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Informatics 474
Final Project Research Paper

The Dream State

Introduction

Every person has experienced a dream, however, only few can explain what they are and why they occur. When deciding upon a topic that would utilize an explorable explanation and multiple interactive visualizations, we aimed to choose one that would be interesting to a wide range of audiences, as well as one that has not already been simply explained. As we initially thought about creating an explorable explanation about dreams, we knew there were a few things we wanted to accomplish in our final deliverables. It was essential to provide information on dreams that allowed users to understand what a dream is, how a dream is formed, and where in the brain a dream is formed. With our explorable explanation and interactive visualization, this information should be able to be understood in an efficient, intriguing, and aesthetic way to the users. Upon doing research about what current information on dreams exist, it became apparent that every visualization or website that attempted to explain what a dream is and how they are formed was extremely complex and took a great amount of time to get through – and this was exactly what we wanted to avoid in our final project. The Dream State provides an interactive and fascinating explanation as to what dreams are, where in the brain and sleep cycle they take place , and how they are formed, and aims to give users a better understanding of dreams in an efficient and effective way.

Related Work

While conducting the research necessary to begin creating the explorable explanation and interactive visualizations, we did not come across many research papers. There are a lot of articles and websites that seek to explain the current existing research, however, not many published academic research papers. Therefore, a significant amount of our research was done via the web and through academic articles.

One person that we aimed our focus at was Sigmund Freud — an infamous psychoanalyst and figure in the field of psychology, and the first to shed light on dreams when he published the book, *The Interpretation of Dreams*. He pioneered the concept that our conscious and hidden dreams and desires play a role in the meaning of dreams. Along with the psychoanalytic theories about dreaming that we discovered in our research, information and research on the sleep stages became increasingly relevant in how they affect dreams. In the 1970's, it was discovered by Johan Allan Hobson and Robert McCarley, with the use of an electroencephalogram (EEG) machine, that electrical impulses from the brainstem are the origins of dreams. However, this is where the controversy lies in the topic of dreaming. Because dreams tend to make somewhat logical sense, it is believed that there is a deeper explanation as to how they are formed rather than just random electrical firings from the brain stem. This is where Sigmund Freud's theory plays a part. After the brain receives energy from these electrical firings, "the dreaming mind tries to make sense of them based on unconscious reasoning," such as lessons we have learned or perceptions of the world that we may have (Turner, 2011).

Once it was established that electrical firings in the brain do play a role in dream formation, it was time to learn when dreams take place during the sleep cycle. When experiments were conducted trying to answer this question, it was discovered that most dreams occur during REM (rapid eye-movement) sleep - the sleep stage characterized by "rapid, jerky, binocularly symmetrical" eye movements and muscle paralysis (Nordqvist, 2015). It was in this stage of sleep that when participants were woken, they recalled the most intense and detailed dreams, whereas when woken during other stages of sleep, the accounts were less common and vibrant. REM sleep

is the third stage a person experiences in their sleep cycle, and accounts for about ~25% of a person's sleep cycle each night (National Institute for Child and Human Development, 2013). The REM cycle begins anywhere between the first 70 to 90 minutes of a person's sleep, and lasts only for a short period, but as the cycle repeats, grows longer and longer each time (Nordqvist). It is in the REM stage of sleep that the body and brain become energized, and responses to signals being sent from the brain are first triggered. These signals are sent to the cerebral cortex where learning, thinking, and organizing information occur, as well as to the spinal cord, which temporarily restricts muscle movement and creates a "muscle paralysis" during REM sleep.

Although REM sleep is the sleeping stage in which dreams take place, dreaming is not the purpose it serves. It is believed that REM sleep is important in the consolidation and stabilization of special and procedural memory (Nordqvist). Studies have shown that when people spend little time in the REM stage of the sleep cycle, they often have trouble remembering things they have learned that day and before they went to sleep. REM sleep is also crucial in the development of the central nervous system, especially in infants. Neural stimulation takes place during REM sleep that helps in developing neural connections, especially in infants, and tends to slowly decrease as a person ages (Nordqvist).

