Review article

Dreams: integrating psychoanalytic and neuroscientific views

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INTRODUCTION

Mauro Mancia,[1] a neuroscientist and psychoanalyst, in an article published in the International Journal of Psychoanalysis, in 1999, points out the differences between the neuroscientific and psychoanalytic approaches to dreams. Whereas the neuroscientists are dedicated to the study of the brain structures and functions involved in the production of the dream, the psychoanalysts are interested in its meaning, considering the biological aspects to be of no relevance for its understanding. However, for other authors, such as the psychiatrist Morton Reiser,[2] the study of dreams represents a great opportunity to explore the relation between body and mind. According to him, the psychoanalytic and neuroscientific models for dreams, although being quite different, should not be seen as antagonistic or irreconcilable, but as complementary. Reiser believes that an association between these two areas of knowledge could be mutually enriching.

We carried out a literature review about dreams, in which we compare the psychoanalytic and neuroscientific views, with the aim of identifying possible points of convergence and divergence between them. By promoting a dialogue between psychoanalysis and neuroscience, we will have subsidies to assess the feasibility and usefulness of bringing them closer or even integrating them in the study of the human mind.

We started our literature research with the studies about dreams by Sigmund Freud, the "father of psychoanalysis", by James Allan Hobson, a neuroscientist who fiercely criticizes the Freudian theory, and by Mark Solms, one of the main researchers in the area of neuro-psychoanalysis, a recently created discipline that deals with the integration between the psychoanalytic and neuroscientific concepts. We searched for scientific articles about this topic on the databases MEDLINE, LILACS and PsycINFO, using the search word "dream" (or *sonho*, in Portuguese). We also searched some of the most important national and international journals concerning psychoanalysis and neuroscience in libraries and on the Internet, through the CAPES (Coordination and Improvement of Higher Level Personnel) site. We chose to preferentially include original articles and recent reviews, or those considered classical articles in the scientific literature.

The Freudian theory about dreams

"The Interpretation of Dreams," published in 1900, is considered the first psychoanalytic work by Freud. In this study, particularly in chapter VII, a general theory of the psychic apparatus can be found. It is formulated based on Freud's studies about dreams, which are, according to him, the "royal road to a knowledge of the unconscious activities of the mind."[3]

For Freud, dreams represent "a (disguised) fulfillment of a (repressed) wish." They have a manifest content, which is the conscious experience during sleep, and also a latent content, considered unconscious. The latter is composed of three elements: the sensory impressions during the night (for example, the feeling of thirst during sleep), the day's residues (register of the events of the previous day) and the id instinctual drives (related to sexual or aggressive fantasies). These elements of the latent dream tend to wake the individual. During the sleep, due to the total absence of voluntary motor activity, the repression is weakened, which increases the possibility of drives reaching consciousness. Nevertheless, the dream works as "the guardian of sleep." Because of a compromising solution between the id and the ego – which is the instance responsible for repression –, a partial gratification of the instinctual drives is allowed, reducing their force and, consequently, allowing the individual to continue to sleep. Such gratification takes place through a visual fantasy (the manifest content of the dream), which is the result of a regressive process: the flow of the psychic energy, instead of going towards the motor pathways, returns to the sensory pathways.[3,4]

Still according to Freud, the manifest content of dreams is apparently incomprehensible, because it consists of a distorted version of the latent content. Such distortion occurs, in the first place, because during the sleep there is a deep regression of the ego functioning, which makes the primary process of thought prevail. This is characterized by the predominance of visual images (instead of verbal language) and by the mechanisms of condensation (fusion of two or more representations) and displacement (replacement of one representation by another). Furthermore, there would be an instance of censorship between the conscious and the unconscious, which would

deliberately disguise the content of the dream, so that the dreamer does not recognize its instinctual, prohibited origin.[3,4]

