Ouch, My Brain: a model of brain injury for judging fifth graders

Jamie Anson, James Bales, Programs in Neuroscience, Washington State University, Pullman, WA USA

Abstract:

The complexity of the human nervous system is perhaps most appreciated in its absence. This idea is stressed to a group of fifth grad students at the Kid's Judge Science Fair 2004, in the interest of getting students to realize the importance of their central nervous system. Our presentation aims to illustrate three concrete and simple processes that cause brain injury: mechanical shearing and tearing, brain swelling, and chemical toxicity. Upon review of the kids judging, it appears that the hands-on 3 part explanation worked quite well. By quickly highlighting physical anatomy, connectivity, and chemical communicating systems, kids understood the devastating effects of not protecting their brains.

Introduction:

An interest in the actuality of neural trauma, the physics of head injury, has grown substantially in the past ten years. What scientists have termed Traumatic Brain Injury (TBI), spans from the measure of molecular changes, to the permanence of structural changes upon injury. New research has significantly improved the detection and classification of neurotrauma. The purpose of this publication is to create a model for neural trauma, which is presentable to a fifth grade primary class. We aim at outlining specific types of brain damage, and resulting cognitive deficits. Attention will be paid to three major kinds of damage to the CNS: mechanical shearing and tearing, brain swelling, and chemical toxicity.

Upon injury to the brain, it can generally be stated that these three kinds of damage happen in the above order. Sheering and tearing is instantaneous with impact, blood and CSF cause swelling which increases pressure, and chemical leakage can further increase axonal swelling, scar tissue, and programmed cell death. It becomes quite clear just why the time course and pathophysiology of injury is correctly described as "a process not an event" (Gaetz 2003). Neural tissue is quite unique in that destruction from a single injury is continual; the brain literally continues to die for weeks.

Early researchers observed that loss of consciousness occurred much less when the head position is fixed during injury, as opposed to rotating [2]. Sheer strains occurred in the brain, primarily as a result of rotational acceleration forces [3]. These forces tend to target changes in density (grey to white matter), large axons, nodes, and axons that traverse other structures, such as blood vessels [1]. Taken together, these studies have led numerous clinicians and researchers to conclude that acceleration injuries result in sheer strains within the cranial vault, and these in turn lead to sheering of neurons and blood vessels occurring principally in the brainstem [1]. Therefore mechanical sheering and tearing can be likened to the movement of a string of people holding hands. As individuals accelerate forward and backward, and twist, connections break function is lost. This method will be employed with the fifth grade primary students.

Since blood vessels are sheared, fluid leakage becomes a major problem, especially since blood is toxic in the brain. Resulting hemorrhages, and hematomas create fluid filled pockets that expand the brain tissue into the CSF increasing cranial pressure, which pushes back in on the brain. As pressure and space fight one another, the result is more damage. Swelling is analogous to a balloon inflating inside a Styrofoam cup. As the balloon (brain) expands the pressure from the walls of the cup (skull) cause further bruising and damage. This analogy will be enacted for the fifth grade judges to illustrate swelling.

CSF and blood however, are not the only chemicals that can cause injury in the brain. In a relatively new focus of TBI, attention is being paid to the affects that stretching and sheering have on the conformation of ion channels. For example, the flooding of Ca^{2+} through damaged channels of axon terminals can cause a tremendous efflux of neurotransmitter (NT) into the synaptic space [1]. If the toxicity of high doses of NT, such as glutamate, is not concern enough, NT efflux can also cause a massive opening of postsynaptic channels, activate second messenger systems, or even trigger cell death cascades [1]. By instructing students to roll wiffle balls (NT) to one another, synaptic activity can be imitated. Chemotoxicity can then be illustrated analogously as a flood of wiffle balls (blood, CSF & other NT's) disrupting an orderly exchange (synaptic activity) between the students. The concept of chemotoxicity will be recreated in this manner for our model.

These three models: mechanical shearing and tearing, brain swelling, and chemical toxicity, are very representative of the many neuronal mechanisms that ultimately contribute to TBI. The communication of the brain and its many functions are lost as these processes are destroyed, which in turn, keep on dying and mostly cannot be regenerated. It is our hypothesis that deficit based on injury will reveal the importance of the nervous system to the judging fifth graders.

Materials and Methods:

Poster: A poster made from foam core board set up with MRI pictures showing the way in which the brain sits in the skull, serves as a backdrop. A cartoon diagram of the brain and spinal cord on the board serve as reference, as well as a picture of the nervous system showing projections to all of the limbs. References made to these pictures as much as possible during the explanation of head injury, help students visualize the concepts.

Functional CNS Model: Lined up and given name tags, the kids designate themselves as "brainstem" and "spine." After instruction to hold hands, they squeeze hands one after another to show how the brain can send signals. With the analogy of trying to ride a bike the kids, pass a signal and the last member of the spinal cord, yells "move your legs."

Axonal Sheering and Tearing Model: This functioning nervous system is contrasted with a damaged one by assuming that the "bike rider" is not wearing a helmet, and that injury occurs, simulated by the throwing of a wifffle ball at the rider's head. Impact and whiplash are simulated by having the "brain" jog forward and backward, while the "spine" stays still. The kids should have difficulty continuing to hold hands, simulating mechanical sheering and tearing.

