frontiers FOR YOUNG MINDS

NEUROSCIENCE
Published: 18 December 2019
doi: 10.3389/frym.2019.00140

THE SCIENCE OF DREAMS

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AGES: 8–14

STEM GIRL AMBASSADORS

AGES: 10–12

Dreams are a common experience. Some are scary, some are funny. Recent research into how the brain works helps us understand why we dream. Strange combinations of ideas in our dreams may make us more creative and give us ideas that help us to solve problems. Or, when memories from the day are repeated in the brain during sleep, memories may get stronger. Dreams may also improve our moods. Together, these studies show that dreams and sleep are important for performing well when we are awake.

When she was 8, my daughter told me about one of her dreams. She was in a spaceship with some animals. Although she knew she was in a spaceship in her dream, when telling me about the dream, she realized the spaceship was actually a washing machine. At times, she and the animals would be out in space, but they also came back to earth. She told me the dream with a laugh and then moved on with her day, ignoring the crazy animals and spaceships that entertained her in her sleep.

Since we remember our dreams and then often forget them, what is their purpose? Why do we dream about the things we do? New

research tools, particularly those that can be used to investigate the brain, are being used to answer these questions.

WHAT ARE DREAMS?

Although it is hard to define what a dream is, for the purpose of this article, we will define dreams as our thoughts during sleep that we recall when we wake up. So, sleeping dreams are not the same as "daydreaming." Dreams are mostly visual (made up of scenes and faces; sound, taste, and smell are rare in dreams [1]). Dreams can range from truly strange to rather boring, snapshots from a recent event.

To study dreams, scientists need a measure of dreaming. Most studies use dream reports (a person writes out her dreams when she wakes up) or questionnaires (a person answers questions like "How many dreams have you recalled in the past month?" [2]). Dreams are more likely to be recalled when a person is woken up from REM sleep. REM sleep is a type of sleep that is named for the **rapid eye movements** that can be measured during this stage of sleep. We do not dream as much in non-REM sleep, the sleep stages that make up the rest of the night, and dream reports from non-REM sleep are often less strange.

RAPID EYE MOVEMENT (REM)

A stage of sleep in which the eyes move rapidly and there is no muscle activity.

Dream frequency (how often dreams happen) and content (what dreams are about) is very different for everyone, and there are many reasons why this may be true. For example, you will remember dreams more if you are woken up by someone or by an alarm clock. This might be because you can still recall that dream memory while it is fresh but, if you wake up on your own, you will transition through a few sleep stages and possibly lose that dream memory. Dream recall changes with age, too. Older people are less likely to report dreaming. This could also be related to memory: since older people have weaker memories, it could be that they dream but cannot remember their dreams by the time they wake up. A brain area called the **medial prefrontal cortex** is also related to dream recall. If this brain area is damaged, the person recalls few dreams, which may mean the person dreams less (or not at all). Also, how tightly packed the brain cells are in the medial prefrontal cortex can vary from person to person, which may cause some healthy people to dream more or less than other healthy people. There are also genes that affect how much REM sleep people get. People with less REM sleep may not have the strange dreams that tend to come in REM. So, how long you sleep, your age, and your genetics may all explain why you dream more or less than someone else.

MEDIAL PREFRONTAL CORTEX

A specific area in the front of the brain that is associated with dream recall but also has a role in memory and decision-making.

MAGNETIC RESONANCE IMAGING (MRI)

A tool used to take pictures of internal body parts (including the brain). MRI can also be used to measure the activity in the brain.

Do dreams actually happen while we sleep, or are they ideas that come to us when we wake up and we just "feel" like it happened during sleep? A recent study using a type of brain imaging called **magnetic resonance imaging** or (MRI: Read more in the Young Minds article "How Is Magnetic Resonance Imaging Used to Learn About

