Medical Hypotheses 127 (2019) 63–65

Contents lists available at ScienceDirect

Medical Hypotheses

journal homepage: www.elsevier.com/locate/mehy

Hypothetical role of gravity in Rapid Eye Movements during sleep

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A B S T R A C T

Dream periods during sleep have been observed in most mammals as early in history as antiquity.

Sleep researchers at the University of Chicago, discovered the phase of rapid eye movement (REM) during sleep and connected it to the dream period. During this period, called the REM phase (after the American terminology), although the brain shows electrical activity, it is insensitive to external stimulations, including light, sound, contact and, a little unexpectedly, gravity. However, since this discovery was made there has been no definitive explanation of the rapid eye movements Many possible explanations have been offered, and yet, the causes and contributing factors of the REM sleep phase are inadequately understood.

It has often been proposed that the eyes observe the images produced during dreams, but researchers are not convinced.

It is proposed here that the movements of the eyes during REM sleep are due to a feeling of disorientation and a subjective loss of landmarks. During the REM sleep phase, the brain has a reduced sensation of gravity, and the sleeper is in a state similar to weightlessness. The instinctive search for the vertical or horizontal direction triggers movements of the eyes, looking for usual points of reference. This hypothesis is reinforced by an original experiment that was conducted in space. The frequency of the eye movements of astronauts during their first night in space is 10 times more than what is experienced on the ground, and that moment in time is when the feeling or the sensation of weightlessness is certainly the most disturbing. Upon the return to Earth, the frequency of the eye movements increases again the first night after landing. These two moments are when the effects of gravity are felt most drastically.

The present assumption needs to be validated experimentally and may necessitate further research.

Introduction

Discovery of REM sleep

At the University of Chicago in 1952, Eugene Aserinsky and Nathaniel Kleitman [1] discovered the phase of rapid eye movement (REM) during sleep and connected this phase to the dream period.

At that time, brain waves could be measured via polysomnography, which enabled the REM phase to be unequivocally identified.

As this is a universal feature of sleep among mammals, sleep scientists have adopted the term “REM sleep”. Other names, such as “paradoxical sleep” [2] or “active sleep” refer to the same phase but take into account the activity of the brain and the fact that the brain waves observed through electrodes during this phase are similar in amplitude and frequency to the beta waves observed during wakefulness and that all the muscles of the body show atonia, so the body is inert. The REM phase is so characteristic that the rest of the sleep duration is best defined negatively as non-REM (NREM) sleep.Dreams, which are thoughts and mental images coming to the mind, have retained most of the attention and the efforts of sleep scientists searching for a reliable explanation to their origin and content.

Rapid eye movements are the authentic marks indicating the REM period. REM sleep has been observed in many living species, but mammals represent the class most studied . In mammals, REM sleep occurs after an NREM sleep period when all sensations coming from the outside world – light, sound, contact, odor, and taste – are drastically reduced and when the brain and the nervous system, via relaxed muscles, tend to decrease the control of gravity as well, though this had not been established before [3].

Vigilance against a possible fall is reduced. This occurs when the following conditions are met: a “preparatory” phase of NREM sleep and feeling safe in a safe posture and position. REM sleep leads to an almost complete paralysis and unconscious awareness of the outside world.

Potential explanations of the eye movements

The scanning hypothesis

One explanation for eye movements is based on the “scanning hypothesis”. This suggests that the eyes are following visually what happens in dream, for instance, a game of tennis [4]. This dream is rarely quoted in the list of the most frequent dreams, such as falling or flying [5]. The scanning hypothesis has not yet been validated experimentally [6,7].

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https://doi.org/10.1016/j.mehy.2019.03.027
Received 2 February 2019; Accepted 26 March 2019

Wakefulness similarity

Another proposal suggests that the eyes are rearranging previously seen images. Velocities of saccades were comparable to velocities of open eyes during wakefulness. Thus, REM may be related to exploratory saccadic behavior during wakefulness to remember visual stimuli [8].

Another comparison with eye movements during the awake period has been proposed: "A candidate for this equivalence is attention. Body signs indicating the state of attention can be observed and measured. When the organism is solicited by stimulation, it turns itself towards the source of it." [9].

