Salud Mental 2014;37:49-58
ISSN: 0185-3325
DOI: 10.17711/SM.0185-3325.2014.007

The origin and functions of dreams based on PGO activity

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Update by topics

SUMMARY

Understanding the phenomenon of sleep and dreams has always fascinated humans. However, the scientific study of sleep is relatively recent. In 1953, Aserinsky and Kleitman found that slow wave sleep (SWS) was periodically interrupted by episodes of rapid EEG activity, which are accompanied by rapid eye movements (REMs), and named this sleep phase as REM sleep. Subsequently in 1957, Dement and Kleitman discovered that these rapid eye movements coincided with the appearance of dreams. By using experimental animal models, the subcortical mechanisms underlying REM sleep have been studied, and it has been demonstrated that this activity depends on the serotonergic activity from wakefulness, which promotes the formation of peptides that trigger certain structures of the brainstem, where cholinergic mechanisms of REM sleep are integrated. In turn, on the pontine region monophasic phasic potentials (300-400 μV) are generated that can also be recorded on the lateral geniculate body and in the occipital cortex, hence the name of ponto-geniculo-occipital waves (PGO). These potentials spread to the oculomotor system to provoke the REMs of REM sleep and possibly give rise to visual hallucinatory phenomena. Furthermore, it has been shown that certain limbic structures related to emotion and memory are activated by these potentials. This suggests that PGO waves generate mnemonic and emotional components of dreams. Several aspects of the functions of these PGO waves remain to be determined, but knowledge about the origin of brain phenomena that generate dreams has had a breakthrough from its study. In this present work we review the literature concerning the work done on PGO waves and its contribution to the knowledge of the origin and functions of dreams.

Key words: Dreams, PGO, consciousness.

RESUMEN

El fenómeno del sueño y de los sueños es algo que siempre ha fascinado al hombre. Sin embargo, el estudio científico del sueño es relativamente reciente. En 1953, Aserinsky y Kleitman encontraron que el sueño de ondas lentas (SOL) es interrumpido periódicamente por episodios de actividad EEG rápida, que se acompañan de movimientos oculares rápidos (MORs), y denominaron a esta fase "sueño MOR". Posteriormente, Dement y Kleitman, en 1957, descubrieron que estos movimientos oculares rápidos coinciden con la aparición de los sueños. Utilizando animales de experimentación se han estudiado los mecanismos subcorticales que subyacen al sueño MOR y se ha demostrado que éste depende de una actividad serotoninérgica de la vigilia, que promueve la formación de péptidos que ponen en marcha ciertas estructuras de la región pontina del tallo cerebral en donde se integran los mecanismos colinérgicos del sueño MOR. En la región pontina, a su vez, se generan potenciales monofásicos de alto voltaje (300-400 μV) que también pueden registrarse en el cuerpo geniculado lateral y en la corteza occipital, de allí el nombre de potenciales ponto-genículo-occipitales (PGO). Estos potenciales se propagan hacia el sistema oculomotor para provocar los MORs y posiblemente den origen a los fenómenos oníricos visuales. Además se ha demostrado que ciertas estructuras del sistema límbico, relacionadas con las emociones y la memoria, son activadas por dichos potenciales. Lo anterior sugiere que los potenciales PGO generan los componentes mnésicos y emocionales de los sueños. Quedan aún por determinarse varios aspectos sobre las funciones de estos potenciales, pero el conocimiento sobre el origen de los fenómenos cerebrales que generan los sueños ha tenido un gran avance a partir de su estudio. En el presente artículo se revisa la bibliografía concerniente a los trabajos realizados sobre los potenciales PGO y su aportación al conocimiento del origen y las funciones de los sueños.

Palabras clave: Sueños, PGO, conciencia.

Translation of the original version published in spanish in:
Salud Mental 2014, Vol. 37 Issue No. 1.

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Received: Octubre 24, 2013. Accepted: Noviembre 29, 2013.

"Sleep is relief from misery to those who are miserable when awake..."
Miguel de Cervantes Saavedra.

