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Neuro 430
Kids Judge Neuroscience Fair 2006 Exhibit
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Writing in the Major Assignment

"What Do You See?"

An interactive model; representing the organization and processing of information within the visual system

Abstract

The visual system is highly organized and processes a ton of information every day. One interesting aspect of our visual capabilities is our ability to produce such a descriptive image based on the physical world in which we live. This capability is made possible by the intricate circuitry within the many elements of the visual system that produces an image of activation within cortical regions of our brains while we are observing the outside world. In order to encourage neuroscience as a scholastic endeavourer, we built a model to present to fifth graders at the 2006 Kid's Judge Neuroscience Fair, concerning the visual system. Our model was highly interactive and incorporated a lot of hands on time for the students. Due to much complexity within the visual system we had to narrow down the expectation of understanding to a single idea. The objective of the model was to teach kids that images can be represented by stimulus characteristics and relayed as information to reproduce the image. The kids learned a lot about the visual system from the model and we learned better how to express our scientific thoughts to people who haven't necessarily been exposed to neuroscience.

Introduction

Visual transduction is the process by which photon energy of light is adsorbed by retinal (photopigment) and causes a series of molecular events leading to the processing of visual information by the brain. Visual sensory systems in the mammalian brain involve complex organization. The eyeball, the primary visual sensory organ, containing the retina, contributes to stimulus organization with neuronal differentiation, molecular machinery and intricate circuitry. Within the retina, are many types of differentiated neural cells: photoreceptors, bipolar cells, ganglion cells, horizontal cells and amacrine cells (Wassle 2004). Probably the most important of these cells being the photoreceptors. Photoreceptors are responsible for absorbing light energy (photons).

There are two types of photoreceptor found in the retina, Rods and Cones. These receptors differ on many levels but we will focus on their different absorption frequencies. Cones are responsible for color vision, while Rods are responsible for black and white vision. Photoreceptors contain photosensitive molecules, like Rhodopsin found in rods (Chabre 1989). Rhodopsin is a membrane bound protein housing retinal, a separate molecule which is photoisomerized after being struck with a photon. This photoisomerization of retinal causes a conformational change in Rhodopsin. This conformational change, of Rhodopsin, causes both direct and indirect cellular changes via metabotropic interactions involving cGMP (Chabre, 1989). With the activation of rhodopsin comes the closure of cationic channels leading to a hyperpolarization of the photoreceptor. This hyperpolarization is transmitted to bipolar cells and horizontal cells via chemical and electrical synapses. The hyperpolarization transmitted to the bipolar cell will either cause it to hyperpolarize or depolarize based on the type of bipolar cell. The purpose of the horizontal cell is to communicate with surrounding photoreceptors to create an organized response (Wassle, 2004).

The optic nerve relays, via a labeled line code, characteristic information from the retinal ganglion cells to the lateral geniculate nucleus of the thalamus and then to the visual cortex in the occipital lobe. The organization of visual characteristics within the optic nerve is maintained in parallel within many classifications. We were specifically interested in the parallel processing of color and location. Differentiated cells and circuits within the visual pathway are responsible for segregating the different characteristics. For instance, there are three different types of cones which capture three different wave lengths, combining the capabilities of each cone cell assembles an entire spectrum of wave lengths (Wassle 2004).

Once the segregated information reaches the visual cortex, it is further organized into a cortical map. Cortical maps correspond to areas within the eye ball's field of view (Xiangmin 2005). Cortical columns represent pixels on the surface of the cortex. The collection of these pixels within the cortex constitutes the visual map. This visual map, built into the primary visual cortex, is activated in the same pattern as the visual stimulus in the physical world.

In an effort to translate the general idea of this complex system to elementary students, we constructed an interactive model; representing the integral and elementary components of visual processing. At Eye station #1 we instructed a student to create an image on a projector screen by filling in boxes on a transparent grid. Another student at the Optic Nerve (Station #2) relayed the information about the image on the screen by choosing numbered balls and colored chutes to roll them down that correlate with the image displayed by the projector in respect to number and color. At the other ends of the chutes was another student at the Primary Visual Cortex (station #3, at this station the initial image projected on the screen cannot be seen). This student had the same grid as the one on the screen, only on paper. By analyzing the information given to them through the tubes they attempted to reproduce the same image on their paper grid without ever seeing the initial image. We hope that this model will show the students how an image can be communicated by taking apart the image based on characteristics, turning these characteristics into information, sending the information somewhere else and putting it back together.

One objective of this model was to represent the travel and organization of information within the visual system in an interactive framework. Each interactive station within the model will directly teach the students the role of that certain component within the visual system. For example, if a student drew the picture on the projector screen, an instructor will be there to explain to her/him the process of forming an image on the retina and how the "what do you see?" model projector physically represents the structure of the eye. Because the students are acting as the components, there is emphasis on individual parts of the system working together, using teamwork, to accomplish the communication of information, another hallmark of the nervous system.