A very detailed study involving the implantation of electrodes in the brain measured slow waves corresponding to the eye movements during the imaging of visual scenes.

> "The results suggest that REM during sleep rearranges discrete epochs of visual-like processing as during wakefulness. Nevertheless, given that the vast majority of awakenings from REM sleep yield vivid dream recalls, it seems reasonable to assume that REM episodes analyzed here were likewise associated with dreaming." [10]

The 'environmental information' hypothesis

The insidious role of gravity

Acceleration due to gravity has not changed much since the Earth was formed billions of years ago. Gravity produces the force of attraction between matter and the Earth and gives weight to all things on Earth.

Gravity plays a primordial role in the perception and control of the orientation that is made in relation to the perception of the vertical.

Over the millennia, humans have evolved to stand perfectly vertically, and in humans, the evolution of the brain has allowed eye movements to be dissociated from movements of the body. The vestibulo-ocular reflex is involved in the stabilization of eye movements during the natural movement of the head as a person walks, runs or is exposed to vibration. The vestibular system exercises control over the eye muscles to stabilize the image of an object on the retina as the head moves. A major activity of the brain of most vertebrates during awake behavior is the processing of sensory information, preponderantly visual.

Movements of the eyes

It is proposed that during the REM sleep period, when the sensation of weightlessness occurs, the instinctive search for the vertical or horizontal direction triggers movements of the eyes, looking or searching for usual points of reference. It is suggested that the eye movements are due to a feeling of spatial disorientation and an effort to recognize what is up, down, left and right.

A very original and important study that was conducted in space confirms and consolidates this hypothesis [8].

The scientists analyzed the eye movement frequencies of an astronaut working and sleeping in space. This was the first experiment in which the eye movement patterns during sleep were recorded in space, namely, during the Spacelab-1 flight, which was conducted in 1983. "To summarize, the number of high frequency eye movements (D) was higher during the first night in-flight and during the first night after landing. The numbers returned respectively to normal during the second night." (See Figs. 1 and 2.)

> "The higher values of D during the first night in-flight and the first night after landing indicate that the changes in gravity have a cumulative organising."
> "The present results also provide evidence that the eye movementsduring sleep cannot be regarded merely as an optical system, but rather constitute an important extension of the brain itself."

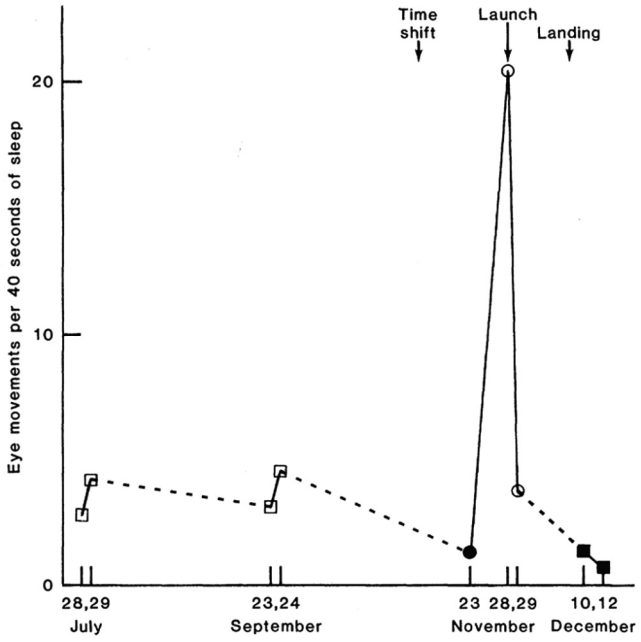

Fig. 1. Number of eye movements per 40 s of sleep at various times.

