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Neuro 430
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Big Blind Busted Brain

Abstract

The intent of this experiment was to explore the neuroscientific anatomical basis of vision in the brain. The history of this subject stems back to Rene Descartes and continues right into modern neuroscience. By explaining and showing children models and diagrams of the brain and the neural basis of vision we hoped to explain how the visual system works. After the students had a rudimentary understanding of these concepts we asked them to 'diagnose' a patient with an imitated lesion and localize the damage. Ultimately we found that the children were moderately interested in learning about the neural basis of vision, and; in the end, we made a few sacrifices for the sake of simplicity that made our project somewhat inaccurate or unrepresentative.

Introduction

The subject of this endeavor was to explore the neuroscientific anatomical basis of vision in the brain. In the 1830's, achromatic microscopes provided the first glimpses of the neural basis of vision and the experiments that followed provided a plethora of information about the dimensions of these nerve fibers. The great French Philosopher Rene Descartes hypothesized that the size of the nerve fibers in the optic nerve provided the basis for our visual resolution.¹ Based on the speculations of Descartes, later neuroscientists hypothesized on the relative size of nerve fibers in the brain. Johannes Muller gave an estimated size of optic fibers at 0.0030 mm^2 ; with later support from Porterfield, Smith and Jurin based on the foundations of Descartes work in visual acuity and fiber size relationships. The development of the achromatic microscope lead to further refinement of these estimates; placing the new value at 0.0021 mm derived by Jabez Hogg in the late 19th century.³ Although the assumptions of Descartes were later proved to be scientifically inaccurate, his contribution was immense in terms of logical analysis applied to a developing understanding of neural science.

Given that the cerebral cortex has many well defined functional areas, the development of the cerebral cortex can give several clues on plasticity and specificity of cortical processing networks. Studies involving loss of function determine what extent

these relationships are plastic or specific and generalizable to all individuals.⁴ The visual cortex seems to have well defined boundaries and specific functional areas, wherein lie ocular dominance columns, orientation preference and spatial frequency preference.⁵ Many of these relationships responsible for visual information are established well before the visual cortex; between the LGN and the visual cortex. Furthermore, these relationships are subject to change as indicated by artificially induced strabismus experiments causing modifications in horizontal connectivity.⁶ This does not imply that modifications in the visual system are completely responsible for cortical visual representation; rather they are related to intrinsic cues.

Sir David Ferrier conducted a series of experiments to localize and map the cortical representation of retinal projections in the visual cortex. Working with monkeys Ferrier concluded that destruction of the angular gyrus on one side resulted in blindness of the contralateral eye. The damage was later determined to be localized in the optic radiations. These findings were significant insofar as they indicated an intimate relationship between location of lesion and type of visual deficit experienced by subjects.⁷

We explored the neuronal basis of vision by examining the visual pathways and the cortices they implement in visual processing. This was accomplished by discussing structural mechanisms involved in the visual pathway; and the emerging view of the world that arises from these pathways, specifically the binocular theory of vision. By illustrating the visual pathways and the nature of how they function in the presence of lesions and in normal patients, we showed the students the basics of the visual pathway. Specifically, a lesion in one of the optic nerves will result in complete loss of vision in the corresponding eye, and a lesion in the optic chiasm will result in a loss of vision in the temporal halves of both visual fields. The third and final lesion will be a lesion in the optic tract, which will result in loss of vision in the contralateral visual field. Through these exercises, the students will learn which eye and which part of the visual field project to the visual cortex in specific circumstances.

The students, after having a crash course in visual neuroscience, will then be introduced to the visual perceptual fields of the eye, in particular, which part of each eye receives information about the world in reference to the particular individual. By color-coding the visual field we hope to convey the importance of the visual field, and the relative position of the visual fields. We then ask the students to predict which parts of the visual field will be perceivable with lesions to specific locales in the visual pathway.

Methods

The model was constructed using one-half inch plywood, a broomstick, Plexiglas, newspaper, a sheet, electrical tape, cardboard, paint, yarn and paper representations of well-known cartoon characters. We made a representation of a brain slice to illustrate the

visual pathways using toilet paper rolls, cardboard and paper mache. See appendix for approximate representation of the model. We painted the representation in such a way that the colors represented the visual field projections and visual pathways in order to simplify the material. On a board we placed a sheet color coded to represent the areas of the visual field and placed in front of the brain model. We represented the projections of the retina in the field sheet by attaching the corresponding parts with color coded pieces of yarn. Behind the brain model, we placed the visual deficit box which was a small plywood compartment that was specifically designed to limit the subject's visual field to the sheet. Within the box, we placed placards made out of Plexiglas with electrical tape to mimic specific lesions along the visual pathway as described above. We briefly explained the basic anatomy, terms and concepts vital to the understanding of visual processing at a base level to the children. After the subject was in the visual box position, we read the scenario card so as to give the students a possible hint or clue to the location of the lesion; then asked the subject in the box to identify what she saw on the sheet by asking which cartoon characters they could or could not identify. After the deficit was recognized, we asked the students to hypothesize the location of the lesion on the corresponding brain model. Then we asked the children to switch places and repeated the box process. After a few trials, we then quizzed the children on the anatomy of the brain as it relates to vision.