Some remarks against the Freudian theory

The Freudian theory about dreams has been criticized in and out of the psychoanalytic area. It is questioned whether the images we perceive during sleep would really represent a disguise or distortion. Luborsky & Crits-Christoph[5] studied the dreams of a group of patients using the Core Conflictual Relationship Theme Method (CCRT), an instrument that assesses the interpersonal relationship pattern of individuals based on their reports. After comparing the assessment results related only to the manifest content of the dream with those obtained when the dreamer's free associations were also considered (which would indicate the latent content of the dream), no differences were found. Several empirical studies found a significant correlation between the mental activity during waking and the manifest content of dreams. In the sample used by Greenberg et al.,[6] the problems dreamed by the individuals were the same they were going through in their daily lives. Smith,[7] in his turn, observed that separation or death were the predominant theme in the dreams of hospitalized patients with heart diseases. Other clinical trials showed that stimuli presented previously to the sleep – such as movies, photographs or word games – clearly reappeared in the dreams.[8]

On the other hand, some authors do not believe it might be possible to recover the latent content of the dream in the analytical session. For them, the free association causes the production of a new material, originated from the patient-analyst relationship.[9,10] Blechner[10] states that a great deal of what is bizarre or confusing in the dream is not a result of repression: they are originally extralinguistic elements that may not be expressed in words. For Robbins,[11] dreams purely express the language of the primary process; therefore, the presence of an instance of censorship, which would reflect a rational thinking (characteristic of the secondary process), is not possible.

Freud's statement that the desires are the cause of all dreams is also questioned. For several authors,[1,12,13] dreams reflect not only the desires and defenses against them, but the mental activity as a whole, and have many other functions besides discharge (of the psychic energy), such as problem solving (intellectual or emotional),[6,14,15] creativity,[8] self-knowledge,[1,16] mind integration,[14,17] adaptation,[17] learning,[8] stress neutralization,[8] among others. McCarley & Hobson,[18] in their turn, argue that, although themes related to desires may be present in the dreams, it does not mean that they represent a causal factor in the process of dream formation. Finally, some authors[1,9,10,12,17,19,20] highlight the patient-therapist relationship and transference as the main components in the formation of dreams during the treatment.

Opposite to the importance given by Freud to dreams in order to investigate the mind, the psychoanalysts' interest in them has been significantly decreasing over the past decades. Kantrowitz,[17] in a study of the curricula of 28 American psychoanalytic institutes, verified that the total number of hours dedicated to the study of dreams in clinical and theoretical courses in 1998-1999 was much lower than in 1980-1981. For several analysts, the intrapsychic aspects brought about by dreams may be equally obtained by studying the symptoms, personality traits, parapraxis or free associations.[10,17]

The neurophysiological aspects of sleep

In the 1950's, Nathaniel Kleitman and his students William Dement and Eugene Aserinsky described the paradoxical, or REM sleep, for the first time.[1,2] The REM sleep represents around 20% of the total sleep time in adults. It is characterized by the occurrence of rapid eye movements (hence the abbreviation), loss of muscular tone, irregular heart and respiratory frequencies, and oscillations in the systemic blood pressure. These authors found that subjects awakened in this stage of sleep usually reported having been dreaming. In 1962, Jouvet showed that the electroencephalographic activity during the REM sleep is very similar to the waking: unsynchronized (irregular) and with fast waves (β rhythm). On the other hand, in the deep sleep,

non-REM (NREM), in which there is no increase in the peripheral autonomic activity, a synchronized activity and the δ and τ rhythms prevail – hence it is also known as slow wave sleep (SWS).[1,21]

Today it is known that, although dreams are much more common during the REM sleep, they may also occur during the deep sleep: it is estimated that 25-50% of NREM sleep periods are associated with dreams.[21] Moreover, 5-30% of REM sleep periods occur without any dream.[22] However, depending on the sleep stage, the characteristics of dreams are very different. Compared to the NREM dreams, the REM dreams are more vivid and bizarre, present a greater participation of the dreamer and a greater spatial structuring, are more easily remembered, and reported using a higher number of words. The NREM dreams are more conceptual than plastic, besides being composed of non-organized and non-reportable reality fragments. They are rarely remembered and present a more passive participation of the dreamer.[1,21]

