**REVIEW ARTICLE**

# A state of confusion in information processing makes the sleeping brain a dream generator.

**Authors**

Wenlu Zhang[1] and Jinhui Zhang[2]

**Affiliations:**

[1] Key Laboratory of Molecular Biology, Ministry of Education, Institute of Life Sciences, Chongqing Medical University, Chongqing 400016, China

[2] Chongqing Police College, Chongqing 401331, China

**Correspondence**

Wenlu Zhang;

E-mail: zhangwenlu@cqmu.edu.cn

Jinhui Zhang;

E-mail: zhangjinhui0303@163.com

**Abstract:**

Dreams, generated by the sleeping brain, are one of the most common and fascinating phenomena of human mind. But the role and mechanism of dreaming remain largely unknown. This paper provided the phenomenon showing that the brain is trying, but always failing, to correctly process information in the sleeping state. We proposed that dreams are the product of the brain retaining partial activity and functioning during sleep, and the bizarre nature of dreams is attributed to the sleeping brain's confusion in information processing. Hence dreams can be presented as a kind of mental disorder that occurs in healthy brain during sleep. Furthermore, clues suggest that mental states similar to dreams may occur in waking brain, which can result in many kinds of mental illnesses.

**Key words:** dream; sleep; consciousness; mental disorder

Copyright 2018 KEI Journals. All Rights Reserved

**Introduction**

The first theory about dreams was Freud's wish fulfillment interpretation of dreams.[1] In this psychoanalytic theory, unconscious wishes are disguised via censorship forming the bizarre dream contents. Another influential theory was Hobson's Activation-Synthesis hypothesis.[2] According to this Activation-Input-Modulation (AIM) model, dreams are the result of the forebrain's attempts to respond to random ponto-geniculo-occipital (PGO) waves that originate in the brainstem during rapid eye movement (REM) sleep. Recently, more theories about function of dreams have been proposed, most of which emphasize an adaptive function related to evolution or a role in learning and memory consolidation. However, the phenomena of dreams are still not well explained in theories. According to professor Foulkes and Domhoff's conclusion, theories that have dominated the field do not explain why we dream,[3-6] and this suggests the need for a completely new one.

The brain always receives and processes information while awake and this should occur during sleep as well, because our brains never turn off and still respond to various kinds of stimuli while sleeping. Many established remarkable similarities between waking and dreaming consciousness suggested the strong connection between them. We proposed and argued that the essence of dreaming is information processing of the brain while sleeping, and therefore dreams are similar to waking mental experiences in essence. However, at its most basic level, human sleep is a restorative process of the brain and body. To rest and recover, the brain may not be fully active during sleep and only function partially. This half-working state means that the sleeping brain cannot process information correctly, and therefore, the times, places, people and activities cannot be correctly identified during sleep. We provided further evidence showing that illogical and unreal dream contents are attributed to the sleeping brain's confusion in information processing.

## Similarities between waking and dreaming suggest that dreams are similar to waking mental experiences in essence.

It seems that we are completely deaf, blind and inactive during sleep, but the sleeping brain has been shown to be responsive to various kinds of stimuli.[7-10] This has demonstrated that our brains are still receiving and processing information while sleeping, as they do in waking state. Accordingly, there are many remarkable similarities between dreams and waking consciousness. In this study, it is argued that dreaming is information processing of the sleeping brain in essence, and consequently dreams are similar to waking mental experiences. (1) **Continuity between dream contents and waking conceptions or concerns.** Many dream elements are linked to what the dreamer recollects of waking experiences.[11,12] Dream contents are closely related to personal