INTRODUCTION

When we sleep, we spend 20% of the time dreaming. While we sleep, we experience involuntary episodes of mental activity accompanied by sensory perceptions that evoke personal experiences with an emotional tone. But what is the origin of these phenomena, and what is their function? What does our brain need these nightly episodes for? These are age-old questions, and dreams have been understood in various ways according to the time or culture. They have interested humanity since ancient times. We do not have, or possibly have not sought signs of primitive man being concerned about dreams. With the appearance of reflexive writing, we have the first evidence of this interest. Dreams not only caught people's attention, they were also used to interpret the future, and have also been considered magical and mystical. Some witches and/or shamans used to use them and continue to do so, as a means of communication with the gods or the spirits of ancestors. Towards the end of the 18th and beginning of the 19th century, dreams were used by fortune-tellers and charlatans to predict people's future and fortune. The success of this practice led to the publication of books where the reader could find the meaning of their dreams in accordance with a series of esoteric symbols.

During these centuries, medical science occupied itself with the quantification of vegetative variables during sleep. Exact descriptions were made of the gradual reduction of cardiac and respiratory frequencies, but doctors paid little attention to dreams themselves. Due to the complexity of the mental changes that accompanied them, dreams were considered abnormal phenomena; the product of a poorly-oxygenated brain. However, the scientific study of dreams and the identification of them as a physiological cerebral state is relatively recent, within the last 60 years.

BRIEF HISTORY OF THE STUDY OF DREAMS

In 1862, Alfred Maury made the first attempts at explaining the cause of the mental content of dreams. He proposed that they appeared as reflections to sensory stimuli in the surroundings. Currently there is data that supports Maury's proposal to some extent. On occasion, sensory stimulation can modify the content of dreams, but they also occur in the total absence of external stimuli. However, it should be recognized that Maury was a pioneer in the exploration of the mental phenomena of dreams. Furthermore, he described the appearance of another type of perceptive phenomenons at the start of dreams, which he called hypnagogic hallucinations, and which he distinguished from dreams due to their brevity and less-developed content.[1]

Later, Sigmund Freud used the content of dreams as the basis for his theory of thought processes, which he proposed as useful in the treatment of nervous disorders. Freud distinguished two primary components of dreams: the manifest content (expressed by the patient) and the latent or subconscious content, which was inferred by Freud in accordance with sexual symbology.[2,3] He later proposed that dreams occurred as a constant during sleep or during the transition from sleep to wakefulness. Now we know that dreaming is not a constant, but the second proposal was justified, as the dreams we generally remember are those that cause us to wake up. In this way, we can appreciate that only the mental aspect of dreams was taken into account, without an interest in the relationship this has with the functional state of the brain.

In 1929, Hans Berger developed the electro-encephalogram (EEG), making it possible to record electrical activity in the brain of humans. This allowed a direct relationship to be established between states of consciousness and the electro-physiological activity of the brain. Berger also demonstrated that rapid low-voltage EEG rhythms appear during a state of alertness, and that upon the start of a dream, slow, high-voltage rhythms appear.[4,5] This led other researchers to classify dreams into four states (A, B, C, and D), according to the proportion of slow waves that appeared.[6] However, there was still no indication of the relationship between dreams and a particular state of sleep.

THE DISCOVERY OF REM SLEEP IN HUMANS

In 1953, Aserinsky and Kleitman found that the slow, high-voltage rhythms (slow wave sleep – SWS) are periodically interrupted by episodes of rapid EEG activity, accompanied by rapid eye movements.[7] These episodes were called rapid eye movement sleep (REM). Later, Dement and Kleitman described an extremely important phenomenon: that the rapid eye movements (REM) of this phase coincide with the appearance of dreams.[8,9] For the first time, the precise moment when they occurred was known, as well as the fact that they were linked with a specific physiological cerebral state. This discovery gave rise to the start of a new era in the study of dreams, in which systematized analysis was made of them within the field of neuroscience.

