (Bradbury, 1979).

In order to facilitate transport of nutrients from the blood into the brain specific transport systems are present in brain endothelial cell membranes, which carry nutrients, ions, and hormones into the brain. (Greenwood et al., 1995). In addition, there are transport molecules that pump substances out of the brain to maintain a constant neuronal environment. (Greenwood et al., 1995).

Today we know the general properties of the BBB are to protect the brain from viruses and other foreign objects and to maintain a constant environment for the brain. This means it stops large molecules, low lipid (fat) soluble molecules, and molecules that

have a high electrical charge to them from going through. (Chudler, 2003). The BBB does allow lipid soluble molecules and more importantly glucose (sugar) into the brain. The brain needs glucose to function. Things that can damage the protective barrier include hypertension, hyperosmolality, microwaves, radiation, infection, and head trauma. (Chudler, 2003).

Bringing me to our model we used for the "kids judge" brain awareness day. What is more fun than playing with water, oil, and food coloring? Adding rubbing alcohol to the mixture and somehow represent part of the brain. The blood brain barrier simplifies into a liquid density model that is both fun and understandable. The water on the bottom, the green oil in the middle, and the rubbing alcohol on top all in a kitchen glass make a great brain (water), BBB (green oil), and blood (alcohol dyed with red food coloring).

Method

The model starts with a tall kitchen glass with about a third of it filled with warm water, which will represent brain matter. The next thing into the glass is green olive oil, which represents the blood brain barrier itself (the layer is only about an inch or so in depth). At the very top is rubbing alcohol, dyed red with food coloring. The rubbing alcohol represents the blood outside of the brain. The three layers do not intermix because each of the densities allows them to float on top of each other, making a very good model of the blood brain barrier.

We had two glasses for each group, so the kids could have a clear view of what was going on, being in groups of 3 or 4 instead of 6 or 7. To demonstrate how the BBB works, we used candy Skittles to represent glucose that the BBB allows into the brain. The kids drop a skittle into the glass, and because they are so dense, they fall right to the bottom, representing how glucose passes through the BBB into the brain. Next, we had little green marshmallows, which were analogous to viruses and other harmful microns. Kids would drop these in and they would float on the rubbing alcohol layer, showing how the BBB would keep these harmful things out. (Some kids tried to get creative by squishing the marshmallow into a smaller, denser piece and throwing it into the glass, however, sticking in the oil, still demonstrated that the virus could not get through.)

The last demonstration used denture cleaner. The kids would put this into the glass and the pellet would fall straight to the bottom in the warm water, it would then start to effervesce causing the three layers to become turbulent and wild. The layers would start to intermix, and the red alcohol layer would start mixing into the water causing the whole glass to turn a dark, almost brown color. We compared this reaction to when somebody hits their head really badly, and though it would have to be quite a crash the kids learned that wearing a helmet was generally a good idea.

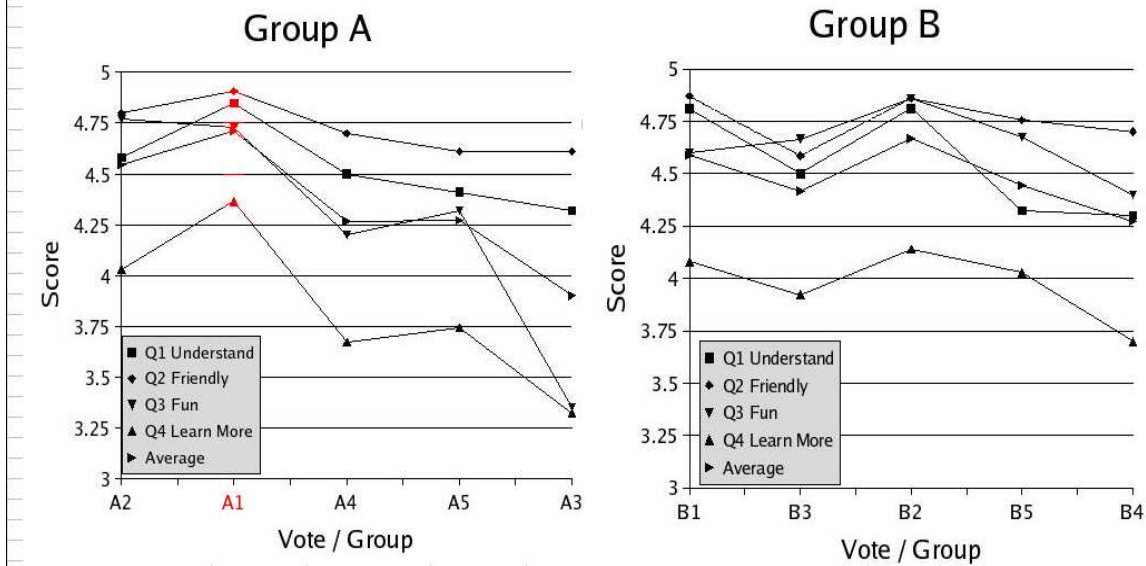
Results

Overall, both the kids and adults enjoyed our model of the BBB and the judging forms reflected this with very high ratings. Although we only placed 2nd in the A group, our scores were higher than all the other groups in every category but one. The grading