The last area that we needed to research was the "how" of dream formation. This part did not serve very difficult, as we quickly found a simple explanation of how a brain creates a dream. Furthermore, this section does not include any interactive visualizations, so a simple explanation and example could suffice.

In short, a dream is created naturally by the subconscious mind's stored Schemata. This is a person's built up experiences that form his/her abstract mental structure or set of rules for what things are and how they should be. Typically, a dream will begin with a single image (often the last one the person thought about before falling asleep), and the person will be in a location that their schema associates with that object (e.g. holding a pencil in a classroom). From here, more and more objects will take shape in the dream that are in the same schema as the initial object (e.g. a desk and paper). The dream becomes more and more vibrant as the brain forms more shapes and scenarios, until a complete dream and/or nightmare can take place (Infinite Minds, 2010).

In summary, there is an abundance of information available on how dreams are affected by cognition and brain activity, as well as REM sleep. Once our research was completed for this project, we knew we wanted to include information on all aspects of dreams – where in the brain they occur, REM sleep and what it is, and a timeline of the different stages in the sleep cycle. This final deliverable would be an effective overview of all the detailed research we discovered on the multiple aspects of dreaming, all in one place, for a simple, interesting, and interactive explorable explanation of dreaming.

Methods & Results

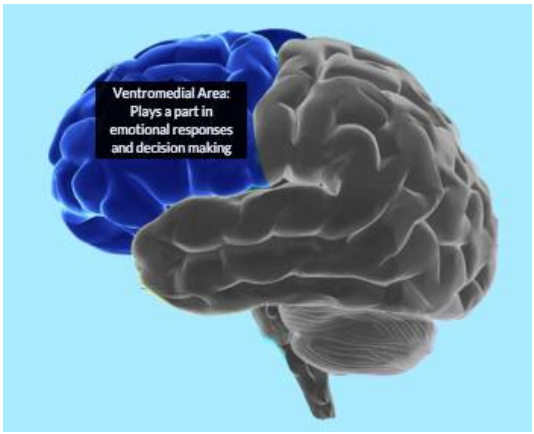
Because dreaming is such an abstract topic to tackle for an explorable explanation, as well as a complex one at that, it was important to think thoroughly about how the final deliverable would be implemented. We knew there were going to be multiple components in the final deliverable: scrollytelling, some sort of brain visualization, one or two graphs based on data, and perhaps a timeline or some sort of procedural representation. We then began researching possible JavaScript libraries that we might find useful in our beginning stages of implementation.

Because we had used D3.js in a past assignment, we knew it would be an option for the graphs that would need to be created, therefore we put a great deal of time into researching libraries that could be used to model brain visualizations. We ended up finding BrainBrowser, a JavaScript library that can create 3D interactive models of the brain. After searching on GitHub, we were able to see an example of an implementation of the BrainBrowser 3D interactive brain that would work well for our purposes, and began trying to model our implementation from that example. It ended up being a library that was extremely complex to use, in terms of data and implementation, and we came to the realization that although the visualization

could be amazing, we simply did not have the time to learn such a complex library. This is when our creativity and ability to problem-solve kicked in.

