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Big Blind Busted Brain

Abstract

We hypothesized that we could stimulate different types of visual deficits in which specific regions of a visual field were blinded to teach children about the neurological pathways involved in visual perception. Through this process, we presented our model to groups of fifth grade students. We constructed a visual apparatus in which we could manipulate the visual areas viewed through it. We showed the students the visual pathway and engaged them in the scientific process. With our guidance, the students learned how to use scientific knowledge and techniques to make a medical diagnosis of their fellow students looking through the visual apparatus. The kids judged our model and we received third place. Despite our placing, we concluded that our model did teach the kids everything we aimed to teach. They demonstrated that they were capable of understanding the visual pathway, how it corresponded to the visual field, and were able to make correct diagnosing hypotheses.

Introduction

Among the many nervous system functions studied by neuroscientists, visual perception may be considered a relatively simple subject. It has been well studied for over a century and is adequately described in most neuroscience textbooks. However, a simple subject for neuroscientists is likely to be a complex and difficult one for fifth graders to grasp. For this reason, we developed an interactive model to demonstrate how visual information flows from the eyes to the visual cortex.

Our model demonstrated a fundamental concept of visual perception by showing where visual stimuli within four parameters of a visual field are received by the eyes. This location of the stimuli within the visual field determines what regions of the eyes receive the information, and corresponds to the anatomical pathway that the information follows for visual processing. Furthermore, we developed an activity in which the students may assess a visual impairment within the visual field by following the visual pathways through the model. This will help them determine the brain region along the visual pathway that is damaged and preventing visual information from reaching its final destination.

The projections of the visual field were originally derived through the assessment of visually impaired individuals. Gordon analyzed patients with lesions in their visual cortex to conclude that the visual scenery, as viewed by the retina, was topographically projected onto the visual cortex. Through his methods, it was necessary that the patients

were able to communicate their visual perceptions in response to presentation of visual stimuli. This allowed Gordon to map the blind regions in which the patients were unable to perceive visual stimuli while their eyes were set on a visual scene. He then mapped the shape of the brain lesions that penetrated the visual cortexes. His analysis of the two types of maps found that the shapes were identical. However, Gordon's conclusions also confirmed that each eye projected neural fibers to both ipsilateral and contralateral visual cortex. This assumption was made based on the findings that blindness to the right half of the visual field was caused by damage to the left striate area of the visual cortex and vice versa (Gordon 1945).

Gordon's findings were extensively developed by Hubel and Weisel. Their methods were quite different from Gordon's as they used visual stimulation to activate specific receptive fields to analyze the organization of the visual sensory system. They stimulated areas of the visual system to map how receptive fields originating in the retina projected to specific regions of the visual pathway. They found that the retina was composed of many types of complex receptive fields. The receptive fields' sizes were correlated to their locations on the retina. This accounted for the specificity of the receptive fields' functions and would prove to be beneficial for determining how the eyes respond to visual cues placed throughout various regions in the central and peripheral visual fields (Hubel and Weisel 1977).

Receptive fields convert a visual stimulus into information that can be sent via neural fibers to be processed by the occipital lobe for visual perception. Neural fibers from both eyes converge at the optic chiasm before they travel to their destinations in the occipital lobe. Both eyes contribute fibers that process information from the right visual field. These fibers meet at the optic chiasm and travel to the occipital lobe of the left brain hemisphere. Similarly, fibers from both eyes responding to the left visual field meet at the optic chiasm, but project information along the visual tract to the occipital lobe of the right brain hemisphere. The terminating fibers are highly organized within the striate cortex according to the complexity level, function, and location of the original receptive fields that compose the retina (Hubel and Weisel 1977).

The anatomical design of the visual pathways accounts for various forms and degrees of visual impairments. Optometric studies have correlated visual field impairments with physiological damage to specific locations along the visual pathways. Medical assessment by Lakhanpal, Arun and Selhorst analyzed two individual cases in which damage along the visual tracks spread to increase blindness of specific regions of the individuals' visual fields. Analysis of the first case found that it was possible for one to have a blind spot that crossed peripheral and central visual fields in the upper division of the visual fields. This was due to a partially collapsed optic nerve. Analysis of the second case found an individual with absolute blindness in the entire lower peripheral and central visual fields. The methods used to map the areas of blindness were similar to

Gordon's, as the individuals communicated their visual perceptions to a physician as visual stimuli were presented throughout a visual field (Lakhanpal 1990).