Copyright 2018 KEI Journals. All Rights Reserved 

concerns and past or present emotional preoccupations.[13] Furthermore, dreams reflect our personality dimensions once cognitive skills have been well developed. The dreams of older persons do not differ from those of college students.[14-16] In addition, dreams share many characteristics across cultures.[17-19] For example, men's dream has a higher percentage of physical aggression than women's in almost all societies, although there are variations from society to society in the percentage of all aggressive interactions.[20] (2) **High consistency of sensory modalities between dreaming and waking.** Both vision and audition are the most common sensory modalities in daily life and they can be imagined vividly. Almost all dreams contain one or more visual elements. Vision is the most prevalent sensory modality in dreams. Audition is also one of the most prevalent modalities. Tactile and movement sensations are less frequent. Smells, tastes, and pain rarely occur in dreams,[17-19] similarly all these sensations are difficult to be imagined vividly when awake. It is also interesting that brain lessons that impair waking visual imagination show parallel visual deficits in dreams.[21,22] **(3) Development of children's dream features is consistent with cognitive and neural maturation.** The frequency and cognitive structure of children's dreams were different from those reported by adults.[18,19] The median dream recall rate was only 15% in preschoolers when awakened from REM sleep, compared with 80-90% in adults.[5] The children's dream contents have fewer characters with moving about, social interactions and episodic memories compared with those of adults. Perhaps the lower frequency of dreaming in children is partially related to their amnesia or poor verbal skills, but the main reason may be associated with the sleeping state of children. Children sleep more deeply and are harder to be awakened than adults. This means that children would have a higher threshold for intense consciousness while sleeping; when awakened, children are not aware that they were dreaming at all. The lack of movement in dreams is consistent with the notion that preschoolers cannot imagine continuous visual transformations.[5] Visual imagination depends on visuo-spatial skills, which are primarily based in the parietal lobes and develop gradually during childhood.[23] Accordingly, injuries to either parietal lobe in adults showed a decline in waking visuo-spatial abilities, and caused impairment both in waking imagination and in dreams.[24,25] The lack of narrative structure in preschoolers' dreams is consistent with their inability to exercise conscious episodic recollection in memory. In addition, individuals who are blinded after 5-7 years of age still have visual imagination and dream with visual imagery throughout life, whereas blinding at an earlier age leads to the absence of visualization in both waking and dreaming.[21,22] These results indicated that the ability to dream depends on cognitive skills and dream contents are relevant to experiences in memory. With time while learning continues and memory is updated,

Copyright 2018 KEI Journals. All Rights Reserved 

dreams begin to reach full maturation. **(4) Specific neural lesions lead to an analogous impairment or loss in both dreaming and waking imagination.** Patients with lesions in visual association cortex reported impaired visual imagery both in waking imagination and in dreaming, even though their normal waking vision was preserved.[25,26] In addition, patients with frontal and temporal lesions reported misidentification of faces in both dreaming and waking life.[27] These findings parallel with those in motional imagery or color vision impairment.[24,28] Some lesions to certain brain regions can result in global cessation of dreaming. The inferior parietal lobe is a brain region that may generate the perception of a fictive space and is thought to be important for imagination. Patients with injury to inferior parietal lobe reported complete loss of dreaming and deficits in waking imagination.[24,25] Other patients with damage to the deep white matter of the frontal lobes exhibited global cessation of dreaming, as well as the loss of initiative, curiosity, and fantasy in waking life.[25,28] In general, it seems that lesions, which impair waking imagination, have a parallel influence on dreaming. For many of these brain lesions, dreaming returned when lesions healed. However, some brain lesions that have no influence on waking imagination do not affect dreaming at all. It was reported that patients with lesions to the primary visual cortex still dreamed with visual images and exhibited vivid visual imagination while awake,[25,29] in spite of their cortical blindness.

These established parallels between waking and dreaming consciousness suggested that mental processes during sleep are strongly connected with those during wakefulness. It seems that a person in sleep has the same set of psychological and cognitive style as that in waking. The mental experiences during sleep, which we call dreams, should not essentially differ from those in waking life. In contrast, eyes are closed and the ambient is typically quiet during sleep. Conscious experience should be normally driven by internal stimuli including wishes, thoughts, emotions and memories. Therefore, most dreams are more closely related to imagination and strong evidence exists to demonstrate the intimate relationship between dreaming and imagination.