The possibility of collecting verbal reports on various dreams during a night favored numerous investigations that characterized their mental components and made attempts to relate them with different biological variables.[10,11] For example, a relationship was found between dreams and the appearance of a raised number of REMs. Furthermore, a coincidence was observed of bursts of large-amplitude REMs with dreams of an intense emotional content; that is, distressing or vivid dreams, with a large number of characters, scenes, and elaborate stories.[12-14] The appearance of dreams was also related to modifications in the electrical resistance of the skin and to changes in cardiac and respiratory frequency.[15]

Cerebral integration mechanisms of REM sleep

It is undeniable that the discovery of REM sleep in humans favored the knowledge of the mental structure of dreams, their relation with a physiological cerebral state, and with various peripheral changes. However, due to the impossibility of exploring the human brain in depth, data around the sub-cortical mechanisms underlying REM sleep and dreams was not obtained at that time. This has only been possible through the use of animal experimentation which has studied sub-cortical mechanisms underlying REM sleep, and it has been demonstrated that this phase is regulated by peptide-based humoral factors. REM sleep depends on the serotonergic activity present in wakefulness, which promotes the formation of hypothalamo-hypophyseal peptides that initiate the structure in the pontine region of the brainstem, where the mechanisms of REM sleep are integrated.[16-20]

Various cellular nuclei are located in the pontine region, which generate different components of REM sleep. Fibers emerge from the *locus coeruleus* that relay in the *reticularis pontis oralis* and *reticularis pontis caudalis* nuclei,[21] in order to arrive at the anterior horn of the spinal cord, where nerve impulses that travel through them cause hyperpolarization of motor neurons and with it, the inhibition of muscle tone.[22,23]

The *reticularis pontis oralis* and *reticularis pontis caudalis* nuclei also participate in the cortical activation of REM sleep.[21] Acetylcholine plays a primordial role in the generation of REM sleep. The cholinergic activation of the gigantocellular tegmental field (GTF) produces the rapid (5-7 min) installation of prolonged episodes of REM sleep.[24-27] Furthermore, the cholinergic activation of the *peri-locus coeruleus* induces the installation of this phase of sleep.[28,29]

Another neurophysiological phenomenon of REM sleep is muscle atonia. Dreams are hallucinatory episodes that appear spontaneously and involuntarily. On occasion they contain volatile motor behaviors, which if carried out, could endanger the physical or social wellbeing of the body. For probably homeostatic reasons, nature has provided a mechanism that suppresses muscle activity during dreams. This mechanism is integrated into the brain stem and spinal cord.[22,23] In summary, muscular atonia causes a state of immobility, probably for the restoration of the antigravity muscular system and to avoid the motor expression of dreams. The cortical activation provides a particular state of conscience which is intermittently interrupted by hallucinatory phenomena (dreams), including motor activity and movement perception.

Origin and propagation of PGO potentials

During REM sleep, the pontine region, specifically in the peri-brachial region (PBL) intermittently generates monophasic potentials of high voltage (300 to 400 μV),[30] that can also be registered in the lateral geniculate body[31] and in the occipital cortex of cats.[32] It was from this anatomical distribution, where they were initially registered, that the name of Ponto-Geniculo-Occipital (PGOs)[33] phasic potentials was derived (figure 1). PGO potentials do not present themselves randomly in the geniculate body and the occipital cortex; rather, they are generated in the pontine region and they spread to the visual system.[34,35] This indicates that the PGO potentials travel to anterior cerebral regions to activate them or modify their activity intermittently. PGO potentials also spread to the thalamic relay nucleus and the auditory cortex,[36] as well as the oculo-motor system to provoke the REMs of this phase of sleep. It is important to mention that these potentials are not generated simultaneously in both PBLs. They can be generated in either the left or the right PBL, and as such they occur distinctly from one another. Until this time it has not been known whether they are generated more in one side or the other (figure 1).[37,38]

Spreading to the limbic system

It has been demonstrated that certain structures of the limbic system (LS) are activated by PGO potentials. The LS plays an important part in the processes of memory consolidation. It is also a strategic part in the association of sensory and emotional elements, which allows the formation of the cognitive elements of mental activity during wakefulness. The above allows us to suppose that the emotions, personal reminiscences, hallucinatory phenomena, and vegetative changes of dreams are integrated in these structures.[39-42] What follows is a reference to three limbic regions in particular: the cingulate gyrus, the hippocampus, and the amygdala of the temporal lobe.