Our model was designed to engage students in the process of visual perception. The visual perception was first visually demonstrated to the students in a model that designates the differences between the left and right visual fields. The model was color coded so that visual stimuli from the left visual field followed a path that terminated in occipital lobe of the right-hemisphere. Likewise, visual stimuli from the right visual field followed a path that terminated in the occipital lobe of the left hemisphere. Next the students used the model to run through several "brain damage" scenarios in which a section of the visual field is blinded. One student looked through a visual apparatus that has been set to stimulate the visual deficit in the appropriate visual field. The students were guided through the process of testing the "brain damaged student" to localize the area of damage that is obstructing visual information from being properly processed and perceived. This process required a simplistic method of mapping the blind visual field through communication with the brain damaged student. The students assessed the task using the methods similar to those of Gordon, other neurologists and other optometrists who have attempted to determine how visual information travels through the visual pathways resulting in visual perception.

Methods

Our model consisted of three distinct structures: a massive horizontal brain section, a visual field, and a visual apparatus.

We constructed the brain section out of paper mache. The paper mache paste consisted of 2 parts water, 1 part starch, and a few bottle squeezes of Elmer's glue—the precise proportions varied with each application. We made a frame out of large plastic containers and toilet paper rolls. The objects were arranged to resemble gyri, then taped with masking tape to a 2' x 3' piece of plywood. We applied a layer of paper mache to the outer frame. After the first layer of paper mache dried, we added more structural details to depict the visual tract: left and right optic nerves, an optic chiasm, and ascending visual tracts that terminated in the left and right occipital lobes. These structures were elevated an inch above the rest of the brain to place emphasis on the visual pathway. We applied six more layers of paper macho to the entire structure, allowing the structure to dry for at least 24 hours between each application. When the structure was complete, we painted it. The areas corresponding to the left visual pathway were painted yellow while the areas corresponding to the right visual pathway were painted blue. The remaining areas of the brain were sponge painted with black, gray and white paint to roughly represent gray and white matter.

To construct the visual field, we folded a white full size sheet in half. The sheet was ironed with several applications of starch and fabric stiffener. We then mapped the

parameters of the visual field using masking tape and a ruler. We painted the left peripheral visual field blue and the right peripheral visual field yellow. To designate the areas of the visual field where left and right visual pathways overlapped, we used two shades of green. The left medial visual field was painted a dark green, while the right medial visual field was painted a lime green. Once the paint was dry, we removed the tape to reveal precise borders between the fields.

We constructed a 3”x 5”x 8” wood box resting on a 10” stand to serve as the visual apparatus. We designed one side of the box with a forehead rest to position the viewer’s head while he looked through the box, and cut eye holes for him to look through. The opposite side of the box was left open. On the top of the box, we designed a slit in which we could slide plexi-glass into. We cut eight pieces of plexi-glass to individually fit into the slit, and then designed eight brain damage scenarios in which we could block vision in specific areas of the visual field.

The brain damage scenarios stimulated blindness in the following areas of the visual field: entire left field, left and right medial fields, right peripheral field, entire right field, right medial field, left medial field and right peripheral field, a horizontal rectangle running across the right visual field, and both left and right peripheral fields. To create the scenarios, we set up the visual box roughly ten feet from the visual field. With black electrical tape we blocked out specific regions of the plexi-glass pieces, corresponding to each brain damage scenario. We used a system of trial and error to test and block out the visual field areas. Furthermore, for each brain damage scenario, we wrote a short silly story. Each story described an accident or event that brought a patient to the doctor for visual field testing and diagnosis of the location of brain damage along the visual pathway.

To complete our model, we used safety pins and color coded yarn to connect the parameters of the visual fields to their corresponding locations on the retina of the paper mache brain. The brain was arranged roughly five feet in front of the visual field with the visual box placed directly behind it. We then labeled the left and right sides of the visual fields to prevent confusion. On the brain, we labeled the eyes, the optic nerves, the optic chiasm, the visual tracts, and the occipital lobes.