## Confusion in information processing during sleep makes the difference between dreams and reality.

Despite many remarkable similarities, dreams are fascinating because of their bizarre differences from waking consciousness. Fragmented people, places and activities in memory are seamlessly reflected in dreams. Why are dreams so bizarre and illogical? Where do they come from and how may they be modified during sleep?

It is difficult to manipulate and predict the contents of certain dreams, and rather than direct observation, dream contents can only be

Copyright 2018 KEI Journals. All Rights Reserved 

obtained via report. In my experience, when I slept with eyes open, the scene in reality was directly reflected in dream while sleeping (Fig. 1).

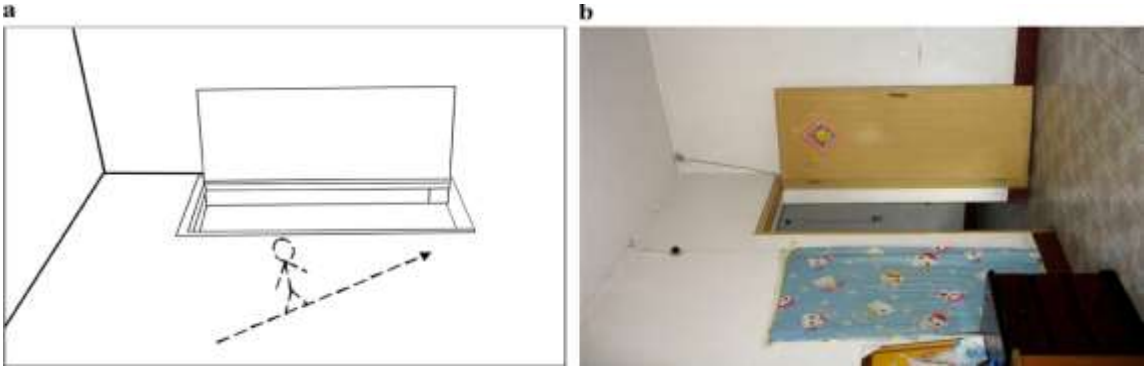


**Figure 1| Dream caused by the scene in reality. (a)** The scene of dream. **(b)** The scene in reality (when lying on my right side facing the door). In the daytime, I slept with eyes open by sticky tape, accompanied with rhythmic tapping on the desk nearby. With eyes opened, the scene in reality was reflected in dream. In the dream, I felt I was in a room, and a staircase with an open cover was in sight. At the same time, I heard some strange footsteps climbing up the stairs and felt that a stranger was entering my room (see the figure 1a). I was frightened and felt in danger. When I suddenly awoke from my sleep, the open door of bed room was in sight (see the figure 1b), and the tapping on the desk was heard.
It is clear that the staircase with the open cover in dream correlated with the open door in reality, because their figures looked so similar; the footsteps heard climbing up stairs was associated with the tapping on desk, for their frequencies were the same. The dream suggested that we are never completely isolated from outside world during sleep, as in waking, our brains are still receiving and processing various kinds of information. This is consistent with the notion that dreams are similar to waking mental experiences in essence. However the brain may not be fully active during sleep, and only functions partially. This half-working state of the sleeping brain causes confusion in information processing, and then leads to bizarre dream contents.

