IJHSR
ijhighschoolresearch.org
REVIEW ARTICLE

Comparative Analysis of REM and NREM Sleep in Mammals, Reptiles, and Cephalopoda with Relations to Dreaming

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ABSTRACT: The normal human sleep period has two main cycles: REM [rapid eye movement] and NREM [non-rapid eye movement]. Typically, people go through the three stages of NREM sleep, then to the one stage of REM. Human dreaming occurs during both cycles, more frequently during REM. Whether non-human animals go through the same sleep cycle is still in question, and the answer could determine whether animals dream or not. Analyzing sleep-enacting behaviors, sleep experiments, and other research done with non-human mammals, reptiles, and cephalopods will help the author conclude whether animals go through REM/NREM sleep and dream. Establishing a definite answer in the future will allow neuroscientists to delve deeper into the measurement of dreaming in humans, the purpose of dreaming, and the true meanings of dream content.

KEYWORDS: Behavioral and Social Science; cognitive psychology; animal brain activity; sleep cycles; sleep behaviors; dreaming enacting behaviors; mammalian sleep.

Introduction

Dreaming influences human life, consciously and unconsciously. For centuries, dreams have not been studied as thoroughly as other topics. Finding the answers to key questions regarding the purposes of dreams and their effects on humans would revolutionize scientists' understanding of the human brain. The interpretation of dream content plays a significant role in this process. Analyzing specific dream content would be most effective during REM sleep, where humans have the most vivid dreams. To clarify, the human sleep cycle begins with three stages of NREM sleep, followed by a single REM phase. This cycle repeats itself throughout the night. REM sleep is characterized by reduced muscle tone, twitching, increased brain activity, vivid dreaming, and only one stage. This stage of sleep is imperative to humans as it affects brain development, memory, and the ability to process emotions. In adults with normal health, REM sleep takes up about 25% of total sleep, while in reptiles such as the bearded dragon, putative periods of REM sleep take up 50% of total sleep.[1,2] The human NREM sleep phase is characterized by synchronous EEG patterns, less frequent dreaming, and three separate stages: N1, N2, and N3. N1 sleep lasts about 1-5 minutes, as brain activity starts to decrease with occasional fluctuations and a swift transition to N2.[1] During the second stage of NREM, the body begins to relax more, portrayed by a decrease in heart rate, slowed breathing, and a drop in body temperature. The N2 stage of sleep typically lasts between 10-25 minutes, though brief brain activity fluctuations are still present.[1] The last stage ranges from 20-40 minutes: N3, classified as the most profound state of NREM, is when the body reaches its peak tranquil state.[1] N3 sleep in humans can be identified by delta waves, patterns of slow brain waves. This stage of deep sleep is critical for the healthy development of cognitive skills and for promoting muscle tissue growth and immune health. It's noted that the N3 sleep stage is vital for both mental and physiological recovery and growth. Despite lower levels of brain activity, studies demonstrate a positive correlation between deep sleep [N3] and "insightful thinking, creativity, and memory."[1] Ursin observed through his sleep experiments on twelve adult cats that they, too, experience rapid eye movement and twitching during REM sleep.[1] However, unlike humans, their sleep patterns show no evidence for three NREM sleep stages. There's not as much information concerning the sleep cycles, sleep stages, and characteristics of reptilian and cephalopod sleep, which is partially due to too many outside factors to be considered. For instance, measuring and comparing body temperatures during REM and NREM in mammals and reptiles would be ineffectual, considering that mammals are endotherms and reptiles are ectotherms. The body temperature of reptiles and birds is innately colder than that of humans and other non-human mammals. This disruption, one of the main components of measurement for stages of sleep, creates conflict when collecting and interpreting data for bird and reptilian sleep. A core characteristic of transitioning to the deeper sleep phases is a drop in body temperature. Finding a way to accurately measure REM and NREM sleep for a wider taxa of animals would open new paths to conclude which animals can/do dream. There are several ways to measure dreaming. Verbal reports are humans' primary measurement of dreaming, though animals lack this vital ability.[3] In addition, developing new technologies to measure dreams in non-humans would be a step forward to potentially analyzing dream content in animals and humans. Establishing and comprehending a relationship between the different stages of sleep through such a comprehensive taxonomy of life species would be fundamental for developing new technologies to monitor sleep/dreaming, therapies, and practices.