Cingulate gyrus

This structure intervenes in the emotional integration of sensory information coming from the thalamic relay nuclei.[43] Electrical stimulation of the cingulate gyrus in animals produces a disruption of motor behavior in process; animal shows surprise and anxiety, and visceral responses also appear.[44] In humans, electrical stimulation of the cingulate gyrus produced complex dream phenomena, emotional changes, rapid eye movements, and the sensation of dreaming.[45,46]

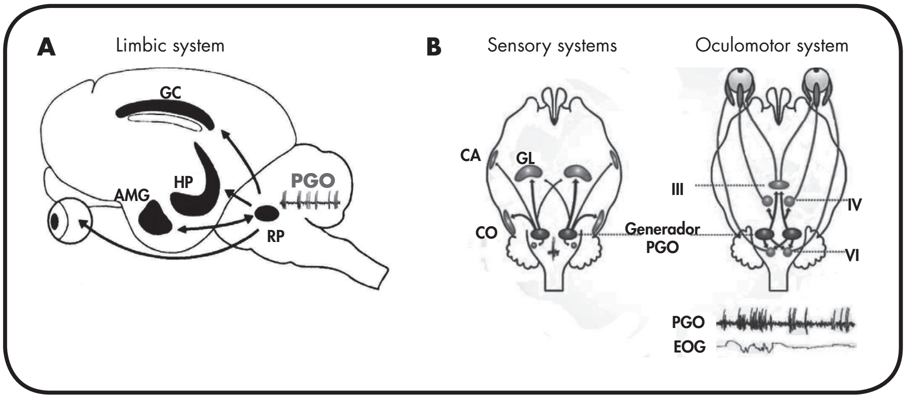

Figure 1. Generation and propagation of PGO potentials. **A.** The structures of the limbic system, such as the cingulate gyrus (CG), the hippocampus (HP), and the amygdala (AMG) of the temporal lobe integrates functions related to emotion and memory. These structures are phasically activated by ponto-geniculate-occipital potentials (PGO) generated in the pontine region of the brainstem (RP) during REM sleep. The above suggests that said activation generates its mnemonic and emotional components. **B.** These potentials also propagate themselves to sensory systems such as the auditory cortex (AC), occipital cortex (OC), and the lateral geniculate body (LGB) This activation probably generates auditory components (eg. language and conversations) and visual phenomena (eg. colors, shapes, characters, faces, places, objects, and animals). However, it has been suggested that dreaming is closely related to imagination more than perception. It is important to mention that these potentials also activate the III, IV, and VI cranial pair nuclei generating the motor component, thus producing the REMs that are recorded on the electroencephalogram (EEG).

Hippocampus

The hippocampus is different from other limbic structures due to presenting EEG theta activity (from five to seven cycles per second), which occurs constantly during REM sleep.[47] This theta rhythm covers more hippocampal regions and is slightly quicker during a state of wakefulness. In awake animals, the hippocampal theta rhythm appears in spurts and is associated with orientation and displacement behaviors around a significant stimulus.[48,49] On the other hand, the hippocampal theta rhythm is also associated with the processing, storage, and evocation of memory.[50] It is possible that during REM sleep, the hippocampal theta rhythm is an indicator of the mnemonic phenomena of dreams, and on the other hand, a sign of the orientation towards a perceptual phenomenon behind these. The hippocampus also integrates the emotional tone of sensory thalamic information. Its electrical stimulation in animals produces defense and attack reactions. Respiratory and pupillary changes have also been observed upon stimulating the hippocampus, and damaging it lowers the threshold for emotional reactions (fury and exaggerated emotional behavior).[51-53] Electrical stimulation of the hippocampus in humans provokes respiratory delay and psychic associations reported by patients as elaborate dreams.[54,55]