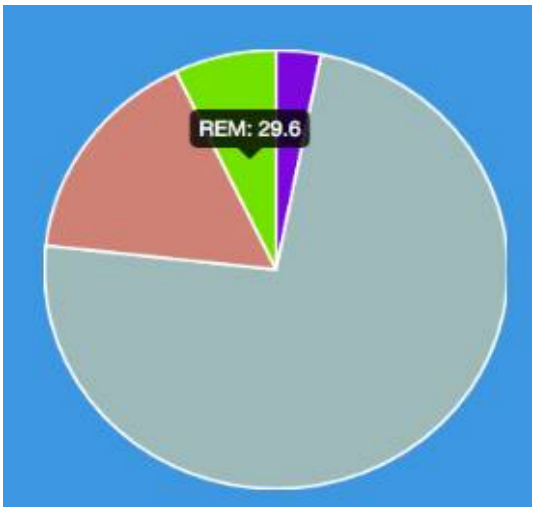
We realized some sort of brain visualization would be necessary in engaging users to learn about dreams, as well as to cover the information about how the brain is involved in dreaming. After doing some brief research on a few more brain visualization libraries and coming up empty-handed, we found a solution that ended up working quite well. We were able to find a high-quality, 3D image of a brain, and wanted to highlight the different sections of it and show how they are involved in dreaming. Utilizing Adobe Photoshop and Adobe Illustrator, we were able to divide the image into sections (the correlating lobes of the brain), assign each section coordinates, and with jQuery, JavaScript, and some CSS, were able to successfully create an interactive brain that highlights the different lobes when a user hovers over it, as well as provide a tooltip that includes detailed information on each section of the brain and its functionality *(3.1)*. This added an element of interaction to our explorable explanation, as well as allowed us to include an interactive diagram of the brain without struggling to work with an extremely complex library such as BrainBrowser.

(3.1)



In terms of data visualizations utilizing a data set, we were able to find a data set showing the amount of time spent in each stage of sleep for one person over a year. From this, we were able to find the average amount of time spent in each stage, which helps users visualize how long we approximately spend in each stage of sleep, and how that relates back to dreaming. In terms of implementing these data visualizations, we knew there were two possible JavaScript libraries we could use: D3 or Chart.js. Although we used D3 in a past assignment, we were drawn to the wide range of visualizations that Chart.js could help us create, and because it seemed to fit well into the aesthetic of the website we were creating. Utilizing Chart.js, we were able to create a pie chart *(3.2)* and radar chart *(3.3)* of the data with a small component of interaction. The data that is displayed on the graphs was taken from a dataset that we discovered online. It shows the time in each sleep stage for a user over a 7-hour sleep cycle. We ran a pivot table on this data to find the average amount of time (in minutes) that an average male spent in each of the four sleep stages. Both graphs include tool tips that allow the user to browse each graph and see each individual data value.

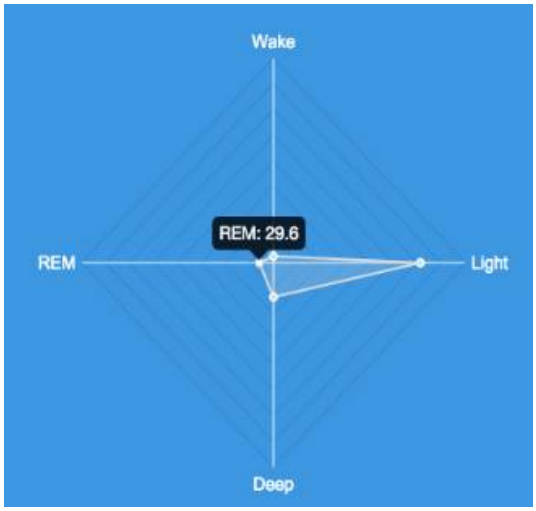
(3.2)



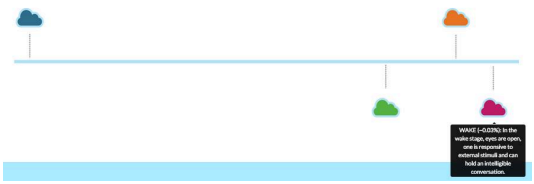
Another component of our explorable explanation was creating a timeline, describing a normal sleep cycle. There were many options that we could have utilized to implement this component, however, none seemed to fit exactly what we were looking for. There are libraries such

as Timeline.js as well as online timeline generators that produce a script for a website to read, however, this was not the route we wanted to take. We wanted to customize the timeline to go along with the "dream theme" we have in our final deliverable, so we decided to create a timeline in Photoshop and Illustrator, and like the interactive brain, add interaction to it via coordinates *(3.4)*. Doing so adds a component of interaction to information that could otherwise be somewhat underwhelming. This visualization allows users to see approximately how long a person spends in each sleep stage, and how each sleep stage is associated with dreaming; and does so in a way that provides added interest and engagement for the user.