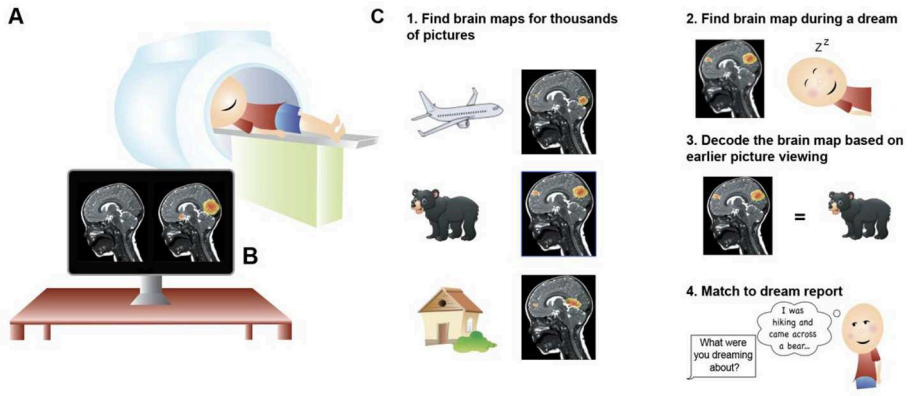

Figure 1

(A) Magnetic resonance imaging (MRI) is a way to investigate the brain. The person lies on a bed inside a giant magnet. **(B)** MRI can measure the structure of the brain and the areas of the brain that are active. **(C)** MRI was used to measure dreaming. First, while the participant was awake, they viewed thousands of pictures in the MRI. This told scientists the specific brain responses to specific pictures. Later, when the participant slept in the MRI, scientists measured the brain activity patterns and matched this to the brain responses to the pictures the participant saw when they were awake. Scientists guessed that the best match would tell them what the participant was dreaming about. By asking the participant about their dreams in the MRI, scientists found that the dreams did tend to match the pictures predicted by the brain activity.

the Brain?" [3]) helped answer this question (Figure 1A). The scientists made maps of the brain activity that occurred when people looked at pictures of things—keys, beds, airplanes. Later, the people in the study slept in the MRI machine. The scientists matched the pattern of brain activity from the people as they slept to brain activity patterns for the pictures they viewed earlier, and then chose the best match (Figures 1B,C). This match predicted what the person said they dreamed about 60% of the time. Although 60% is not perfect, it is better than guessing! [4]. This means that dreams are created in the brain during sleep.

DREAMS SUPPORT MEMORIES

What is the purpose of our dreams? Researchers have found that sleep is important for memory (see this Frontiers for Young Minds article; "Thanks for the Memories..." [5]). Memories move from temporary storage in the **hippocampus**, a brain structure that is very important for short-term memory, to permanent storage in other parts of the brain. This makes the memories easier to remember later. Memories improve with sleep because the memories are replayed during sleep [6]. If you want to learn all the words to your favorite scene in a movie, you might re-watch that scene over and over again. The brain works the same way: **neurons** (brain cells) that are active with learning are active again and replay the learned material during sleep. This helps store the memory more permanently.

Memory replay may show up in our dreams. Dreams in non-REM sleep, when most memory replay happens, often contain normal people and objects from recent events. However, sleep switches between non-REM and REM sleep (see Figure 2). So, bizarre dreams in REM sleep may come from a combination of many different recent memories, which were replayed in non-REM sleep, and get jumbled up during REM sleep. If dreams help with memory processing, does that mean your memories are not being processed if you do

HIPPOCAMPUS

An area in the brain that is thought to be important for short-term memory.

NEURON

A cell in the nervous system (brain and spinal cord) that can transmit information to other cells.

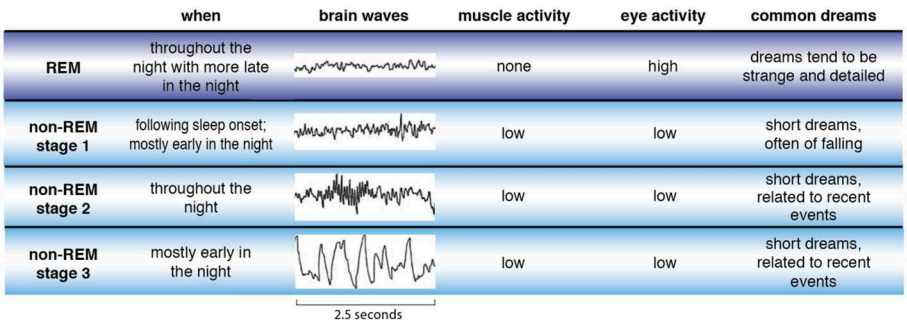

Figure 2

There are four types of sleep—REM sleep (purple) and three stages of non-REM sleep (blue). REM stands for rapid eye movements, which happen during this stage of sleep. During REM sleep, muscle and brain activity also differ from other sleep stages. Characteristics of dreams tend to be different for each of these sleep stages.

not dream? No. Memories are moving to storage even if we do not dream.

DREAMS IMPROVE CREATIVITY AND PROBLEM SOLVING

My daughter's dream of a spaceship made a great story that she recited to me, and later, to her classmates. The images were intense and interesting, inspiring her to draw scenes in a notebook and write about the dream for school. This is an example of how dreams can help make us more creative. Mary Shelley, the author of the book Frankenstein, got the idea for her book from a dream. Even scientists get ideas from dreams [7].

To measure creative problem solving, scientists used a remote associates task, in which three unrelated words are shown, and the person is to come up with a word they have in common. For instance, HEART, SIXTEEN, and COOKIES seem unrelated until you realize they all are related to SWEET (sweetheart, sweet sixteen, and cookies are sweet) (Figure 3). The scientists wanted to see whether sleep helped people do better on this task. They found that people were better at thinking of the remote solution if they had a nap, particularly a nap with REM sleep. Given that REM is when most bizarre dreaming occurs, this supports the idea that these dreams might help us find creative solutions to problems [8].