We found that there is a link between dream and reality, which allows us to observe dream directly. This is a typical dream with a vivid plot and intense emotion, which I have never experienced in reality. Obviously, this dream is neither the disguise of unconscious wishes nor the interpretation of random neural signals, but rather the result of the brain receiving and processing information during sleep, similar to mental experiences that occur when one is awake. Also it clearly revealed the inaccuracy in information processing when stimuli were applied during sleep. The effect of pre-sleep experience upon dream content also demonstrated the inaccuracy in information processing when the brain processed memory information during sleep (Fig. 2). Other studies about dreams have also found that various kinds of stimuli can be processed during sleep.[7-10] A water spray on skin is the stimulus most often

Copyright 2018 KEI Journals. All Rights Reserved 

used, which can be frequently incorporated into dreams. In the experiment, subjects in sleep still received the information that some liquid dropped on their faces, and perceived that the liquid drops were cold. The brain still knew that the liquid was water even when sleeping. When awakened, most subjects reported that their dream contents were water-related events. Sounds and other stimuli given during sleep were found to be processed to some extent as well. However, dream contents of subjects in the same group varied greatly, and some bared no relation to the corresponding stimulus. This demonstrates that information was received and processed, but information processing is error-prone during sleep.

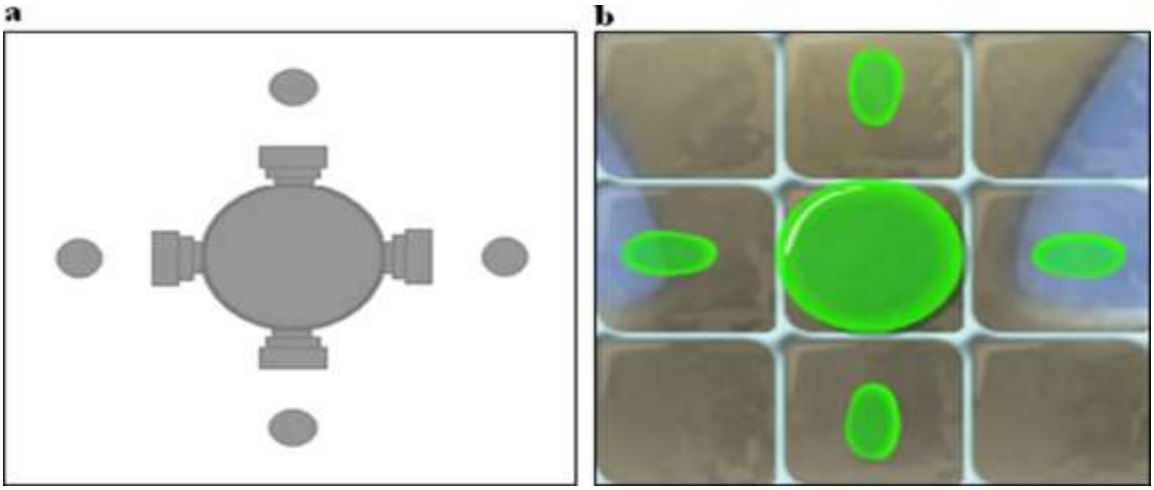


**Figure 2| Dream caused by pre-sleep stimulation. a,** Dream content associated with the game. **b,** The game Puzzle Drops performed before sleep. There was some difference between the game and dream content, though the correspondence between their figures indicated the game Puzzle Drops as the source in the dream. It demonstrated that the dream was the result of the sleeping brain trying, but failing, to process memory information. During sleep, the brain was still processing information about the game Puzzle Drops performed before sleep. However, the sleeping brain was unable to do this correctly, and then confusion in information processing caused the difference between dream content and reality.

My dreams showed that consciousness generation is not directly dependent on the received information but rather on the information processing. Only accurate information processing can generate consciousness consistent with reality; whereas inaccurate information processing can generate consciousness completely opposite to reality. The brain is efficient and accurate in waking life, but it is error-prone during sleep and cannot even accurately recognize the most common things in daily life. This suggested that the brain in sleep is only partially active and with incomplete functioning. This half-working state of the brain influences its information processing ability, which results in confused

Copyright 2018 KEI Journals. All Rights Reserved 

information processing and generates bizarre dream contents. This is why dreams are always weird and illogical. Consequently, dreams can be presented as a kind of mental disorder that occurs in the sleeping brain with limited ability.

