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Diagnostic Possibilities of Dream Analysis: Theoretical Background and Methodological Approaches

Zinaida I. Berezina[1], **Oleg I. Kit**[2], **Ekaterina F. Komarova**[1,2], **Yulia Yu. Arapova**[1*], **Tatiana P. Protasova**[1]

[1] Rostov State Medical University, Rostov-on-Don, Russian Federation
[2] National medical research centre for oncology, Rostov-on-Don, Russian Federation
* Correspondent author: to.juli.arapova@gmail.com

Abstract

Introduction. Violation of some cognitive functions and general mental state after massive treatment makes it difficult to use generally accepted survey methods for the diagnosis of neurological and psychological status during rehabilitation. In this regard, the analysis of dreams seems to be an actual method, which, according to modern research, makes it possible to identify violations of the psychological and somatic state of patients at the early stages and make a forecast about their recovery. **Theoretical justification**. The possibility of using dream analysis as a diagnostic method is based on modern ideas about the neurophysiological and mental mechanisms of dreaming. Different author notes changes in dream activity while neurological, mental and somatic diseases. More and more researchers agree that dreams can be harbingers, a kind of «signal system» of emerging somatic, neurological and mental disorders. Clinical and diagnostic analysis of dreams in neurotic disorders revealed their features both in different variants of neuroses and at all stages of the disease – from compensation to decompensation. The existence of a relationship between dream images and a predisposition to anxiety, depression and asthenia has been established. **Discussion**. Existing scientific research suggests the possibility of using dream analysis as an early diagnosis of neurotic conditions and somatic pathologies, the clinical symptoms of which have not yet manifested themselves symptomatically but already appear in dreams. The article provides a literature review on modern concepts of neurophysiological and mental mechanisms of dreams and the possibilities of using the results of their analysis as a diagnostic model are indicated.

Keywords: dream activity, mental activity, diagnostic, neurotic states, somatic disorders, visceral theory of sleep, REM sleep

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Introduction

Sleep with dreams is a unique and greatest mystery for science, a kind of third state, separate from ordinary sleep and different from wakefulness (Kovalzon, 2021). All the data obtained at the moment confirm that rapid sleep differs from slow-wave sleep and wakefulness not only by neurophysiological mechanisms of its launch and maintenance but also by the presence of a special type of mental activity - dreams.

Dreams are also present in slow-wave sleep but in a significantly weakened form (Siclari et al., 2017; Fazekas & Nemeth, 2018; Frohlich, Toker & Monti, 2021). Thus, upon awakening from a shallow slow-wave sleep, 80–90% of the surveyed people report dreams, which, as a rule, are vivid hallucinatory experiences – the so-called hypnagogic hallucinations. Unlike dreams, hypnagogic hallucinations are static, do not contain their own plot (Kelmanson, 2018; Siclari & Tononi, 2017), and their content may be influenced by events preceding sleep (Stickgold, 2013; Picard-Deland, Pastor, Solomonova, Paquette & Nielsen, 2020; Picard-Deland, Allaire & Nielsen, 2022). There are quite a few reports of dreams received upon awakening from deep sleep (Stickgold, 2013; Chambers, 2017). These dreams are qualitatively different from those in rapid sleep: they are usually shorter, less vivid and more conceptual, contain few scenes with movement, are more controlled and believable, and less emotional (Fazekas & Nemeth, 2020; Sikka, Valli, Revonsuo & Tuominen, 2021; Ghrouz et al., 2019). Despite numerous studies indicating the presence of dreams in both slow and rapid sleep, an increasing number of scientists tend to believe that dreams are inherent only in REM sleep, and during slow-wave sleep, there is somehow a «reflection» or «introduction» of mental activity from REM sleep (Fagioli, 2002; Fazekas & Nemeth, 2020; Yu et al., 2022).

Study purpose

In accordance with the above, the article aims to review studies devoted to the research of neurophysiological and mental mechanisms of dreams and the possibility of using dream analysis in various diseases, such as neurological, somatic and oncological.

Theoretical justification

Neurophysiological mechanisms of dream activity

Dreams are a reflection of personality, individual experience and creative potential. Dreams have their own plot and characters and include all categories typical of wakefulness (familiar faces, places, situations, and objects) (Nir & Tononi, 2010; Konkoly et al., 2021; Vanek et al., 2020) and can also reflect the worries and experiences of the day (Voss & Klimke, 2018; Samson-Daoust, Julien, Beaulieu-Prévost & Zadra, 2019; Martinec, Miletínová, Kliková & Bušková, 2021). As a rule, reflexive thinking prevails in a dream: a person asleep can easily accept the unreality of images and events (which is reflected in such phenomena as flying in a dream, inconsistent changes of scenes, and the presence of unreal fantasy objects) (Avakumov, 2009), disorientation, lack of a sense of time and perception of their sometimes-altered personality. Dreams may contain elements of sensory perception of different modalities (for example, colour perception, sounds, tactile sensations, smells and tastes, and feelings of pleasure or pain) (Kraehenmann, 2017; Johnson, Hendricks, Barrett & Griffiths, 2019). Dreams are not realized contextually, and a person asleep is not aware of themselves either awake or asleep, while the uniformity of the thought process and changing images is noted (Hong, Fallon, Friston & Harris, 2018; Konkoly et al., 2021).