(3.3)



(3.4)



Many of the resources we referred to during our research provided an abundance of useful information, however, greatly lacked in user engagement and interaction. Adding interaction to visualizations and explorable explanations keeps a user engaged, and increases their interest in learning about the topic that is being presented. Adding elements such as scrollytelling, interactive diagrams, and interactive charts creates more reason for a user to continue searching through our explorable explanation, as well as learn more about dreaming entirely.

Discussion

Dreaming is an extremely complex and abstract topic to grasp, and there are still a lot of unknowns associated with dreaming. Because of this, we had to choose our visualizations wisely. It was particularly difficult finding a dataset relevant to dreaming, which is why we had to rethink our concept and include the stages of sleep in the explorable explanation of dreaming. Due to the variation of visualizations we included, the audience learned that visualizations can be drastically different, depending on the topic that is of focus.

Since there was not a lot of raw data associated to dreaming that we had access to, we had to shift our visualizations from being interactive data visualizations to interactive diagram visualizations, such as the brain and timeline. The audience was able to see that visualizations help make information more interesting, as well as help simplify a complex topic, whether the visualization included actual data or not. Visualizations such as the interactive brain or timeline that we included are great examples of making an image interactive, and serve a greater purpose in an explorable explanation. Instead of just including a mere image of a brain or timeline for the audience to look at, adding the component of interactivity allows the audience to become more consumed in the information they are viewing, and hopefully, engage them to learn more about the topic. Our hope was for the audience to learn from the visualizations that we created, that a complex topic can be fun and interesting to learn about, as well as provide opportunity for them to interact with the explanation, allowing each user to gain a better understanding as to what dreaming is, where it occurs in the brain, and when it takes place during the sleep cycle.

Future Work/Conclusion

Since there is still a long ways to go in terms of what the world knows about dreaming, there is much room for growth in our explorable explanation. The sole reason as to why we dream is still unknown, and there is still much debate over the meanings of dreams. Until those discoveries are made about dreaming, the amount of information currently available is limited. However, the explorable explanation we created can be extended with the research that is available.

One way The Dream State could be extended would be to include the BrainBrowser 3D interactive brain model like we had originally planned. Although this would require a great amount of technical skill, it would be extremely beneficial to show users how neurons and brainwaves behave in each stage of sleep. This would provide an interactive and astonishing visual as to how complex the human brain is, as well as display the activity that takes place in the brain when a person is dreaming. With more time to focus on the complexity of each visualization, our explorable explanation could include a greater amount of interaction and better display the complexity of the topic of dreaming.

Another way in which our system could be extended would be to include visualizations and information on lucid dreaming. Although lucid dreaming is another controversial, complex, and relatively unknown topic, it would be interesting to provide information on what lucid dreaming is, in what way it affects the brain differently than normal dreaming, and how to lucid dream. Expanding our explorable explanation to include lucid dreaming would round out the topic of dreaming in its entirety, as well as potentially interest another audience of users who find lucid dreaming particularly interesting.

Therefore, if there were more time and resources available, it would be extremely fascinating to see how much more detailed and complex we could make our visualizations, as well as what other topics related to dreaming we could include. The Dream State aims to intrigue users to learn more about dreams, and helps provide an overview of what data currently exists about dreaming. Although there are obvious ways to extend our project as mentioned previously, The Dream State effectively provides information on what dreams are, how they are born, and where in the brain they occur, in an interactive and imaginative way. Until further research is conducted and discoveries made, we can only dream about the possible explanations as to why we dream.

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