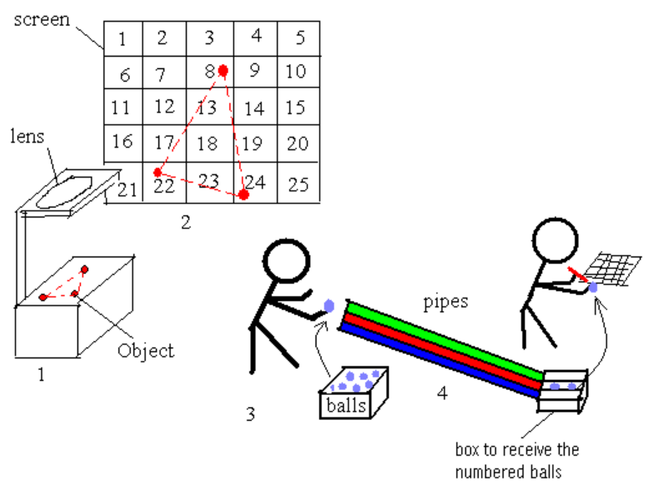
Once again, presenting this idea to elementary kids hopefully taught them a little about visual processing. More over, we hope by engaging interactively with the children in a scientific environment we will be able to cultivate their thought and interest in neuroscience.

Methods

The model consisted of: one white screen, one upright divider, one overhead projector, one numbered transparent grid, three PVC tubes (colored green, blue and red), one box containing three inner boxes, as many numbered balls as numbered boxes on the grid, many paper grids to transfer the information from the numbered balls to, crayons (blue/green/red), two tables and one wedge (for elevating the input ends of the PVC pipes).

To put the model together, we hung the white screen on the upright divider. Next, we taped the transparent numbered grid to the light surface of the projector, and positioned the projector so that the grid projected uniformly on the white screen. We then used two tables to pin the upright divider. We positioned the colored PVC tubing at a declining angle on top of the two tables and pointed the tubes so the receptacle box was behind the divider. The balls needed to end up behind the divider so that the students at the Primary Visual Cortex (Station #3) had no opportunity to see the image on the white screen.

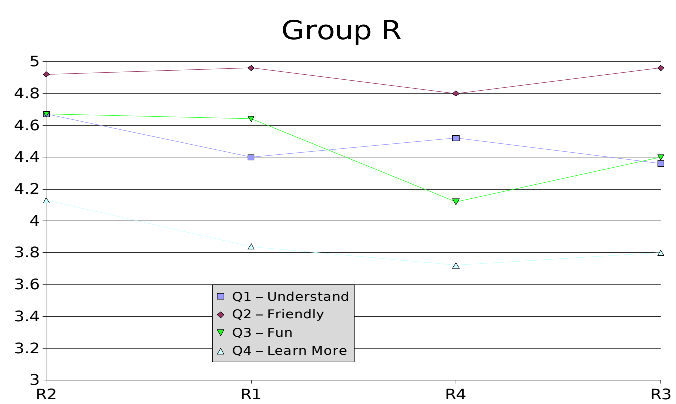
Figure 1.



Results

The students at the 2006 Kid's Judge Neuroscience Fair participated in our model very well and based on their evaluations (figure 2) we placed 2nd out of 4 in the Red group. They enjoyed getting to do all of the stations, and the interactive nature of the model seemed to get them inside the circuitry of the visual system. Most of the students were not very shy and asked questions when they didn't understand. Based on the comments from the evaluation forms and the actual experience, the students really liked it when they got to compare the picture that was generated at station #3 with the one drawn on the screen. The students were excited and amazed about generating an image with only categorized information, and never actually saw the image. This led us to think that they understood the idea we were trying to teach them. Almost every student claimed to have learned "about the eye", "about parts of the visual system", "about vision", or "parts of the eye having to do with color".

Figure 2.



Discussion

By interacting with the kids at the Fair and seeing their eyes light up with realization when they were rolling the ball down the tube or drawing in the grid, we felt the model was successful. To back this thought up with statistics, the data (Figure 2.) supported that we were successful in relation to our peers. We came in second place based on the votes and comments from the kids.

Reflecting on the results inspired some thoughts about how we could improve our model. We didn't score as well as we could have in the category concerning the students understanding of the topic. Perhaps we were trying to give them too much information at first without earning their attention. Perhaps a better method would let the kids do a test run with the interactive model first, and then inform them about the similarities between the model and the visual system. This sequence might attract them to the topic before we load them with words that they do not understand. Another way we could make our model better would be to make it more extreme. Our model was very mentally and physically engaging but not very physically exciting. Fifth graders are generally more interested in things that are bigger and faster, rather than more intricate. It would be advantageous to incorporate a more exciting element into the model. Regardless of the lack of excitement, we were able to give the kids something to do for the whole time and these exercises engaged them in the topic.

This is a very complicated topic to be trying to teach fifth graders, (just like every neuroscience topic) so there was definitely an abundance of information left out. It would have been good to teach them about the circuitry within the primary visual cortex involved in the processing of orientation and shape. However, to fifth grade students, the facts and information are less important aspects of neuroscience than the ideas. The ideas surrounding the topics are the fun things to learn about, the easier aspects to convey and also stimulate the young student's scientific mind; the most important effect of the Kid's Judge! Neuroscience Fair.

References:

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