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Why You Can't Sleep with the Lights On

ABSTRACT:

The suprachiasmatic nucleus is an important factor in regulating sleep/wake cycles. We presented a simple pathway in the form of a relay race to show how light and the SCN help regulate wakefulness. The activity they performed included shooting balls of "light" from a Nerf gun, through an eye poster, to the SCN, and then to the pons. After the pons the kids delivered neurotransmitters to the proper places causing a specified person to do five jumping jacks. After the kids completed the task they filled out surveys and voted for their favorite models. We were in the green group. Our model placed second out of four. The kids were successful in learning the basic concepts and gave good feedback about what they learned.

INTRODUCTION:

Everyday we use cues from our surroundings to aid in our responses. Light is one environmental cue that is very important to regulating a person's circadian rhythm. A circadian rhythm is the term given to the sequence that regulates a 24 hour cycle of biological processes in plants and animals. The term circadian is derived from latin meaning literally, around a day. Some of the first observations with lab animals and plants showed there must be some kind of internal rhythm controlling them. The reason researchers suspected an internal clock was because the animals and plants did not immediately respond to artificial changes in daily rhythms. With additional exploration researchers found that it is possible to change rhythms but this takes time and training.

In mammals, the suprachiasmatic nucleus (SCN) is located in the hypothalamus. The environmental cues that each day reset the rhythms are called zeitgebers, light is the zeitgeber we presented in our model. Some of the initial experiments explored pinealectomy, this produced some interesting results, such as disappearance in paradoxical sleep. As the lesions got larger they extended into the SCN, resulting in loss of circadian rhythms. As a result researchers knew that SCN was involved in these rhythms and further study was launched. Later, from these experiments they found the SCN receives direct inputs from the retina as well as dense projections from the raphe,

control of rhythm of serotonin-N-acetyltransferase and adrenal corticosteroid rhythm (Mouret, et al., 1978). After finding that the SCN was involved in this process they were able to isolate and study the specific pathway.

Other studies have supported the idea that the suprachiasmatic nucleus is important in circadian rhythms. Using squirrel monkeys researchers abolished circadian rhythms and increased total sleep by lesioning the suprachiasmatic nucleus. This was an important finding because these animals are diurnal, and are more similar to humans in comparison to other animals commonly used for this research such as rats (Edgar, et al., 1993). Other studies have also shown that the SCN is a major component in regulating these circadian clocks, researchers lesioned the SCN and then grafted healthy cells to the lesioned area after which the animal showed restored locomotor activity (Tousson, 2004).

The suprachiasmatic nucleus works to gate the sleep/wake cycles but is not ultimately controlling the process (Edgar, et al, 1993). Further investigation into this process has shown that an animal's rhythm is linked to the light-dark cycle. For example, an animal kept in total darkness for extended periods eventually displays a free-running rhythm. A free-running rhythm occurs when an animal's sleep cycle is pushed back or forward, depending on whether the animal is nocturnal or diurnal, by about one hour. In diurnal animals free-running rhythms are close to 25 hours. The importance of these free-running experiments is that without proper cues the pathway will be disrupted. This is proof that animals have an internal clock which is guided by zeitgebers, but are not entirely dependent on them.

Humans that are blind can still entrain themselves to be awake and sleep at the correct time of the day. This is because the pathway is not reliant on the rods or cones. People who are blind are either missing all or a majority of these cells. These specific cells are photoreceptive like rods or cones but have a different job. These cells are found in the retina and are called melanopsin ganglia. Melanopsin ganglia, contain a photo pigment called, melanopsin. These cells follow a pathway called the retinohypothalamic tract, which leads to the SCN. It has been demonstrated with blind mice, completely missing rods and cones, can still establish photic entrainment like normal mice (Berson, 2002). Currently melanopsin is the only known photo pigment involved, though it may not be the sole photo pigment involved in this photic entrainment ability (Albrecht, 2003).

Our model engaged the children in a type of relay race. The sequence of events is a physical representation of how light interacts with the brain to regulate wakefulness. We wanted the kids learn how environmental signals such as light can work in conjunction with your brain and body to synchronize into a routine. In our presentation we isolated the very simple pathway of light going through the eye, to the SCN and from there regulating wakefulness. We also wanted to give them insight into what types of questions can really be answered with the developing field of neuroscience. This may get them

interested in asking more questions and ultimately, could lead them to pursue a career in the sciences.

METHODS AND MATERIALS:

The materials we used included a Nerf gun with four balls, an eye poster, cones, cups, a skateboard, and a “pons” box with egg neurotransmitters. Our obstacle course was set up so that there was a different participant at each station; the first was the Nerf gun station, where they had to shoot one of the balls through the eye. The balls represented light from the sun. At the eye there was another participant waiting to retrieve the ball. After they got the ball from the eye, they then sat on a skateboard and delivered the ball to a cup, this cup represented the SCN. At the SCN there was another child was waiting to get on the skateboard; they then skateboarded over to another specified area and tagged off the next station where two people searched for their neurotransmitters in the pons box,. The neurotransmitters were represented with Easter eggs labeled a 5-Ht and NE. The kids then put the Easter eggs under their chins and had to drop them in cups this represented delivery of the neurotransmitters to various areas of the brain, like the pre-frontal cortex. After delivery of the eggs this triggered the last station to do five jumping jacks. Initially, when the kids came up in the groups we gave them some background about the brain and sleep and the suprachiasmatic nucleus and how it is involved in wakefulness. We also talked about neurotransmitters and parts of the brain that are affected by their release.