Amygdala of the temporal lobe

The role of the amygdala in emotional and instinctive behavior has been demonstrated by numerous researchers. Its damage or electrical stimulation provokes hypersexuality, anxiety, aggression, fleeing and attack behaviors, depending on the amygdalin nucleus damaged or stimulated. This structure receives visual, auditory, somesthetic, and visceral information coming from the thalamic relay nuclei and the brainstem.[56-59] Furthermore, amygdalin stimulation produces pupillary changes, and variations in blood pressure and cardiac frequency.[60] Electrical stimulation of the amygdala in patients produces a sensation of fear or terror.[61] To date there has been enough evidence to demonstrate that the amygdala forms part of the neuron circuits involved in the modulation of REM sleep. In studies of patients with epilepsy of the temporal lobe who present states of increased excitability in the amygdalin and hippocampal regions, an increase of REM sleep has been found on the nights when these patients present paroxysmal discharges.[62,63] This supports the hypothesis that limbic structures participate in the induction of REM sleep, a physiological state necessary for the brain. However, it is interesting to note that in these patients, the number of REMs was found to be reduced, which suggests that paroxysmal activity does not necessarily promote other components of REM. We propose that epilepsy can inhibit REM, and as such, PGO potentials. The function of other limbic regions during REM sleep remains to be explored, but it is clear that the cingulate gyrus, the hippocampus, and the amygdala present physiological changes related to the propagation of PGO potentials. The participation of the insular (pain), the *septum* (reinforcement, pleasurable behaviors), and the nucleus *accumbens*, is currently unknown, but we think that, due to their functional characteristics, they could participate in the sensory integration of dreams.

Neuropsychophysiology of dreams from PGO potentials

The findings related to PGO potentials in cats aroused interest in analyzing their probable existence in humans. Various researchers have demonstrated the presence of cortical potentials in humans equivalent to the PGO potentials in cats. They have also shown that these potentials are indicative of a certain type of mental activity.[64-67] From the exploration of dreams in humans it has been determined that these are made up by diverse sensory, vegetative, emotional, and mental components (table 1).

Sensory components

In humans, as in cats, REM sleep is accompanied by a low-voltage, desynchronized cortical activity similar to that observed during wakefulness. Cortical activation during REM sleep indicates that the brain is in a condition of carrying out certain mental activity in humans, or even of having a particular state of "conscience" in animals. Cortical activation during wakefulness is due to an excitation effect coming from the reticular formation of the brainstem and the midbrain.[68] During REM sleep, some regions of the reticular formation of the brainstem, such as the *reticularis pontis oralis* and the *reticularis pontis caudalis* nuclei, also have an excitation effect on the cortex.[69] Based on the above, the sensory phenomena of dreams could be explained in part by the spread of the PGO potentials to the sensory systems. Furthermore, the vegetative phenomena that accompany dreams could be generated in part by the phasic activation of the pontine nuclei where they are regulated. In our laboratory, further to these phenomena, we have analyzed the activity of different muscle groups of the face during episodes of REM sleep. We have found that the *frontalis* muscle and the zygomaticus muscle have important activations during dreams. These activations are probably related to the emotional quality or modality of dreams and their content.[70]

The electrophysiological changes of the hippocampus and the amygdala during REM sleep indicate the activation of these regions during phasic phenomena which accompany dreams. It is well known that the hippocampus and the amygdala intervene in the consolidation of memory. As a consequence, it is probable that the PGO potentials provoke changes in their neurons to favor the establishing of memories in the long term. Brief electrical stimulation of the reticular formation during a state of wakefulness in cats provokes a state of "hyper-alertness" which is accompanied by an orientation reaction. During REM sleep[71] the reticular formation is submitted to intermittent activations produced by the cellular generators of PGO potentials, which could be compared with the electrical stimuli that trigger an orientation reaction during wakefulness.