The functioning of brain is not absolutely accurate or flawless, and it is possible that limited information processing ability may happen in waking life. When there is any confusion in information processing, mental states that are similar to dreams may happen in waking state. It can be imaged that if there is horrific imagery in mind when I am awake, which is evoked merely by common daily things, just like fig.1. I must have suffered from mental disorders. It is also interesting that many kinds of psychotic patients' waking consciousness is remarkably similar to their dreams including bizarre imagery, delusional belief that one is awake, lack of self-reflective awareness, orientational instability, intense emotions and poor memory. This suggested that some mental illnesses are similar in essence to dreams. Both of these mental states may be caused by the limited information-processing ability of the brain and so it seems likely that these patients 'dream' while awake. But in waking state, they can take action based on confused judgments, and they are often driven by intense emotions such as fear or anger, which may result in serious harms. Therefore, the half-working state of brain, which creates dreams, may also provide some valuable information to understand mental disorders of the waking brain.

## The meaning or biological function of dreams

Most dreams are so weird and have not been experienced in waking life that many people often believe dreams may reveal certain meaningful but hidden truths. Furthermore, dreams are often thought to be figurative, especially in terms of metaphors, metonymies and conceptual blends. In order to determine the hidden symbolic meaning of dreams, dream interpretations have been arbitrarily developed throughout recorded history. In addition, many theories about function of dreams have been proposed, most of which focused on the adaptive function of dreams in the evolution of our physical and psychological health, or the role in learning and memory consolidation.[30-41] While some researchers suggested that dreams serve no real purpose.[4,6] No single consensus emerged.

Dreams are the result of the sleeping brain trying, but failing, to process information, and dream contents are generated by confusion in information processing. Moreover, it is impossible to know the original information that evoked dream contents. Therefore, any analysis of the hidden symbolic meaning of dream contents is meaningless. Also there is no reason to confer any biological function on dreams even if some dreams may have inspired scientific creations or works of art. Nevertheless, dreams are based primarily on recent concerns and experiences stored in memory. Therefore, dream contents can reflect the dreamers' emotions,

Copyright 2018 KEI Journals. All Rights Reserved 

interests and personalities to some extent, and may carry some psychological meaning.

Why then do we dream? Humans are vulnerable during sleep, especially in ancient times when there was no stable housing for protection. The brain maintains certain activities and functioning during 'deep rest' and still receives and processes information. Thus, I have dreams and I could perceive the danger of someone breaking into my room, which awakened me from my sleep. Of course, I do not need to treat it as a danger and interrupt my sleep. However, if I would have no dream, it means that the brain cannot try to receive and process information during sleep. It would be difficult for me to perceive the danger if someone did break into my room when I was sleeping. Therefore, dreams are nothing more than the product of the brain retaining partial activity and functioning during sleep. This half-working state of the sleeping brain, which creates dreams, may serve an adaptive function. Our brains partially shut down during sleep to get rest. However, they are still trying to receive and process all kinds of information although their abilities are limited. We therefore can be never completely isolated from the outside world and can wake up from sleep when any danger or abnormal condition is perceived. Thus, our brains get rest and recover, while simultaneously retain contact with the surrounding environment to sustain vigilance.

## Conclusion

Both waking and dream consciousness depend on information processing of brain, suggesting that dream consciousness is of the same essence as waking consciousness. Consequently there are many remarkable relations between them. However, information processing of the brain is more error-prone during sleep, and thus dream contents are bizarre and illogical. Here, dreams may be defined as a kind of mental disorders that occurs during sleep. Perhaps, this would provide a new approach to understand some mental illnesses of waking brain.