During the REM sleep, the cortical blood flow is more intense than in the slow wave sleep, and sometimes even more intense than in waking.[23] Positron-emission tomographic studies (PET scan) show that, during the REM sleep, the extra-striate visual cortex (associative) and the limbic and paralimbic regions are activated; at the same time, the striate visual cortex (primary) and the prefrontal cortex are deactivated. Several aspects that are characteristic of the dream may be related to these findings: the richness of visual images, when the associative visual cortex is activated and the primary visual cortex is deactivated; the intense emotional response, when the limbic and paralimbic regions are activated; and bizarreness, incoherence, loss of criticism and forgetfulness, when the prefrontal cortex is deactivated.[1,24,25]

It is believed that the consciousness of waking is mediated by the noradrenaline and by serotonin, and the consciousness of the dream (REM sleep) by the acetylcholine.[24,25] The aminergic activity (noradrenaline and serotonin) is high during waking, diminishes during the NREM sleep, and is absent in the REM sleep. The cholinergic activity is at its peak in the REM sleep and waking, and minimum or absent during the NREM sleep. It has been recently discovered that the

hypocretins play a major role in the sleep-waking cycle: they present maximum activity during waking and are absent during the REM and NREM sleep.[26,27]

Consolidation of the memory during the REM sleep

For most neuroscientists, dreams do not have any function: they are only a collateral effect of processes of memory consolidation dependent on sleep, the conscious manifestation of these.[27] Several data indicate that the sleep is essential for memory and learning. In the first place, during the REM sleep, the cholinergic activity prevails, and the acetylcholine is clearly involved in the cognitive functions.[28] In several experimental studies, some carried out with rats, others with humans, it was verified that the REM sleep deprivation caused a loss in the learning of perceptive or perceptive-motor skills (implicit memory), which were trained a little before falling asleep.[27,29,30] In other studies, in which the animals or humans were submitted to this type of training, but were not deprived of sleep, there was an increase in the total duration of the REM sleep.[28,31] Such increase only occurred when the task was really learned.[28] Based on that, there was a belief in a relation between the REM sleep and the consolidation of the implicit memory.[32]

On the other hand, a clinical trial showed a reduction in the ability of acquiring explicit memories in individuals deprived of NREM sleep.[30] In electroencephalographic studies performed in rats, birds and humans, it was noted that the firing patterns of certain hippocampus neurons recorded during waking reappeared during the sleep when cognitive task were trained (explicit memory). Such phenomenon of neuronal reactivation, or reverberation, predominantly occurs in the NREM sleep, but is also seen in the REM sleep and even during waking.[28,33,34]

Experiments in rats demonstrated that those exposed to unfamiliar environments a few hours before sleeping presented an increase in the zif/268 gene expression – particularly involved in neuroplasticity processes – in the hippocampus and cerebral cortex during the REM sleep, which did not occur with the control animals.[34]

Nonetheless, there are doubts as to the role of sleep in memory consolidation. For Vertes,[32] it does not seem to make sense to attribute this role to sleep, which is an eminently amnestic state. In addition, it is known that the consolidation of some forms of memory also takes place during waking.[28]

In approximately half of the studies of sleep deprivation in animals, the results did not show a learning deficit,[32] and in several experiments with humans submitted to presleep training activities, there was no increased duration of the REM sleep.[31] On the other hand, the methodology used in several studies with rats is criticized, since the training and sleep deprivation usually cause stress, which in their turn may cause a longer REM sleep, as well as loss in the acquisition of new memories.[28,31,32] It should also be stressed the fact that the monoamine oxidase-inhibiting antidepressants, widely prescribed in a recent past, although causing the elimination of the REM sleep, have never been related to a memory deficit.[31,32]

Siegel[31] argues that, if the fact that the neuronal activity during waking reappears in the sleep is implied in the consolidation of memories of daily events, the dreams would be faithful copies of such events. But it does not seem to be so. Fosse et al.[35] assessed the content of 299 dream reports by 29 volunteers. Although 65% of dreams were related to recent personal experiences, only 1.4% of them had elements that could be considered a repetition of such experiences.