RESULTS:

The feedback from the kids told us that they enjoyed themselves and were learning at the same time. We had many participants verbally express that they thought our project was the best. However, the voting didn't reflect this but we were still happy that even one participant made a positive comment. The kids asked some good questions, but not as many as we would have thought. We thought they would relate the subject to a broader area such as sleep or why we have neurotransmitters, but this didn't go as planned and they seemed stuck on this one finite subject. The participants seemed to understand the topic, they got the basic concept that the eye uses light to wake the brain up using neurotransmitters, though some of the detail information about the SCN and its pathway was lost on them seemed. But mostly we were happy that they were getting the basic concept of the project down. We would periodically ask the kids to explain the cycle and what it represented this was how we checked for comprehension during the presentation of the model.

We placed second in our group, but it seemed that many of the participants were interested in our project, so we were somewhat surprised. I think they liked our project

because it involved an activity and got them doing something instead of just listening to a presentation. The evaluations we received were overall positive, mostly they expressed that the best part was the activity and they felt it was fun (mean = 4.52), and that we both friendly (mean = 4.74). They also rated their understanding as being quite high (mean = 4.5), but their rating of wanting to learn more was lower than expected (mean = 3.48). Overall the most comments we got were about the activity and how much they liked it. Usually they mentioned what area of the obstacle course they participated in, like using the skateboard or the Nerf gun. When the kids were asked to write down what they learned on their evaluation sheets a majority wrote comments such as, we learned how the eyes transmit signals, we talked about the SCN, or the sun is important in wakefulness.

When the kids were asked to draw some pictures about a week later explaining what they learned some decided to draw about our model. One of the responses was a picture of the Nerf gun shooting the balls into the eye. The participant said, "I learned you can't sleep with the light in your eyes because that's how your brain and body wakes up. The balls are the light going in the eye." When I read this response I was happy that he had taken home the basic message that we wanted the kids to learn, light from the sun is used to entrain your brain in a proper cycle. Some of the other comments with the pictures were, "the balls represent light, which goes in the eye to give it light," or "when the light hits the eye, it wakes up the brain," there were some inaccuracies but overall we felt that we were able to give the kids a broad foundation in our subject.

DISCUSSION:

Our results were pretty clear that the kids liked our project; they thought highly of the activity, felt that we were friendly and they understood what we were trying to tell them. The only aspect that we felt was low was the wanting to learn more, there could have been several reasons for this response, it could have been they didn't know how much more complicated the process was than we were showing them. Another could have been the way we chose to present the material, maybe next time we could do a question and answer that involves candy giveaways.

I think that the activity went as planned and was successful in getting the kids involved, and could better remember the activity since they were actually performing an action. Our aim was to inform participants of the pathway by which light enters the eye and then activates a pathway that goes to the SCN and subsequently to the pons where neurotransmitters are released to help wake the brain up. The kids really seemed to grasp this concept and many of them could verbally repeat the pathway. There are a few ways that we could have improved the project. One possible way to make the process run smoother would be to know how the dimensions of the area ahead of time. Another possible improvement would be to use more visual aids or analogies to help the kids

understand the concept better and with more detail. It seemed that the participants thought that this pathway cut and dry and they didn't have anything else to learn, it could have been possible to widen the topic. By making the subject matter broader it may have sparked their interest further thus; they would want to learn more about the topic as a whole. However, we were very happy about our project and how it was executed; we wished that there was more space, enabling us to incorporate the jump rope to make some of the other activities more exciting for the kids and really being able to drive home the fact that eventually even if the same signal is coming in that the brain will stop responding.

During the event, we needed to alter the original sequence of events. This was primarily due to the space that was available. One feature that was changed from the original plan was the jump rope, at first we were going to have the last person jump rope ten times, after setting up we found that there was not enough room to do this and make the presentation run smoothly. We also changed the carrying of the eggs with spoons to carrying them under their chins; the purpose was to make the sequence more challenging for the kids.

There were some limitations to the model because this cycle is complicated and compromises were needed to get the presentation down to the basics so that they could understand the concept, this was due to the fact that the kids didn't have a large background in neuroscience, and so we had to reduce the language when explaining it as well as leave out some of the pathway details and innervations. I think that the important concepts were understood but the details were lost on the kids. Really we had to get rid of almost all the fine details of the pathway, for instance we didn't talk at all about the raphe nucleus, and we generalized the pons as being the point of all neurotransmitter release. We also didn't include the specifics of the pathways from the retina to the SCN or how the SCN sent out a signal, we also didn't talk about melanopsin or the how the retinal photo receptors are different from rods and cones. I don't think that this was a mistake to take these topics out but it would have been nice if they had had more background in this area.

There were various areas in which we could have elaborated however we decided that it would be far too confusing if we pulled out all of the neuroscience jargon. We tried to maintain the balance between presenting wrong information because it is too simplified and the accurate information which would be too difficult to communicate to them so they could grasp the concept. This project was challenging because of its complexity but overall we were successful in combining the science with demonstration to teach a complicated concept at the level of fifth graders.

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