Bernadette Ronayne
Neuro 430
Kids Judge Neuroscience Fair 2006 Exhibit
(with: Sasha Edmunds)
Writing in the Major Assignment
27 April 2006

Why You Can't Sleep With the Lights On

Abstract: Our model explained the process of how light enters the eye and follows a pathway that ultimately causes neurotransmitters to be released throughout the brain and thus activating certain parts. Using our poster we explained the process so that they could see it. We then portrayed the idea through use of an obstacle course that illustrated the specific pathway. Each kid served a role in the pathway. The kids probably thought that the process was confusing but they seemed to grasp the general idea of how light "wakes up" the brain. The kids seemed to like our project and viewed it as fun but not many of them wished to learn that much more information about our topic.

Introduction

Through abundant and continuous research, scientists have shown that the suprachiasmatic nucleus (SCN) is vital for regulating the body's cycles. Outputs from this part of the brain govern body temperature, feeding schedules, and of course the most studied and understood cycle, the sleep-wake cycle. (Herzog, 2002)

In order for the SCN to work properly, it needs information about the external environment to make the appropriate responses that help regulate the body. Information, in the form of light or absence of light, flows from the retina to the SCN, telling the SCN what actions to perform next; obviously, disruptions in this pathway can cause irregular sleep-wake cycles. Because light plays such a prime role in the SCN's ability to regulate the body, scientists have used it as a prime source of manipulation to study the affects daylight has in sleep-wake cycles. (Herzog, 2002)

Light transmitted through the retina to the SCN does not rely on rods and cones. These types of photoreceptors are responsible for receiving and sending visual information to parts of the cerebral cortex to help visualize the external environment. Researchers have performed numerous studies on this pathway to see if light passing through these receptors were the actual inputs that help regulate the SCN. However, studies showed that mammals who are blind and have impaired rods and cones, still maintain normal sleep wake cycles. Therefore, there must be another mechanism telling the SCN about the light conditions of its external environment. (Berson, 2002)

Through various research methods, scientists have found that there are retinal ganglion cells that are sensitive to light. These cells are not photoreceptors, which explains why blind people can often exhibit normal sleep-wake patterns. These retinal ganglion cells contain melanopsin, the photopigment believed to be responsible for projecting light information to the SCN. Light hits the SCN resulting in a state of wakefulness. (Berson, 2002)

Research indicates that the SCN regulates the body on a 24-hour clock schedule that is controlled through the amount of light available. Scientists have studied the affects of light on mice by observing their wheel-running habits. Normal mice run during periods of darkness and sleep during the day, each period usually consisting of 12-hour cycles of light versus dark. However, when the amount of light exposed to the mice changed, the wheel-running habits changed as well. Normally, light entrainment causes mice to run during the night and sleep during the day. Disruptions in light patterns can ruin this cycle and cause mice to run during times of daylight. (Albreicht, 2003) From this information, they inferred that light plays a pivotal role in stimulating physical activity and various states of arousal.

Activation of these states of arousal are regulated through pathways that have projections from the SCN. The pathways directly projecting to the locus coeruleus and the raphe nucleus are activated in humans when the SCN registers light from the external environment. As a result of this light, outputs from the SCN cause the locus coeruleus to release norepinephrine and raphe nucleus to release serotonin. These neurotransmitters stimulate various parts of the brain and cerebral cortex and thus “wake” the brain as well as the person. When no light is present, these neurotransmitters are inhibited from their normal actions, allowing the body to enter sleep mode. Light modulation is therefore important in keeping someone awake or causing someone to fall asleep.

Our model focuses on the pathways important for keeping the body awake and active. It represents the pathway of light from the retina to the SCN, followed by projections to the pons, where the locus coeruleus and raphe nucleus lie, as well as the projections to other areas of the brain important for keeping people awake.

The model incorporates this information by means of kids “firing” light into the pupil of the eye (a hole that can change in diameter) and runs through a pathway that ultimately stimulates the brain.