Recent studies of the brain using modern neuroimaging techniques have shown that dreams are associated with physiological indicators and brain activity during sleep. In a dream, the person asleep can see and feel how they make movements, even if they cannot move while awake, while the brain structures responsible for these movements in wakefulness are activated. Thus, patients with congenital paraplegia dream of walking, and phantom limb pain may disappear (Siclari, Valli & Arnulf, 2020).

The paradox of REM sleep is that, despite the high activation of the brain, similar to its activity in wakefulness (Sikkens, Bosman & Olcese, 2019; Tivadar, Knight & Tzovara, 2021; Kovalzon, 2021), and a comparable level of metabolism (Zhou et al., 2019; Hoel, 2021; Rué-Queralt et al., 2021; Luczak & Kubo, 2022), in rapid sleep the body is completely paralyzed due to deep inhibition of the spinal cord (Stettner, Lei, Benincasa & Kubin, 2013; O'Malley & Datta, 2013; Kovalzon, 2021). It is noteworthy that in rapid sleep, the person asleep cannot move, as in slow-wave sleep, they lose connectivity to the world: the person asleep does not see, hear or feel anything; moreover, stimuli not only do not cause behavioural reactions but also do not affect the content of dreams (Nir & Tononi, 2010; Gent et al., 2018; Aime et al., 2022).

The lack of communication with the environment during sleep is associated with a change in the activity of the default system, which, along with the sensorimotor and visual cortex, is a likely correlate of dreams (Domhoff & Fox, 2015; Vallat, Nicolas & Ruby 2022). The results of PET and MRI studies have shown that the medial prefrontal cortex - part of the default system - is more active in the rapid sleep phase than in the state of calm wakefulness (Hong et al., 2018; Scarpelli, Bartolacci, D'Atri, Gorgoni & De Gennaro, 2021; Hong et al., 2021), but at the same time, the activity of other structures of the default system (cingulate gyrus, parietal cortex) decreases during REM sleep (Miyauchi et al., 2009; Hong et al., 2018; Hoel, 2021; Rué-Queralt et al., 2021).

Speaking about the neurophysiological mechanisms of dreams, it is impossible not to mention the pioneering work of the British neuropsychologist Mark Solms. When analyzing the dreams of 361 patients with neurological disorders, data were obtained, based on which he showed that the nature of dreams varies depending on the localization of lesions in the forebrain and not in its axis, where, according to most researchers, the main generator of REM sleep is located (Solms, 1997). In most cases, with a unilateral lesion of the parieto-temporo-occipital region of the brain, there is a complete absence of dream activity (Zou et al., 2018; Vallat et al., 2020), which Mark Solms associated with the loss of some cognitive abilities, including the ability to create visual images. Studying patients who underwent leukotomy (cutting of dopamine pathways leading to the frontal cortex in order to weaken hallucinations in psychoses and some epileptic seizures), Mark Solms found that they lose the ability to purposeful behaviour, lose the ability to fantasize and dream while maintaining REM sleep generation (Solms, 2000).

Other researchers have also found that the loss of the ability to dream is noted in patients with damage to areas of the brain that provide visual perception of colour and movement of objects (Solms, 2000). In other cases, patients with lesions of such brain structures as the medial prefrontal cortex, and anterior cingulate gyrus, on the contrary, have an increase in the frequency and brightness of dreams and even their intrusion into wakefulness (Solms, 1997).

From the data obtained, M. Solms concluded that dreams have a complex nature and are carried out with the participation of forebrain structures associated with thinking, memory and emotions; in health, dreams are «triggered» by REM sleep and, apparently, while pathological brain disorders, they can occur outside this phase.

Mental mechanisms in REM sleep

Despite some similarity of the events experienced in a dream with reality, the dreamer's volitional activity and arbitrary control over themselves and the events taking place decreases (Nir & Tononi, 2010). The lack of self-control during sleep may be associated with a decreased activity of brain regions such as the inferior parietal, orbitofrontal, dorsolateral and prefrontal cortex (Van De Poll & van Swinderen, 2021; Vertes & Linley, 2021). Indeed, it has been shown that a decrease in activity in the prefrontal cortex during sensory perception in wakefulness was accompanied by a decreased self-awareness (Yang & Lewis, 2021; Kim et al., 2022).