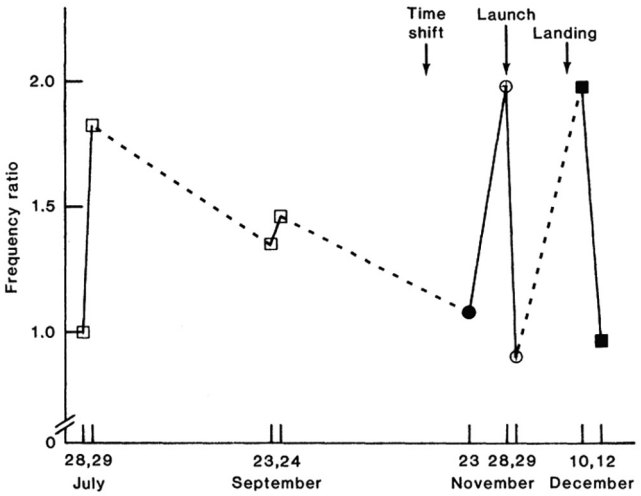

Fig. 2. Ratio of eye movements frequencies higher than 1 per second to those lower than 1 per 2 second at various times.

Although weightlessness allows sleep in any position – even on the ceiling – astronauts mostly tether themselves to sleeping bags to prevent floating around and bumping into things as they sleep. However, the vestibular system does not provide an indication on the position of the body, hence the feeling of disorientation.

Discussion

The fact that fetuses [11] and blind people [12] show eye movements means that a more universal cause than a visual cause is the source of eye movements.

Blind people are submitted to gravity just as every human on Earth, and their muscular system works during wakefulness and needs a period for rest during REM sleep; they also experience a sensation of weightlessness.

In the course of the development of the muscular system, which essentially serves to build the future posture, the fetus may need long periods of rest to relax their muscles during long REM sleep periods, similar to the atonia of muscles in adults.

Another example from a completely different study [13] on lamb fetuses, showed that those placed on a marble table ceased their eye movements, as if they were stabilized.

> "Delivery of the lamb from the warm saline bath onto a warm table, with gentle restraint, arrested respiratory and rapid-eye-movements for an hour; both returned a short time after the lamb was immersed once more."

The horizontal marble table may provide a reference that stops the search for a landmark.

Herein, a possible explanation for the eye movements during REM sleep has been proposed. This assumption needs to be validated by other studies, just like any other new hypothesis, but it suggests strong ties between gravity and eye movements.

Conflict of interest

Dr. Gonfalone declare no conflict of interest.

Funding

Dr Gonfalone will provide all the funding necessary.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mehy.2019.03.027.

References

[1] Aserinsky E, Kleitman N. Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. Science 1953;118:273–4.
[2] Jouvet M. The Paradox of Sleep, the story of dreaming. Le Sommeil et le Rêve. Cambridge, MA: MIT Press; 1999.
[3] Gonfalone A, Jha SK. The influence of gravity on REM sleep. Open Access Anim Physiol 2015;7:65–72.
[4] Lavie P. The enchanted world of sleep. Yale University book. 1996.
[5] http://www.dreams.co.uk/.
[6] Arnulf I. The 'scanning hypothesis' of rapid eye movements during REM sleep: a review of the evidence. Arch Ital Biol 2011;149:367–82.
[7] Leclair-Visonneau L, Oudiette D, Gaymard B, Leu-Semenescu S, Arnulf I. Do the eyes scan dream images during rapid eye movement sleep? Evidence from the rapid eye movement sleep behaviour disorder model. Brain 2010;133:1737–46.
[8] Sprenger A, Lappe-Osthege M, Talamo S, Gais S, Kimmig H, Helmchen C. Eye movements during REM sleep and imagination of visual scenes. NeuroReport 2010;21(1):45–9.
[9] Quadens O, Dequae PA. The eye-movements of sleep : towards a model. Rev Electroencéphalogr Neurophysiol Clin 1986;16(2):107–16.
[10] Andrillon T, Nir Y, Cirelli C, Tononi G, Fried I. Single-neuron activity and eye movements during human REM sleep and awake vision. Nat Commun 2015;6. Article number: 7884.
[11] Birnholz JC. On observing the human fetus. In: Smotherman WP, Scott R, editors. Behaviour of the fetus. New Jersey: The Telford Press Caldwell; 1990. p. 47–60.
[12] Bertolo H, Barrio A, Antona B, Mestre T. Rapid Eye Movements (REMs) and visual dream recall in both congenitally blind and sighted subjects. Third international conference on applications of optics and photonics. 2017.
[13] Dawes S, Fox FE, Leduc BM, Ligginst GC, Richards RT. Respiratory movements and rapid eye movement sleep in the Foetal lamb. J. Physiol. 1972;220:119–43.