According to Francis Crick – winner of the Nobel prize for his research on DNA – and Graeme Mitchison,[36] people dream not with the memories that are being consolidated, but with those that are being erased. For them, the REM sleep is necessary to eliminate wrong or useless information stored in the brain. The dream would be a reflex of a reverse learning process, in which certain synapses are weakened. Although this formulation has not received much support from academicians, it is frequently cited and seems to be coherent with the fact that dreams portray bizarre or unreal events, which must be eliminated from the memory.[32]

The activation-synthesis theory

The activation-synthesis theory, put forward by Hobson & McCarley and presented as a refutation of the psychoanalytic theory about dreams, has been widely accepted among neuroscientists over the past two decades.[22] In the REM sleep, due to a reduction in the aminergic activity, there is a disinhibition of the cholinergic system, particularly in the brainstem. It makes the ponto-geniculo-occipital (PGO) waves be periodically generated, which are detected in the electroencephalogram of the REM sleep. For the authors, they are the basic stimuli of dreams. Their origin is in the brainstem, propagating to the lateral geniculate body of the thalamus and reaching to the visual cortex (occipital), activating it. Therefore, based on stored visual memory traits, the images of the dream are produced. Since this cortical activation takes place at random, chaotic images are formed, which, in a second moment, suffer a process of synthesis, thus building a sequential narrative. Therefore, according to the theory, dreams are born in the brainstem without any meaning. They are not disguising anything; on the contrary, they clearly express the brain activity.[24,37,38]

The dopaminergic mesolimbic-mesocortical system and the rescue of the Freudian theory

Mark Solms[22,39] presents a theory that is at the same time a criticism to the activation-synthesis theory and an attempt to confirm the Freudian formulation about dreams. According to him, the REM sleep and the dream are dissociable states: one might occur without the other. There may be dreams in the NREM stage of sleep, and 5-10% of them are indistinguishable from the dreams in the REM stage. Furthermore, epileptic focuses on temporolimbic regions, i.e., out of the brainstem, may cause recurrent stereotyped nightmares, typically during the NREM sleep. He assessed 22 patients who presented a brainstem lesion and, consequently, total or partial loss of the REM sleep; of these, 18 maintained their capacity of dreaming. On the other hand, Solms points out that, in the scientific literature, there are more than 100 cases of dream elimination caused by lesions in the anterior brain that preserved the brainstem and the REM sleep. In most of these cases,

the area of the parieto-temporo-occipital junction, which is closely related to the formation of dream images, was affected. However, in other patients, the elimination of dreams was due to a lesion in the ventromedial portion of the frontal lobe. This was the affected region in surgeries of prefrontal leucotomy, which were widely used in the past for the treatment of schizophrenia and usually led to a loss in the dreaming ability.

Fibers of the dopaminergic mesolimbic-mesocortical system pass through the ventromedial portion of the frontal lobe, which involves the ventral tegmental area of the mesencephalon, nucleus accumbens, hypothalamus, prefrontal cortex, and anterior cingulate cortex. According to Solms,[22] this system generates the dream. PET scans show an increase in the activity of this circuit during the REM sleep.[23,40] Moreover, dopaminergic agonists, such as the L-Dopa, may cause particularly vivid dreams and nightmares. Such findings reinforce the old notion of a connection between dream and "insanity" – both present hallucinations, loss of critical judgment, etc. –, since there is a clear correlation between dopaminergic hyperactivity and the occurrence of psychotic symptoms.[22,23]

The mesolimbic-mesocortical system is related to motivational states, which instigate behaviors that aim to satisfy the biological needs, such as drinking, eating, and copulating. Stimulating substances and those that cause dependence, such as cocaine and amphetamine, act in this circuit, causing an increase in the release of dopamine in the nucleus accumbens, which in its turn leads to a feeling of pleasure.[22] Another element that indicates a relation between this dopaminergic system and dreaming is the high frequency with which addicted patients in the abstinence period dream about looking for or taking drugs.[41]

According to Solms,[22] the REM sleep and the dream are controlled by different biological mechanisms: the former is controlled by the cholinergic activity of the brainstem, and the latter by the dopaminergic circuits of the anterior brain. These are the common final pathway of several forms of brain stimulation. The PGO waves often play this role of brain stimulation, but not exclusively. Still according to Solms, the involvement of the mesolimbic-mesocortical system in the

generation of dreams, clearly related to what the psychoanalysis calls instinctual drives, seems to confirm Freud's statement about the desire being the instigator of dreams.