system was based on four questions that asked to rate their answer on a 1-5 scale, 5 being the best and 1 being the worst. The first question asked if you could understand what the presenters were telling you, our average rating was a 4.85. Second question asked if the presenters were friendly, our average rating was a 4.91. The third question asked if the exhibit was fun, our average was a 4.73. Lastly, the form asked if they would want to learn more about the topic, our average was a 4.71. For the four questions asked, our overall average was 4.71.

Another indication that the kids had a lot of fun was their comments. Summarizing their statements a little for the question of their favorite part of the exhibit, we had 13 kids say they loved doing the experiment and 9 loved watching the denture cleaner (5 more said watching the “head trauma” which was represented by the denture cleaner). One comment came from an adult, who "enjoyed the demonstration of selective passage through the BBB." The second fill-in question asked them what they learned from the experiment. 8 kids commented on always wear a helmet, 4 found out that viruses do not get through a healthy BBB, and 4 kids all said they learned “a lot.” There were several other comments that all reflected that we definitely had their attention during the exhibit. The best part of the judging forms was the additional comments written in the margins of the paper. Some of them included, “It was really, really fun!” “You're great!” and “The people are sooo fun!”

| | | Understand | Friendly | Fun | Learn More | Average | Place Vote |
|------------------------------|----|---------------|-------------|--------|---------------|---------|-------------|
| | | Q1 Understand | Q2 Friendly | Q3 Fun | Q4 Learn More | | |
| Action Protein | A2 | 4.58 | 4.8 | 4.77 | 4.03 | 4.55 | 1 |
| Blood Brain Barrier | A1 | 4.85 | 4.91 | 4.73 | 4.36 | 4.71 | 2 |
| SNAP | A4 | 4.5 | 4.7 | 4.2 | 3.67 | 4.27 | 3 |
| Don't Bang Your Head | A5 | 4.41 | 4.61 | 4.32 | 3.74 | 4.27 | 4 |
| Brain Parts | A3 | 4.32 | 4.61 | 3.35 | 3.32 | 3.9 | 5 |
| | | -0.75 | -0.83 | -0.9 | | -0.88 | Correlation |
| | | Q1 Understand | Q2 Friendly | Q3 Fun | Q4 Learn More | Average | Place Vote |
| Don't Stick That in Your Ear | B1 | 4.81 | 4.87 | 4.6 | 4.08 | 4.59 | 1 |
| Edible Excitable Neuron | B3 | 4.5 | 4.59 | 4.67 | 3.92 | 4.42 | 2 |
| Sweet Potential | B2 | 4.81 | 4.86 | 4.86 | 4.14 | 4.67 | 3 |
| Nerve Channel Basketball | B5 | 4.32 | 4.76 | 4.68 | 4.03 | 4.45 | 4 |
| Human Salt Bridge | B4 | 4.3 | 4.7 | 4.4 | 3.7 | 4.28 | 5 |
| | | -0.75 | -0.23 | -0.37 | -0.6 | -0.62 | Correlation |



Results from “Kids Judge!” Brain Awareness experiments. We were Group A1 (as noted in Red). Figure from Dr. Rector - Kids Judge Results A&B. http://www.vetmed.wsu.edu/research_vcapp/rector.html

Discussion

Resulting with significantly high scores and many comments, we felt the model was a success. I would not change much in our model experiment, but having all the glasses filled with each of the layers, instead of making them on the spot as they got there, would have eased things a little bit. However, everybody seemed to have a good time, as one person quoted, “Great exhibit-simple but effective.”

There were concepts of the BBB not explained in our exhibit because the model was so simple. The mechanisms of how glucose passes through the BBB by a transport system are never explained, nor how a virus can break through. The brain trauma caused by the denture cleaner is a harsh example and in real life would have to be an extremely hard crash of the brain.

As one kid pointed out during the brain awareness day judging, ‘There's a lot more stuff going on in my head than I thought.’

References:

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