It has been proposed that the psychic sensory components of dreams are produced by the propagation of PGO potentials to the visual and auditory systems. However, Penfield and Rasmussen[72] and Penfield and Jasper[61] demonstrated that electrical stimulation of the primary sensory channels (visual and auditory) in conscious patients only provoked elementary perceptual phenomena such as colors, shades, outlines, etc. in the visual channel, and noises and buzzing in the auditory channel. The latter supports the idea that elaborate psychic phenomena of dreams are integrated in the limbic system, whose electrical stimulation produces elaborate emotional and hallucinatory phenomena, as well as the sensation of dreaming. During REM sleep, the activation of the sensory systems does not come from the surrounding environment; rather, from the pontine region where PGO potentials are generated. These "invade" the sensory channels intermittently, whether that be as isolated potentials or even in bursts of up to ten or more potentials. For their part, PGO potentials are generated asynchronically; that is, there is a temporal difference (approximately eight to 12 milliseconds) between the potentials generated on one side of the pontine region, and those generated on the contralateral side.[37,38,73] This shows that the activation of the sensory channels, the association cortices, and the limbic structure of a hemisphere are asynchronic with respect to the activation of the homologous structure of the contralateral hemisphere. Furthermore, its activation is abrupt and at the same time discontinuous. The fact that the cerebral hemispheres are activated intermit-

Table 1. Dream components

Sensory	Vegetative	Emotional	Mental
Visual	Bradycardia	Anxiety	Hallucinations*
Auditory	Tachycardia	Distress	Personal reminiscences
Somesthetic	Apnea	Fear	Incongruousness
Tactile	Tachypnea	Pleasure	Incoherence
Olfactory	Sweating	Sadness	Discontinuity
Gustative	Penile erection	Joy	Strangeness
Pain	Ejaculation	Rage	Sensation of reality
Movement	Swelling	Guilt	Lucid dreams
Pleasure		Surprise	

* This term is used due to the similarity with pathological hallucinations (perception of something that does not exist in the surroundings), but they are not considered abnormal phenomena during REM sleep.

tently and asynchronically during REM sleep can explain, to some extent, the incoherent and incongruous character of dreams, in which a sensory perception does not correspond with a given emotional tone, or even where a personal reminiscence does not develop in the space and time that would "normally" correspond. On the other hand, the discontinuity of dreams could be given by the phasic character of PGO potentials. These appear and disappear suddenly. This probably provokes the appearance of a brief dream episode, and the occurrence of a new burst of PGO potentials provokes another different episode. With respect to the above, it has still not been documented whether one or more dreams occur during an episode of REM sleep. Furthermore, if more than one occur, it would be very difficult to define where the first ends and the next begins. All of these phenomena can impart the strange feeling of the cognitive aspect of mental activity during dreams.

It has been proposed that the visual and auditory components of dreams originate from the propagation of the PGO potentials to the visual and auditory systems. The same could also be thought of the somesthetic and tactile components, given that the activity in 70% of cortical neurons is modified in relation to PGO potentials, and in various thalamic nuclei, potentials are registered that are related to PGOs. However, it is still necessary to precisely analyze the changes in the structures responsible for proprioception during REM sleep and its relation to PGO potentials. In terms of the origin of olfactory and gustatory phenomena, there is still not the data to indicate their cerebral integration during REM sleep. However, it is interesting to mention that while olfactory perceptions are very common, tastes are rarely reported. Finally, although there are discrepancies around the sensation of pain during dreams, there is data which suggests that this does present itself, albeit not frequently.[74]

Emotional components

Dreams are normally primarily comprised by personal reminiscences, whereas conceptual reminiscences are practically absent. Further to this, it is known that the stimulation of the limbic structure only provokes personal types of reminiscences. During REM sleep, the limbic system probably contributes to the consolidation of memories of personal experience more than concepts, the memorization of which requires selective attention as in the state of wakefulness. The re-programming of genetically predetermined instinctive behaviors (feeding, reproduction, nesting, attack, flight, marking, etc.) is another function proposed for REM sleep.[17] This hypothesis is based on neurons being cells that do not reproduce, and to maintain their function throughout a lifetime, it is necessary for them to be re-programmed at any moment. This re-programming would be carried out during REM sleep and the phasic activation of the brain by the PGO potentials would be responsible for it. The limbic system intervenes in the integration of some instinctive behaviors such as feeding, reproduction, attack, and flight, and it is also activated by the PGO potentials during REM sleep. In this sense, it is possible that the limbic structures are the site where instinctive functions are re-programmed.