Results

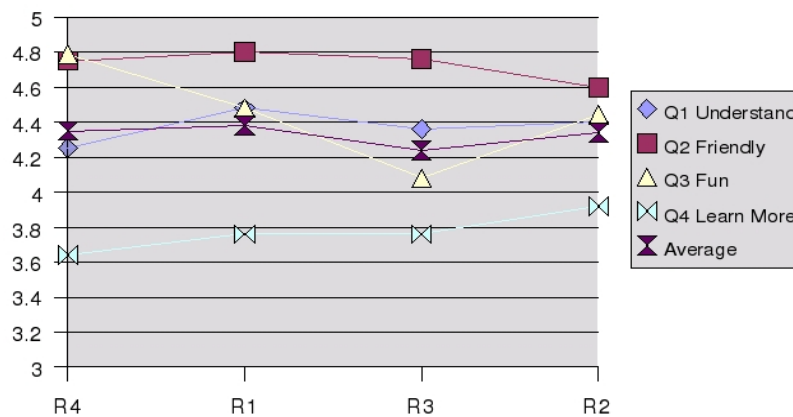
Kids’ Scores for Big Blind Busted Brain:

Question	Average Score
Could you understand what the presenters were trying to tell you?	4.36
Were the presenters friendly?	4.76
Was the exhibit fun?	4.08
Would you like to learn more about this topic?	3.76

Big Blind Busted Brain placed third over all. In individual categories, we were ranked second for having the friendliest presenters and having a topic that the kids would like to learn more about. We received a rank of 4 for fun and average of scores.

Question	Average Score	Rankings			
	Big Blind Busted Brain R3	R3	R1	R2	R4
Could you understand what the presenters were trying to tell you?	4.36	3	1	2	4
Were the presenters friendly?	4.76	2	1	4	3
Was the exhibit fun?	4.08	4	2	3	1
Would you like to learn more about this topic?	3.76	2	3	1	4

Group R



Commentary Summaries on Big Blind Busted Brain:

Question	Summarized Comment *	Frequency of comment
What was your favorite part of this exhibit?	The experimental process and being the experimenter	8
	Looking through the glass (the visual box)	5
	Putting pictures on the visual field	4
	Learning about the optic chiasm and how it crosses	1
	the model	1
What did you learn from this exhibit?	(something about) the optic chiasm and how information crosses	4
	The brain can cause blindness	4
	About the eyes and/or brain	4
	About the eyes	3
Additional Comments	Cool	1
	Good	1

8 out of 25 (32%) of the kids who judged our exhibit said that their favorite part was “the experimental process and being the experimenter.” 5 out of 25 (20%) kids said their favorite part was looking at the visual field through the visual box. Only 19 out of 25 kids commented on their favorite part of the exhibit.

In regards to what they learned, 15 out of 25 wrote comments. 4 out of 25 (16%) of the kids said they specifically learned how information crosses at the optic chiasm. Similarly, 4 more kids said that they learned that the brain causes blindness, 4 more said “eyes and/or brain” while the vaguest 3 kids simply said that they learned about the “eyes.”

Discussion

Big Blind Busted Brain placed third in the red group. While the majority of kids voted for group R4, it was interesting to observe that they also gave R4 the lowest scores in regards to their wanting to learn more about the subject. This suggests that the kids did not necessarily consider the individual score when voting for their overall favorite model—they voted for the model that they thought was the most fun. Our exhibit did not receive high scores for its amount of fun and ranked 4th place out of 4 exhibits. However, it did receive the second highest scores for presenting a topic that the kids would like to learn more about. Also, the majority of the kids who commented on our exhibit said that their favorite part of our model was engaging in the scientific process and diagnosing their patients. In this regard, our model was a success. We engaged the kids in the scientific process and showed them how to use scientific knowledge to assess a problem.

Furthermore, there were several kids whom greatly enjoyed our model and grasped the important concepts in visual processing. One group of kids that had judged our exhibit chose to return during their free browsing time. They said that they thought our stories were funny, and that it was fun to try to make their patient diagnosis. During this time, we gave them our most difficult scenarios to solve. This was the most rewarding aspect of the project as the kids worked through the diagnosis themselves. They appeared to grasp the all of the concepts and followed all the steps we had showed them. They began by testing the visual fields then following the string parameters of the blind regions, and tracing the areas along the visual path. To our astonishment they were capable of making the correct hypothesis and appeared to enjoy working through the problems.

Bibliography

- Holmes, Gordon. "Ferrier Lecture: The Organization of the Visual Cortex in Man." Proceedings of the Royal Society of London. Series B, Biological Sciences 132.869 April 1945: 348-369. JSTOR 5 Feb 2007
- Hubel, David H. and Torsten N. Wiesel. "Ferrier Lecture, 1977: Functional Architecture of Macaque Monkey Visual Cortex." Brain and Visual Perception: The Story of a 25-Year Collaboration. New York: Oxford University Press, Inc. 2005.
- Lakhanpal, Arun and John B. Selhorst. "Bilateral Altitudinal Visual Fields." Annals of Ophthalmology 22:112 March 1990: 112-116.