DOI: 10.36838/v5i6.7

Methods

Key phrases such as REM/NREM characteristics, sleep observations in reptiles, sleep observations in cephalopods, dream-enacting behaviors, and qualities of NREM sleep stages were used to find appropriate data and research. When exploring the key components of human sleep, the author excluded phrases that suggested sleep studies done with those suffering from neurological disorders. Many sleep studies have been done on people with somnambulism, epilepsy, and narcolepsy, all of which were avoided. Only healthy subjects were considered when trying to establish a relationship between sleep stage characteristics and dream patterns.

Results

3.1 REM in mammals, reptiles, and cephalopods:

REM sleep has specific, identifiable characteristics, including rapid eye movements, muscle atonia, twitching, and low-amplitude desynchronized brain activity. Pinpointing similar behaviors in mammalian, reptilian, and cephalopoda sleep could suggest multi-stage [REM/NREM] sleep. In sleep experiments with cats, "frequent myoclonic jerks were seen in the face, vibrissae, extremities, and tail."4 Myoclonic jerks in cats parallel the similarly observed involuntary twitches in humans. In addition to the myoclonic jerks, the twelve cats observed in the experiment by Ursin experienced rapid eye movements during this resting stage.4 In contrast to mammals, reptiles like the bearded dragon show no definitive signs of REM, considering the rare and inconclusive reports of slow brain waves during rest-like states. In past studies from the 1960s, reptilian REM sleep was reported, though insufficiently backed up with concrete evidence.2 Any potential evidence merely suggested the possibility of either one stage of NREM or two stages of REM and NREM sleep. The study of cephalopods' sleep is highly underdeveloped, similar to reptilian sleep findings. Identical to reptiles, the potential sleep stages of the cuttlefish classification have been observed and studied at a remarkably shallow level. Cuttlefish are classified in the cephalopod group, similar to miniature squids. This species contains organs on the outside of their bodies called chromatophores. An observation during a 30-second quiescence-like state in cuttlefish revealed the movement of these organs in spastic patterns and changes in color from dark to light.5 It can be inferred that these spastic movements are equivalent to the twitching in human sleep. Though both reptilian species and cephalopoda species show typical mammalian signs of REM, it cannot be accurately concluded whether they actually go through REM. This is partially because manifestations of REM have not been confirmed to be the same between mammals, reptiles, and cephalopods. It is possible that REM and NREM can be confirmed present in diverse forms of life, though they may be characterized differently than for humans.

3.2 NREM in mammals, reptiles, and cephalopods:

NREM sleep in animals is significantly less researched. Though NREM sleep has no identifiable characteristics, its primary physical component is low muscle tone. Non-human mammals such as chimpanzees and cats do show signs of NREM, though not all go through the three stages that humans do. A cat goes through two stages of NREM: light slow wave sleep (LSWS) and deep slow wave sleep (DSWS). No rapid eye movements had been observed in this stage.[4] Also, the type and quantity of NREM that cats go through affects the amount of REM they go through. Cats that experience more DSWS also go through less LSWS and more REM, and vice versa. Table 1.0 shows no evidence that NREM quiescence periods have been observed in cuttlefish.[5] On the other hand, indications of reptilian NREM are solely based on their similar neural structures to humans. Thus, the author's findings portrayed no thorough research on NREM sleep in reptiles and cephalopods.

Table 1: Concisely reports the characteristics of REM sleep and NREM sleep for a variety of animals, each from a diverse animal classification; this excludes the reports of humans and the chimpanzee as they both reside among the mammalian species.