On the other hand, dreams seem to protect and/or promote the course of the REM phase of sleep. REMs appear when the threshold to wake up is raised. This phenomenon is explained by the inhibition exercised by PGO potentials on the surrounding sensory information. For example, PGO potentials block nervous impulses coming from the optic nerve at a geniculate level, obstructing the arrival of visual information to the cortex.[73] On the other hand, if we deprive a person or animal of REM sleep for hours or days, the loss rate for this phase of sleep tends to be recovered by 65% to 70%, and it is interesting to note that the lost REMs and PGO potentials are recovered by up to 90% respectively.[74-76] This leads REM sleep and PGO potentials to be conferred as necessary for the brain. It could therefore be thought that dreams (linked to REM and PGO potentials) are also regulated in the long term and are necessary phenomena for the brain. The fact that dreams are more vivid and have a more intense emotional content during recovery from REM sleep supports this idea.[11]

DREAM FUNCTIONS

Different authors have proposed that REM sleep is a necessary state for the consolidation of short- and long-term memory, given that the deprivation of REM sleep causes failures and losses in memory and therefore learning.[77-81] On the other hand, learning tasks increase REM sleep and the number of REMs for two to three days after the completion of a task, both in animals and in humans.[82,83] From a neurophysiological point of view, it is still difficult to explain the strange sensations, discontinuousness, incoherence, and incongruousness of dreams. However, these dream characteristics can indicate a lack of synchronicity between both cerebral hemispheres to integrate a coherent and congruent mental activity. In a state of wakefulness, sensory information continuously and simultaneously "invades" both cerebral hemispheres. When there is any alteration in interhemispheric communication, as is the case with split brain,[84] a person can see an object with their left eye, but is not able to name it, and if they observe it with their right eye, they will recognize its name but will not be able to give it an emotional and spatial component. These situations can cause a feeling of strangeness in the subject when faced with external stimulation as it is not easy for them to recognize it.

DISCUSSION

On the basis of all the information presented here, we can say that there is sufficient evidence to support the idea that PGO potentials are the neuronal activities responsible for the generation of the majority of psychophysiological components of dreams, and are probably also involved in meeting the biological functions of REM sleep. The activation of limbic and cortical structures by the propagation of PGO potentials supports this idea. We therefore see that dreams do not only represent the series of mental phenomena that have intrigued men so much since ancient times, due to their impact on daily life. They are also signs of diverse neuropsychological changes that are the result of the activation of extensive neuronal networks and conjunctions, whose initial trigger is the activity of PGO potentials. Various aspects of the functions of these potentials still remain to be determined, but the knowledge about the origin of the cerebral phenomena that generate dreams has come a long way from their study.

It is certain that human beings verbally communicate their dream experiences, but the cerebral changes that accompany them are experienced before speech is acquired. As such, the data collected through the scientific study of sleep and dreams indicates a paradigm for the biological exploration of the function of dreams, whose mental and perceptual components possibly represent an epiphenomenon of vital and homeostatic processes for the individual.

Hobson asserts that they can have a creative function upon providing a model of virtual reality (proto-conscience). Functionally, the brain also prepares itself for integrative functions, including learning and secondary conscience. The activation of the cerebral cortex during REM can remit to a type of primary conscience (proto-conscience) and secondary conscience (metacognition).[85] In accordance with the above, sleep does not present an altered state of consciousness, but a different state of consciousness to being awake. On the other hand, common phenomena within dreams are the times, places, and people that change with no prior warning, and social interactions. The dreamer is regularly the active person. There are autobiographical memory episodes, sequences of events, discontinuity, and incongruence in the story. The sensation of movement is always present, and 80% of incidents have the character of a new event, whereas only 20% have identifiable memory sources. There is gradual loss of orientation within scenes, and sometimes continuity between scenes cannot be recognized.