Throughout all sleep stages, brain activity rises in REM sleep, which is accompanied by an increase of global energy metabolism. During non-REM sleep there is a general decline both in brain activity and energy metabolism.[6,42] The higher the brain activity, the more information is processed and the more intense consciousness is generated. Therefore, dreams are more vivid during REM sleep, and there is an increase in dream recall as well. However, REM sleep is not a necessary prerequisite for dreaming.[3,43] If dreaming is simply thought to be information processing that occurs during sleep, it can be inferred that we dream throughout sleep time. Depending on the different brain activity that occurs during different sleep stages, we might have vivid dreams, thought-like dreams, or 'other dreams' which contain not enough intense consciousness and cannot be perceived or remembered. It can also be inferred that animals can dream as we

Copyright 2018 KEI Journals. All Rights Reserved 

do, because they need sleep and their brains also process information. Some animals may even have vivid dreams, because many types of animals experience REM sleep.

Dreams are universal and may carry some psychological meaning, but dreams cannot have any hidden symbolic meaning and no biological function can be scientifically conferred on them. However, the half-working state of the brain, which creates dreams, is important for sleep. During 'deep rest', the brain still perceives all kinds of information to sustain vigilance. This brain state would be more important for animals because they face more dangers during sleep than humans. Therefore, the half-working state of the sleeping brain may serve an evolutionary and adaptive function.

## Declarations

The authors declare that they have no competing interests.

Copyright 2018 KEI Journals. All Rights Reserved 

## References

1. Freud S. The Interpretation of Dreams. New York, Basic Books; 1900.

2. Hobson JA, McCarley RW. The brain as a dream state generator: an activation-synthesis hypothesis of the dream process. Am. J. Psychiatory 1977;134:1335–48.

3. Domhoff GW. Drawing theoretical implications from descriptive empirical findings on dream content. Dreaming 1999;9:201–10.

4. Domhoff GW. The misinterpretation of dreams. American Scientist 2000;88:175–8.

5. Foulkes D. Children's dreaming and the development of consciousness. London: Harvard University Press; 1999.

6. Foulkes D. Dream research: 1953-1993. Sleep 1996;19:609-24.

7. Atienza M, Cantero JL, Escera C. Auditory information processing during human sleep as revealed by event-related brain potentials. Clinical Neurophysiology 2001;112:2031–45.

8. Dement W, Wolpert EA. The relation of eye movements, body motility, and external stimuli to dream content. J Exp Psychol 1958;55:543–53.

9. Koulack D. Effects of somatosensory stimulation on dream content. Arch Gen Psychiatry 1969;20:718–25.

10. Portas CM, Krakow K, Allen P, et al. Auditory processing across the sleep–wake cycle: Simultaneous EEG and fMRI monitoring in humans. Neuron 2000;28:991–9.

11. Nielsen TA, Stenstrom P. What are the memory sources of dreaming? Nature 2005;437:1286-9.

12. Fosse MJ, Fosse R, Hobson JA, Stickgold RJ. Dreaming and episodic memory: a functional dissociation? J. Cogn. Neurosci 2003;15:1–9.

13. Domhoff GW. Finding Meaning in Dreams: A Quantitative Approach. New York: Plenum Publishing Co; 1996.

14. Howe JB, Blick K. Emotional content of dreams recalled by elderly women. Perceptual and Motor Skills 1983;56:31–4.

15. Lortie-Lussier M, Cote L, Vachon J. The consistency and continuity hypotheses revisited through the dreams of women at two periods of their lives. Dreaming 2000;10:67–76.

16. Zepelin H. Age differences in dreams: I. Men's dreams and thematic apperceptive fantasy. International Journal of Aging and Human Development 1980;12:171–86.

17. Hall C, Van de Castle RI. The Content Analysis of Dreams. New York: Appleton-Century-Crofts; 1966.

18. Domhoff GW. The Scientific Study of Dreams: Neural Networks, Cognitive Development, and Content Analysis. Washington, DC: American Psychological Association; 2003.

19. Foulkes D. Dreaming: A Cognitive-Psychological Analysis. New Jersey: Lawrence Erlbaum Associates; 1985.

20. O'Nell C, O'Nell N. A cross-cultural comparison of aggression in dreams: Zapotecs and Americans. International Journal of Social Psychiatry 1977;125:35–41.