Swelling Model: A balloon is blown up to the size of the brain in the MRI image, and explained to be the size of a normal brain. The balloon is slipped into a Styrofoam cup, explained to be the walls of the skull. Further inflation of the balloon is representative of swelling of the brain, which eventually pops simulating damage. A pin is placed in the Styrofoam to cause the bursting.

Chemotoxicity Model: The kids are then instructed to sit opposite one another on the floor forming a "synapse." One side is given wiffle balls (NT) to roll into cups (receptors) held by the other side. This was practiced a few times. Having been told about internal leakage of blood and other fluids is present from the swelling model, the students were asked to roll the wiffle balls one more time. This time however, a flood of wiffle balls is dumped into the passing zone (synaptic cleft), and activity is disrupted.

Results:

		Q1 Understand	Q2 Friendly	Q3 Fun	Q4 Learn More	Average	Place Vote
Place Power	A1	4.86	4.95	4.84	4.5	4.7875	1
Ouch, My Brain	A4	4.8	4.8	4.7	4.4	4.675	2
Meeting Your Potential	A3	4.84	4.89	4.69	4.27	4.6725	3
Seeing Is Believing?	A2	4.56	4.76	4.56	4.13	4.5025	3
		-0.5639	-0.6071	-0.8748	-0.9218	-0.8053	Correlation

Figure 1: Raw data for the four categories judged by the fifth grade primary students. Our model (A4) scored into second place overall, and second place in every individual category except Q1 and Q2 (see figure 2).

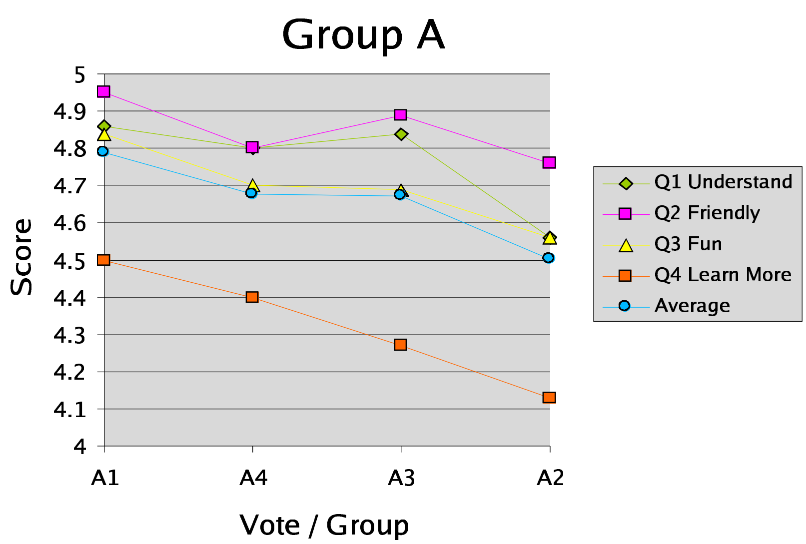

Figure 2: The score of each category judged and plotted against groups.

In the judging competition, each group presentation was scored on a scale of 1-5 in four categories: understanding, friendliness, fun, and the want to learn more. Our presentation received scores of 4.8, 4.8, 4.7, and 4.4 respectively (fig. 1). The results from this data actually show that the kids based their ultimate rankings more off of the "fun" and "learn more" categories, as our presentation was outscored in the "friendly", and "understanding" categories (fig 2). This suggests that the fifth graders were most impressed with the ability to make the presentation fun, and its ability to capture their interest.

The kids responded well to our presentation. We asked them rhetorical questions throughout the presentation of material, waiting for them to respond and engaging them in the process. This seemed to be one of our best stratiges. Because of all of the hands on explanations, the kids quickly examined the situations imposed on them. When told that their brains sit in a fluid called CSF, for instance, they asked what exactly CSF is, and how it got there. They wanted to know if a procedure existed to reverse any of the damage, to which the answer is predominantly no. Thought they thoroughly enjoyed the brain injury scene where my colleague was struck in the head by a wiffel ball, students learned the importance of protection of the nervous system. On the evaluation sheets the most prevalent comment of the kids regards the importance of protecting the head and brain.

Conclusion and Discussion:

Based on our findings we feel that our presentation was not only fun and interesting to the fifth graders, but covered some very representative concepts with in the nervous system. The amount of information was greater that presented by most groups. The ability to separate that information into three simple and practical analogies was the strongest part of our presentation. Also, the enacting of various complex neuro-mechanisms, such as holding hands for axonal signaling, and rolling wiffle balls for synaptic transmission, seemed to generate a sense of reality and interest in the model. Kids were able to generate their own questions, without needing to understand technical language. We took a very rhetorical approach of explanation to the kids, so as to lead them to their own answers by pointing to diagrams and pictures. We feel that this engaged them more into our presentation.

Our ultimate conclusion is that kids love media. The more pictures, props, analogies, and enacting used the better chance they have of understanding and remembering something about the model. We feel that it was a better strategy to employ many simple props rather than one complex one. The judging supports the idea that the 3 well defined topics: shearing and tearing, brain swelling, and chemical toxicity, each with its own set of props and presentations, enabled us to illustrate brain injury effectively. In the end kids were able to verbalize an appreciation of the preciousness of the nervous system, which was our main goal.

References:

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