Frequently, the recognition of people is not exact or reliable, but the dreamer definitely recognizes their mistakes. However, is has now been proposed that even during dreams, we can acquire or present the so-called "theory of mind", due to the dreamer recognizing the mental processes of other people present in the dream. Further to this, the thinking may become logical, although the majority is not rational.

With respect to remembering dreams, although contradictions still exist as to why, sometimes we remember our dreams and other we do not. The physiological explanation of memory has to do with the temporal closeness between the occurrence of the REM episode and waking up. It is important to understand that the quality of these awakenings are not always the same, because we do not always reach the same level of consciousness in our multiple nocturnal awakenings.

However, in terms of functionality, it has been proposed that we do not necessarily have a reason to remember our dreams. Although the memory is not present, the psychic experience has already taken place and should already have met its purpose, above all in terms of learning, memory, and emotional aspects. In general, we can talk about an "amnesia" of our dreams. This is due to the prefrontal dorso-lateral cortex being deactivated during REM, and as such this phase of sleep creates a cerebral state that is not favorable for subsequent memory.[11,85] In contrast, if we compare the level of control (healthy) subjects with that of post-traumatic stress, patients with major depression, and with temporal lobe epilepsy, for example, the number of memories is greater in the latter groups. In the same sense, these are more vivid, anxious, and unpleasant, as well as repetitive. The reports of these patients of experiencing more frequent dreams could be due to the dreams having a greater emotional load (due to usually being negative), and in this sense it has been proposed that a larger or greater memory of dreams could be present when there are neurological and/or psychiatric alterations. As such, it has been suggested that a poor memory could be due to a lighter negative emotional load.

Do we have a conscience similar to being awake when we are dreaming? No, according to Freud[3] and Solms,[86] because of which the dream aspect is strange and includes changes without a sense of time and place, as well as incongruences in storyline, characters, and actions. This is because the true content of the dream is masked by the dreamer. In accordance with the above, these authors propose that to dream may be very similar to mental illness. Hobson's vision also supports this idea. For him, dreaming may be comparable to delirium (a state of acute confusion) that can occur during alcohol withdrawal syndrome. He also proposes that REM sleep shares physiological substrata with those of psychopathological conditions such as schizophrenia, which is characterized by a limbic hyperactivation and frontal hypo-activation.[11] Conversely, theories by Foulkes[10] and Domhoff[87] support the idea that it is possible that dreams are "a very faithful representation of waking life", which to a greater extent are coherent and with a possible internal narrative sequence, instead of stereotyped illogical sequences of strange or incongruous images. Analysis of content indicates strong continuity between the content of the dream and what happens during waking life. The evidence that joins dreams with psychosis is limited.

We think that one of the primary functions of dreams is to believe a "*virtual reality*" that prepares us for probable situations in our subsequent waking lives. This creation of a virtual world and situations prepares us for any eventuality or for the solution to problems that have to do with everyday life. An example of this could be social, work, or family situations that happen within dream behavior. This "virtual reality" provides a model of the world that is functional for the development and maintenance of consciousness during wakefulness. We even propose that during our dreams, we are capable of creating our own "avatar" and at the same time, those of the characters that appear in our dreams. We refer to the term "avatar" in its divine sense, not the modern concept. This term started to be used in the iconographic sense by designers of various *role*-playing games like *Habitat* in 1987, or *Shadowrun* in 1989, and it is commonly used on the internet. The word avatar is associated with graphic representation through a picture or photograph of a person for their identification. Some technologies also allow the use of three-dimensional avatars. Finally, we wish to add that the virtual reality created during our dreams does not differ from all of our real and daily life, that the things that we dream are directly related with our experiences and situations in conscious wakefulness. The primary function of dreams is therefore to simulate events that could actually occur, and as such, have a "prior experience" that grants us functional advantages in biopsychosocial terms, although we may not be conscious of it.

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Declaration of conflict interest: None