The role of dreams in the psychic elaboration of traumatic experiences

In "The Interpretation of Dreams," Freud[3] argues that even nightmares do not contradict the formulation that dreams are the realization of a desire. According to him, in this case, despite the oneiric censorship, the latent content manages to get to the consciousness without many alterations and is recognized by the ego, which reacts by producing anxiety, with the aim of waking the individual. Freud also quotes a variation, the punishment dreams, in which the ego anticipates the guilt (through the realization of the repressed desire), and the manifest content is representing a punishment fantasy. Therefore, it would be a desire of the superego, and not of the id.

Later, however, in "Beyond the Pleasure Principle," published in 1920, Freud[42] himself mentions an important exception to his formulation: the repetitive dreams that occur after traumatic events and those that evoke childhood traumas are not realizations of desires. Such dreams, according to him, obey the compulsion to repetition, which is something more primitive than the pleasure principle (and independent of it), and play the role of submission or domination of the excitements related to the memory of the trauma.

Nevertheless, for Ernest Hartmann,[43] nightmares are not an exception; on the contrary, they represent the paradigm of all dreams. He studied the dreams of people who went through major traumatic experiences and noted that, in the beginning, there was often a mere repetition of the trauma. Later, however, the feelings of fear, vulnerability, guilt or sorrow remained present in the dreams, but in a totally different context. For example, dreaming about being hit by a giant wave or a hurricane was very common, independent of how the real trauma happened. These individuals' dreams had the sensory stimuli related not to the traumatic event, but to the emotion experienced. According to the author, dreams contextualize the dominant emotion, expressing it through a pictorial representation. For Hartmann, this pattern is found in dreams of people who did not suffer

major traumas, but are experiencing an intense emotion, such as in general stressing situations. He states that, when there is no dominant emotion, and several lower intensity emotions are present, such pattern, although less clear, is still present.

Revonsuo,[15] in his turn, used the theory of evolution to explain the dreams. He was based on the following premises: for the first humans, life was short and full of threats; the traumatic events are often expressed in dreams; and the dreams are essential in the learning process. According to his hypothesis, the function of dreams is to simulate traumatic or threatening experiences that were previously experienced during waking. Such simulation, according to him, leads to an improvement in the individual's performance in relation to the detection and confrontation of threats, which consequently increases his survival and chances of procreation.

Several authors[9,14,19,20,44] believe that dreams are extremely important for the elaboration of traumas and psychic conflicts and play a therapeutic role, similar to the role of psychotherapy. In order to explain this elaboration process, the following model of computational neuroscience has been used. It is believed that, in the dream, the neural networks are more easily connected than during waking.[43] Nonetheless, these connections do not occur randomly: the emotions would be the organizers of the neural networks. In other words, the representations tend to associate themselves with others that have the same affective connotation.[2,43] This is in accordance to the Hebbian learning rule, which states that "a synaptic connection between two neurons increases whenever the neurons are activated at the same time by an external source." While we sleep, the recent experiences are first paired with more remote events, with which they present any similarity, and then integrated to the permanent records of memory.[45] Therefore, the remembrance of a trauma (childhood or recent) is associated with other memories, which makes it less powerful and disturbing.[43]

DISCUSSION

Dreams may be defined as states of consciousness that take place during the sleep. But we still know very little about them. The Science magazine, to celebrate its 125th anniversary, presented a list of 125 questions still unanswered by science and that will challenge researchers in the next 25 years. Among them, the following were included: "what is the biological base of consciousness?", "why do we sleep?", and "why do we dream?".[46]

Freud's hypothesis that desires instigate dreams has some support in Solms' proposition[22] of a relation between dreams and the activation of the dopaminergic mesolimbic-mesocortical system. This author, as previously mentioned, was based on the observation of patients with lesions in the anterior brain, on PET scans during the REM sleep, on the effect of dopaminergic agonists on dreams, and on the existence of several aspects in common between dreams and psychosis. However, some doubts about this issue still persist. For example, there is a lack of data in the scientific literature about how the antipsychotics, which are dopaminergic antagonists, affect dreams, both in normal and psychotic individuals. Furthermore, the dreams and the most important form of psychosis – schizophrenia – have remarkable differences from the phenomenological point of view: whereas dreams are basically composed of visual images, in schizophrenia the hearing hallucinations prevail, and the visual ones are much rarer. Also, one should not forget that Freud[42] recognized the existence of exceptions to his rule: the repetitive posttraumatic dreams.