This study and research like it gives us reason to believe that REM dreams may help us be more creative and solve problems. Many different memories may be activated at the same time and when these memories are mixed together, the result when we wake up may be both the memory of a strange dream and a unique perspective on problems.

DREAMS REGULATE OUR MOODS AND EMOTIONS

Dreams are usually emotional. One study found that most dreams are scary, angry, or sad.

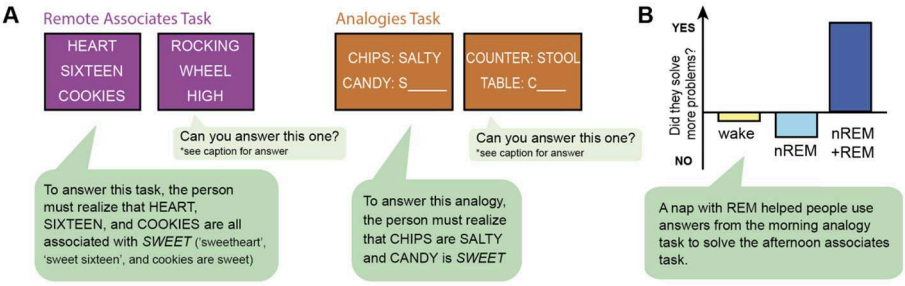

Figure 3

REM sleep helps people find creative solutions. In the morning, participants did two tasks to test creativity and problem solving **(A)**. They did one task again in the afternoon. In between, they either stayed awake ("wake" group) or took a nap. Those that took naps either did not have REM sleep in their nap ("nREM" group) or had both nREM and REM sleep ("nREM + REM" group). **(B)** If subjects stayed awake between the morning and afternoon tests (yellow bar), they did not improve on the task. They also did not improve if they had a nap that was only nREM sleep (light blue bar). But, if they had a nap with both nREM and REM sleep, they did better in the afternoon compared with when they did the task in the morning (dark blue bar). So, REM sleep must help us find creative solutions (from Cai et al. [8]).

Dreams might seem to be emotional simply because we tend to remember emotional things better than non-emotional things. For example, in waking life, the day you got a puppy is more memorable than a normal school day. So, dreams about emotional events might be remembered more easily than boring, non-emotional dreams. It is also possible that dreams are emotional because one job of dreams is to help us process emotions from our day [9]. This may be why the **amygdala**, an area of the brain that responds to emotions when we are awake, is active during REM sleep. If you had a sad day, you are more likely to have sad dreams. But, sleep also improves mood—sleep after a disagreement or sad event will make you happier.

Dreams could also help prepare us for emotional events, through something called **threat simulation theory** [10]. For example, when I dreamt that my young daughter, who could not swim, fell into a swimming pool, recall of that dream convinced me to sign her up for swim lessons. By simulating this fearful situation, I could prevent it by being prepared.

These studies show us that sleep and dreams are important for our emotions. By processing emotions in sleep, we may be better prepared and in a better mood the next day.

AMYGDALA

An area of the brain involved in the experience of emotions.

THREAT SIMULATION THEORY

A theory of dreaming that says that threats (things that could be bad) are simulated or practiced in your dreams to prepare you for those situations when you are awake.

CONCLUSIONS

There are different ways scientists measure dreams—from asking questions to using MRI. These studies show us that activity in the brain while we sleep gives us the interesting dreams we recall when we wake up. These dreams help us remember things, be more creative, and process our emotions.

We know most kids do not get enough sleep. Some diseases (like Alzheimer's disease) also make people sleep less, while others (like REM sleep behavior disorder and mood disorders) affect dreams directly. It is important to study sleep and dreams to understand what happens when we do not get enough sleep and how we can treat people with these diseases.

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SUBMITTED: 30 April 2019; **ACCEPTED:** 22 November 2019;
PUBLISHED ONLINE: 18 December 2019.

EDITED BY: Kathleen Y. Haaland, University of New Mexico, United States

CITATION: Spencer RMC (2019) The Science of Dreams. Front. Young Minds 7:140. doi: 10.3389/frym.2019.00140

CONFLICT OF INTEREST: The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

EXPLORA SCIENCE CENTER AND CHILDREN'S MUSEUM, AGES: 8–14

The Explora Young Minds reviewers are a group of science enthusiasts working with museum educators and mentors from the University of New Mexico. We enjoy learning about the brain through the articles. We also enjoy asking questions and making suggestions to help the scientists make their work more understandable for everyone! We were helped by our Science Mentor, Crina Floruta, who is a M.D./Ph.D. candidate working in a neuroscience lab and who is hoping to pursue a Neurosurgical residency in the future. She loves Albuquerque, hiking, reading, and talking about the brain with people.

STEM GIRL AMBASSADORS, AGES: 10–12

As a group of Amabassadors for STEM we are determined to help everyone around us realize how the skills of STEM are part of every day life. We come from many different schools to work together to encourage girls of all ages think outside the box, to challenge themselves in their learning, to seek support and encouragement from role models and be a strong voice.

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