We want the kids to understand the preliminary concept of sleep-week cycles as a result of light modulation; we also want them to know that even a tiny portion of the brain (the SCN) can have such a huge impact on other bodily processes. We think that by knowing about just one of the ways the brain helps you wake up, it can stem their interest to learn more about the other processes that are regulated through the SCN.

Materials and Methods

Our model did not involve that many items. We constructed a stand up poster of a giant eye with a hole in the middle acting as a pupil. Behind the pupil of the eye was a dark compartment constructed with a smaller box that allowed balls of light to be caught and kept. Other items included in the model were a skateboard, a box containing neurotransmitters (plastic Easter eggs), three cups, and a Nerf gun that shoots balls.

The model consisted of a giant obstacle course that represented the pathway light takes in order to "wake the brain up." First, we set up the eye poster at one end of a table. At the other end of the table a kid fired a ball from the Nerf gun into the pupil (hole) of the eye. Then another kid behind the poster caught the ball and rolled on a skateboard to the "SCN" and dropped the ball of light into a cup. At this spot another kid took the skateboard and rode to the box. This box represented the pons and held the serotonin and norepinephrine neurotransmitters. Once the person on the skateboard reached this point, two more kids each grabbed a neurotransmitter and carried the NTs to their appropriate destination, which was two cups. These cups represented the different parts of the brain that the neurotransmitters synapse on and activate. As a result of this activation, which occurs after the kids drop the NTs in cups, another person started to do jumping jacks signifying the brain "waking up." The following pathway is mapped out in figure 1.1. We continued to do the pathway while letting the kids change which part of the pathway he or she wanted to participate in.

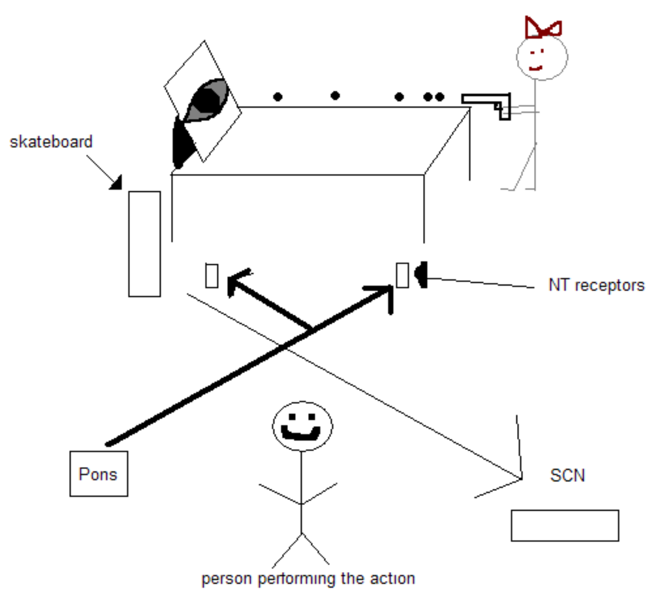

Fig. 1.1

Before running through the above model plan, we asked the kids preliminary questions to introduce our topic such as "does anyone know what nocturnal means" or "can anyone name any nocturnal animals?" Once the kids knew we were going to talk about sleep and how we (humans) were awake rather than during the day we started to explained our poster. Our poster had pictures of the sun giving light off into an eye. We then had two pictures of brains that showed the projections of the neurotransmitters affected by light transduction. We explained the light's role in the regulation of sleep and wakeful cycles and then moved on to the activity.

Results

Once we had the kids' attention, and started explaining the process of how the sun "wakes up the brain," the kids seemed really excited. As we continued to explain our poster, however, they seemed very confused or they were not paying attention. For instance, their heads were looking at the exhibits next to us or their faces showed no expression.

Once the kids got to participate in the obstacle course, they seemed very excited, but because some parts of the course were not that fun, they seemed to lose interest or be more confused.

After we ran through the obstacle course a couple of times, we asked the kids if they had any questions. Almost no kids asked questions.

We placed second with six votes out of a total of twenty-four. Some of the kids did make direct verbal comments that showed their interest in our presentation. One kid said with total enthusiasm: "I'm going to vote for yours and my friend is too." Also, our exhibit never had a break from kids because they constantly wanted to shoot the ball of light into the eye.