On the other hand, the idea that an instance of censorship distorts the dreams has found little support. Robins[11] states that the manifest content is the dream itself, since the prefrontal cortex, which would be essential in any mental disguising mechanism of dreams, is not activated during the REM sleep.

On the other hand, the view of many neuroscientists, such as Hobson & McCarley,[37] that dreams do not have any meaning is challenged by the verification of how much the emotions experienced during waking determine the content of dreams, as described in Hartmann's study.[43] The emotional aspects of memories are codified as implicit memories,[47] which are probably

consolidated during the REM sleep.[32] According to Stickgold et al.,[27] the REM sleep may increment the processing of emotional memories. All this is quite coherent with the hypothesis that emotions play a major role in the formation of dreams.

The model of computational neuroscience about the role of dreams in the psychic elaboration is quite similar to the psychoanalytic model. The development of multiple associations to represent the trauma would correspond to its incorporation to the secondary process thought, which is rational and obeys the logic and the reality principle. Incrementing the modality of the secondary process thought to the detriment of the primary process thought represents a strengthening of the ego's ability to dominate the id, which in its turn consists of one of the main objectives of the analytic treatment.[48]

Freud,[3] in 1900, affirmed that both the irrational and the rational thought take part in the elaboration of the dream. Robins[11] disagrees, stating that the dreams only express the primary process thought; what is related to the secondary process is their report. But the neuroscientist Claude Gottesmann[23] states that the dreams in the NREM sleep are similar to the secondary process thought.

A question is raised here: if dreams are therapeutic because they expand the working area of the ego and increment the secondary process thought, how do they present themselves with characteristics of the primary process thought? In section D of chapter VII of "The Interpretation of Dreams," Freud[3] says that the transformation of thought into visual images favors the connection with thoughts that suffered the same transformation process. Maybe the dream represents only part of the process of psychic elaboration that occurs during the sleep. Although the increase in the number of associations of mental representations takes place during great part – or all – of the sleep, information about this process only reaches our consciousness during the dreams, mainly in the REM stage. Since the prefrontal cortex – essential for attention and rational thought during waking – is inactive in the REM sleep, our consciousness is able to work just according to the primary process, and thus only partially captures the process that is being developed. In other words,

although during the sleep new associations between ideas are being created, we can only dream about condensations or displacements.

Considering what we have seen, the dialogue between neuroscience and psychoanalysis may be quite profitable: psychoanalytic propositions have inspired and guided neuroscientific investigations, and neuroscientific findings have been useful to refine the psychoanalytic theory.

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ABSTRACT

A comprehensive review was carried out about psychoanalytic studies and the most recent neuroscientific researches about dreams. According to Freud, dreams represent "a (disguised) fulfillment of a (repressed) wish." For several neuroscientists, they are formed based on random stimuli originated from the brainstem and do not have any meaning. However, several studies associate the emotions experienced during waking with the content of dreams. The hypothesis that the dopaminergic mesolimbic-mesocortical system, which is associated with instinctual appetitive craving states, is essential to the formation of dreams brings some endorsement to Freudian theory. Nevertheless, there is no empirical data to support the existence of an instance of censorship that distorts the dreams. It is possible that the dreams play a role in psychological working-through of traumatic memories. In our opinion, psychoanalytic and neuroscientific views about dreams can be complementary and mutually enriching.

Keywords: *Dream, sleep stages, psychoanalysis, neurophysiology, literature review.*

Title: *Dreams: integrating psychoanalytic and neuroscientific views*

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