Results

The model seemed to be moderately well received by the children. Although the information was rather advanced, the children seemed to grasp the concept rather quickly and were eager to engage in active learning and mock diagnosis; albeit some were more interested than others. Judging purely based on the lack of questions the children asked we can conclude that they either completely understood the project or did not understand it at all. I would venture that the "dryness" of the subject led to the overall lack of interest from the children. We specifically included a quiz at the end of the presentation to ensure that the children were actively trying to understand, or at least remember some aspects of the project. Some of the most memorable aspects of the project were the cartoon characters or anything visually stimulating; but very few neuroscientific concepts. After all of the votes were tallied, we finished in the middle of the group 'R'; indicating our project was of average interest to the children. We believe that the results coincide nicely with the data we received as feedback from the children. For the question "Could you understand what the presenters were trying to tell you?" we received a mean value of 4.36 with a maximum of 5. For the question "Were the presenters friendly?" we received a mean score of 4.76. For the question "Was the exhibit fun?" we received a mean score of 4.08. For the question "Would you like to learn more about this topic?" we received a mean score of 3.76. We believe this data indicated that the children

understood and liked the exhibit as well as the presentation; however, they were not enthralled by the subject matter. Higher mean scores and more comments on the project would lead one to believe that the children liked the project; because these were not present we can conclude that this is not the case. Some of the most common comments from the children were “cool” and “good”. When asked about their favorite part of the exhibit the most popular response was “the experimental process and being the experimenter”; or some variant of that statement. When asked about what they learned from the exhibit the most common response was “learning about the eyes and brain”.

Discussion

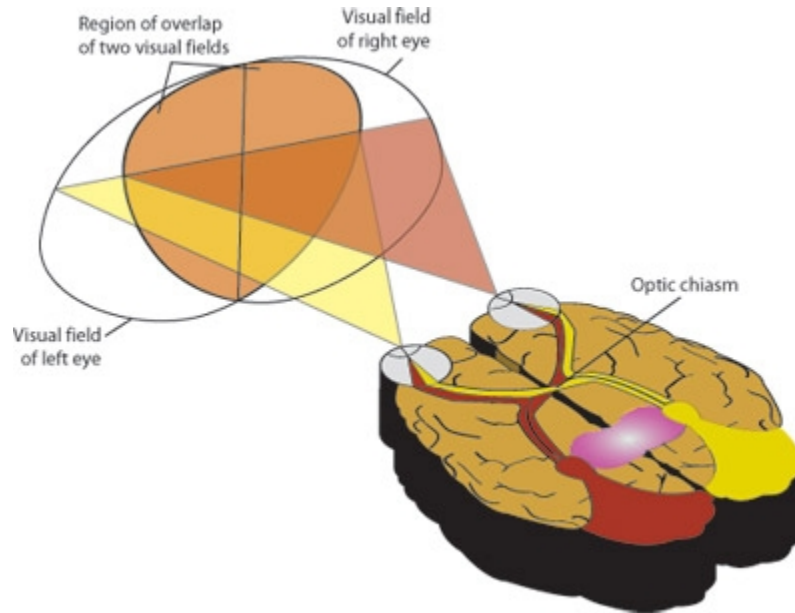
We interpreted the results as being very indicative of the actual sentiments of the children towards our project. Although the project functioned in its goal to teach the basics of the visual system, we feel that a better result could be achieved through a much simpler and more elegant representation of the underlying mechanisms responsible vision in the brain. We also thought that the lack of physical stimulation was instrumental in the lackluster performance of our project in terms of voting. We believe that if the children played more of a physically active role in learning about the brain, they would have had more fun. These problems could be alleviated through the use of electronic devices or a game of some sort for the children to play. A feasible idea we had was to use holiday lights to illuminate the visual pathway, in retrospect this would have made our project much more appealing to the children. Also, we believe that the lack of general interest in the subject matter ultimately doomed us to mediocrity; if we would have chosen a flashier subject in neuroscience, there would have been more interest. Because the nature of our topic was rather static and abstract the children had a difficult time understanding the concepts underlying the model. A model that is more dynamic, stimulating and engaging would have made a tremendous difference.

In building the model we sought to provide a more tangible experience in learning about the visual pathways and how lesions in various areas of the visual pathway can damage the vision of an individual. By having the children learn about the basic pathways and anatomy of the corresponding structures we planned to make the children quasi-informed before having them engage in diagnosis of a specific lesion. By making the scenarios relatable to children we hoped that the children would be more excited about neuroscience. We felt that this model was also very relevant to neuroscience insofar as it explains, at least partially, the fundamental concepts behind one of our most essential neural processes; that of vision. What we accomplished in any of the aforementioned criteria was diminished due to the model’s limitations and omissions. Although the model provided a good general representation of the visual system, we felt the oversimplification of the process made it somewhat inaccurate. For example, we omitted any neural processes from the LGN to the visual cortex. We all are well aware

that there is much that goes on here; in fact, probably far too much for us to have ignored. We felt that this particular presentation would be more fitting for a group of high school aged students. That being said, we felt that the children learned (or at least memorized) the material fairly well.

Appendix

Figure 1.⁸



Works Cited

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