With regards to what the kids wrote on their evaluation sheets, we saw that most were moderately high scores, with the exception of the kids wanting to learn more which yielded a lower average. Table 1.1 shows the results. In addition to the scores, the kids also made comments which explained that they thought the game (obstacle course) was the most fun. The question "what did you learn from this exhibit" yielded many interesting comments. Some were they learned about how the eye transmits signals, about how the sun is important, and about the suprachiasmatic nucleus; these were just the most common answers.

Question	Rating
Could you understand what the presenters were trying to tell you?	4.57
Were the presenters friendly?	4.74
Was the exhibit fun?	4.52
Would you like to learn more about this topic?	3.48

Table 1.1
These scores were based on a five point system where five was the highest score possible.

Discussion and Conclusion:

Our original plan for the model did not span out on the actual presentation day. After running through the exhibit with the kids, we were going to make the hole of the pupil smaller so light could not get through; this would have illustrated the fact that less light entering the eye causes less neurotransmitter release. Also, we were going to explain that no matter how much sunlight was entering the eye, a person still could get tired regardless. Time constraints limited the amount of information we could give the kids.

Because most of the kids wrote good comments regarding our exhibit, I assume that the way we presented the material was pretty good. Our initial questions to the kids got them engaged especially because they knew the answers; this was a good start because it made the kids more comfortable with us and the topic they were going to learn about. Also, once we were done explaining our poster, the kids finally got to engage in the activity that demonstrated what they learned. The kids definitely enjoyed themselves when they got to participate in the different parts of the pathway. I think that it was good that we included this activity because too many words can be boring for kids. Plus, I think that later if they did happen to understand the pathway, they would remember it more because they were a part of it.

Although the activity ran pretty smoothly, I could definitely tell that the kids did not always know what we were talking about. The process of how sunlight transduction causes the brain to be activated is very complicated and I could tell that we lost many of the kids' attentions as we talked through our poster. For example, explaining how the eye operates is actually complex so moving on after that point to explain the suprachiasmatic nucleus made them even more confused; most of the kids were probably still thinking about the eye because they could understand it more readily. Therefore, I would say the length of our explanation of the simple pathway (yet complicated to them) that light takes throughout the brain caused many of the kids to lose interest.

Furthermore, because our activity involved each kid performing a specific task I think that they were more attenuated to their task and not to the entire process taking place. Even when the kids switched positions from, for example, riding on the skateboard to shooting the ball of light into the eye, they probably did not understand the importance of the specific tasks that they performed.

Our model definitely oversimplified the process of "waking" the brain up with the help of sunlight. Light does in fact enter the eye and travel to the SCN that ultimately sends a signal to the pons to release of NTs; however, each step along the pathway is a little more complicated. For example, light has to react with certain photopigments and conduct the message to the SCN. Our model only showed the most direct pathways and ignored other pathways the light signal could have taken.

Ignoring the oversimplified model, I think the kids did get the general idea that sunlight does in fact help you get and feel more awake. Their numerous comments like " I learned that the sun helps wake you up " obviously reflect that. Even though they may not have understood each step along the way, they still learned the basic idea. This is a good start for a future neuroscientist.

Since many of the kids showed general interest, I think that they benefited from the experience. Their experience could help determine what they would be interested in doing in the future such as a career in neuroscience or other applied sciences.

References:

Albrecht, Urs, and Eichele, Gregor. The mammalian circadian clock" Current Opinion in Genetics and Development 13.3 (2003): 271-277.

Herzog, Erik and Schwartz, William. "Functional genomics of sleep and circadian rhythm: a neural clockwork for encoding circadian time." Journal of Applied Physiology 92.1 (2002): 401-408.

Berson, David M., Dunn, Felice A., and Takao, Motoharu. "Phototransduction by retinal ganglion cells that set the circadian clock." Science (2002) 295.5557: 1070-1074.

Table 1.1
These scores were based on a five point system where five was the highest score possible.