	Characteristics of REM	Characteristics of NREM
Humans	-rapid eye movements -muscle atonia -twitching -asynchronous EEG patterns -vivid dreaming -longer durations of REM as sleep progresses	-synchronous EEG patterns -low muscle tone -less frequent dreaming -three stages (N1,N2,N3) -shorter durations of NREM as sleep progresses
Chimpanzee	-average period from one cycle of REM to another is about 85 minutes -takes about 23% of chimp sleep[4]	-multiple stages of NREM -takes about 10% of chimp sleep[4]
Cats	-bursts of rapid eye movement -full body myoclonic jerks[1] -sleep deprivation resulted in longer durations of REM	-two stages of identifiable NREM sleep - light slow wave sleep - deep slow wave sleep
Argentine Tegu	-some reported rapid eye movements -some reported involuntary bodily movements -active EEG -sleep deprivation did not show an effect of increased REM	-no distinct evidence for NREM sleep -lack of electrophysiological distinction between wake and sleep
Bearded Dragon	-high amplitude waves without a dominant rhythm[7]	-lack of electrophysiological distinction between wake and sleep -active wake and quiet wake show almost no differences in electrophysiological measurements[7]
Cuttlefish	-inactivity -rapid eye movements observed only in adult Sepia[5]	-no evidence for stages of NREM sleep

3.3 Dream enacting behaviors:

Recognizing and recording dream-enacting behaviors during REM sleep is a key measurement mechanism in animal dreaming. This method weakens the verbal barrier scientists face in measuring animal dreams. In humans, dream-enacting behaviors have been consistently recorded in pregnant and postpartum women.[3] For instance, in a state of active dreaming during REM, these women experienced involuntary bodily movements and motions suggesting that they were looking for their babies. This sort of observation is not exclusive to postpartum women. The general population can/do experience dream-enacting behaviors, often differing activities based on their genders. The male population seemed to recall more sexual behaviors, while the female population's answers focused more on feelings and behaviors of crying, fear, laughing, smiling, and speaking.[6] Observations as such allow scientists to make more accurate inferences concerning dream content. Scientists presume that when women show dream-enacting behaviors like searching for their babies with their arms seemingly in distress, they dream of something terrible happening to them. Though written observations of sleep in wild mammals haven't been documented, it is predicted by the author that chimpanzees would show similar behaviors. Chimpanzees are the closest mammalian relatives to humans. Additionally, observation of chimpanzees sleeping showed they experienced rapid eye movements and twitching during their REM sleep cycle, making it even more possible to show signs of dreaming if studied. Studying dreams enacting behaviors and expressions becomes particularly challenging with cephalopods like the cuttlefish, as they do not have similar facial or bodily structures. No dream-enacting behaviors have been recorded for cephalopods.

Discussion

Evidence suggests that non-human mammals go through REM and NREM cycles in their sleeping periods, though evidence for reptilian and cuttlefish REM and NREM is limited and indefinite. Considering that evidence for reptiles is limited, a conclusion merely suggesting a possibility of REM sleep can be made; NREM is not considered.

4.1 Limitations:

Limitations play a significant role in the study of dreaming. Animals can't speak. Thus, the ability to provide verbal reports of dreaming leads scientists to resort to different methods. Using alternate methods adapted for non-verbal beings makes measuring and conducting research exponentially more difficult. Trying to overcome such obstacles will inadvertently help scientists better understand the micro-details of animal sleep, similar to how a more thorough understanding of the complexities of human sleep helps scientists dig deeper into human dreaming processes. The purpose of dreams, specific dream content, and their effects on humans have been tried and explored for centuries, yet concrete statements/theories are still rare. This remains true as the conception of definite answers regarding animal dreaming is currently inconclusive.

4.2 Future directions:

The study of dreaming plays a vital role in the neuroscientific world. Analyzing dream content, frequency, and brain activity during dreams opens up not only the answers to a vast quantity of unconfirmed theories but its process will aid in developing new technologies. New technologies can reveal the answers to questions that the medical field strives to answer in the future. For instance, investigating the qualities and quantities of dream memory recall may reveal a more detailed insight into the content of dreams.[8] Detailing content is yet another step forward in characterizing individual meanings and purposes of dreams. These answers may address the purpose of dreaming, REM sleep's potentially similar cognitive benefits in animals as for humans, and even potential technological innovations to measure the neurological conditions in exotherms.

Acknowledgments

I'd like to thank my mentor, Dr. Michael Barlev, for his friendly, constructive guidance through this process.

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Author

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DOI: 10.36838/v5i6.7