21. Hollins M. Styles of mental imagery in blind adults. Neuropsychologia 1985;23:561–6.

Copyright 2018 KEI Journals. All Rights Reserved 

22. Buchel C, Price C, Frackowiak RS, Friston K. Different activation patterns in the visual cortex of late and congenitally blindsubjects. Brain 1998;121:409–19.

23. Casey BJ, Tottenham N, Liston C, Durston S. Imaging the developing brain: what have we learned about cognitive development? Trends Cogn Sci 2005;9:104–10.

24. Kerr NH, Foulkes D. Right hemispheric mediation of dream visualization: a case study. Cortex 1981;17:603–9.

25. Solms M. The Neuropsychology of Dreams: A Clinico-Anatomical Study. New Jersey: Lawrence Erlbaum Associates; 1997.

26. Kerr NH, Foulkes D, Jurkovic GJ. Reported absence of visual dream imagery in a normally sighted subject with Turner's syndrome. Journal of Mental Imagery 1978;2:247–64.

27. Schwartz S, Maquet P. Sleep imaging and the neuropsychological assessment of dreams. Trends in Cognitive Sciences 2002;6:23-30.

28. Solms M. Dreaming and REM sleep are controlled by different brain mechanisms. Behav Brain Sci 2000;23:843–50.

29. Bridge H, Harrold S, Holmes EA, Stokes M, Kennard C. Vivid visual mental imagery in the absence of the primary visual cortex. J Neurol 2012;259:1062–70.

30. Revonsuo A. The reinterpretation of dreams: An evolutionary hypothesis of the function of dreaming. Behavioral and Brain Sciences 2000;23:877–901.

31. Crick F, Mitchison G. The function of dream sleep. Nature 1983;304:111–4.

32. Cipolli C, Fagioli I, Mazzetti M, Tuozzi G. Incorporation of pre-sleep stimuli into dream contents: Evidence for a consolidation effect on declarative knowledge during REM sleep? Journal of Sleep Research 2004;13:317–26.

33. Schwartz S. Life goes on in dreams. Sleep 2010;33:15–16.

34. Wamsley EJ, Tucker M, Payne JD, Benavides JA, Stickgold R. Dreaming of a learning task is associated with enhanced sleep-dependent memory consolidation. Current Biology 2010;20:850–5.

35. Diekelmann S, Born J. The memory function of sleep. Nature Reviews Neuroscience 2010;11:114–26.

36. Stickgold R, Hobson JA, Fosse R, Fosse M. Sleep, learning, and dreams: Off-line memory reprocessing. Science 2001;294:1052–7.

37. Valli K, Revonsuo A, Palkas O, et al. The threat simulation theory of the evolutionary function of dreaming: Evidence from dreams of traumatized children. Consciousness and Cognition 2005;14:188–218.

38. Frank MG, Benington JH. The role of sleep in memory consolidation and brain plasticity: Dream or reality? Neuroscientist 2006;12:477–88.

39. Franklin MS, Zyphur MJ. The role of dreams in the evolution of the human mind. Evolutionary Psychology 2005;3:59–78.

40. Greenberg R, Pearlman C, Fingar R, Kantrowitz J, Kawliche S. The effects of dream deprivation: Implications for a theory of the psychological function of dreaming. British Journal of Medical Psychology 1970;43:1–11.

Copyright 2018 KEI Journals. All Rights Reserved 

41. Nielsen TA, Levin R. Nightmares: A new neurocognitive model. Sleep Medicine Reviews 2007;11:295–310.

42. Maquet P. Functional neuroimaging of normal human sleep by positron emission tomography. J Sleep Res 2000;9:207–31.

43. Foulkes, D. Dream reports from different stages of sleep. Journal of Abnormal and Social Psychology 1962;65:14–25.

Copyright 2018 KEI Journals. All Rights Reserved 