Mental activity in REM sleep differs from mental activity in other states (for example, slow-wave sleep and wakefulness) by strong emotional colouring and extreme brain activity and when experiencing severe emotional stress (Kovalzon, 2021). Studies using neuroimaging techniques have shown that the processes regulating dreams and emotional significance have the same neural substrates that control emotions during wakefulness (Scarpelli et al., 2019; Sikka et al., 2022; Barbeau, Turpin, Lafrenière, Campbell & De Koninck, 2022). So, feelings of joy, surprise, anger, fear and anxiety are experienced in a dream. At the same time, it is believed that sadness, guilt and depressive affects are rare, possibly due to a decrease in self-reflection in sleep (Vandekerckhove & Wang, 2017; Palmer & Alfano, 2017; Witvliet, Blank & Gall, 2022). During dreams in rapid sleep, anxiety and fear can manifest themselves to a greater extent than in wakefulness, which is explained by the activation of limbic and paralimbic structures, the amygdala, anterior cingulate gyrus and insula (Sikka et al., 2019; Lai et al., 2020) – structures responsible for these emotions in wakefulness. According to the degree of manifestation of emotions, dreams vary from positive (joy, happiness, inspiration, etc.) to negative (fear, despair, anger, etc.), and 25-35% of reports about dreams are emotionally neutral (Fosse, Stickgold & Hobson, 2001; Matei, Bergel, Pezet & Tanter, 2022).

The peculiarity of dreams is also that at this time the mechanisms of extracting 'old' memories from memory are actively working, however, the mechanism of memorization is suppressed and only a small part of dreams is recalled upon awakening (Naiman, 2017; Kovalzon, 2021). The reason for this phenomenon probably lies in the fact that during REM sleep, the medial limbic region of the temporal lobe, which is involved in memory processes, is largely active, and in the processes of forgetting dreams, the hypoactivity of the prefrontal cortex of the brain is noted (Nir & Tononi, 2010; De Gennaro, Marzano, Cipolli & Ferrara, 2012; Wamsley, 2020).

V. M. Kovalzon says: «We need dreams not to remember them» (Kovalzon, 2021, p. 181). The existing modern theories of dreams offer different mechanisms for forgetting dreams. So, according to the psychodynamic model of Z. Freud and M. Solms, this process is based on the process of active displacement (Freud, 2021). In Hobson's three-dimensional model, dream forgetting is associated with a change in the state caused by a decrease in the activity of monoaminergic systems ('aminergic demodulation') and a decrease in the activity of the dorsolateral prefrontal cortex (Hobson, Pace-Schott, & Stickgold, 2000; Parrino et al., 2022). The neurocognitive model, founded by W. Domhoff and K. Hall, states that dreams are usually forgotten since the internal dream narrative is often contextually unrelated to events and objects in wakefulness (Wamsley, 2013; Domhoff & Fox, 2015; Alcaro & Carta, 2019).

Information processing in SWS and REM sleep

During both SWS and REM sleep, signals from sensory systems to the cerebral cortex cease to

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flow, information processing in the thalamocortical system, which is the principle of higher mental functions, drops (Hill & Tononi, 2005; Kovalzon, 2021; Steriade, 2003). At that time, intercortical interactions decrease (Bhattacharya, Patterson, Galluppi, Durrant & Furber, 2014; Rao, Cecchi & Kaplan, 2015), and there are functional rearrangements of interhemispheric relations (Liu et al., 2018; Zhu et al., 2020; Arbune et al., 2020).

Experiments of Ivan Nikolaevich Pigarev, a Russian researcher, showed that during SWS, cortical neurons reach a state of depolarization, followed by inhibition or hyperpolarization. According to his visceral theory of sleep, the afferent flow to the cerebral cortex does not stop during sleep, but its sources change: instead of exteroceptive and proprioceptive information, interoceptive information about the state of all visceral systems of the body is transmitted along the same pathways (Pigarev, 2013; Pigarev & Pigareva, 2018; Pigarev, Pigareva, 2018; Pigarev, Pigareva, Levichkina, 2019). In his opinion, visceral systems have no representation in the human mind, therefore, information about the physical state of organs and tissues is not realized, but passes into structures connected with associative visceral regulation (Pigarev, 2013; Pigarev, Pigareva, 2018). Many visceral organs have rhythmic activity, and during sleep, heartbeats, respiration, and peristaltic activity of the stomach and intestine, create a constant afferent flow to the cerebral cortex, and its rhythm stops in REM sleep (Pigarev, Pigareva, 2018).

According to Ivan Nikolaevich Pigarev (Pigarev & Pigareva, 2014; Pigarev & Pigareva, 2017), the cause of dream pathologies (nightmares, obsessive dreams, and others) lies in the fact that the system that blocks consciousness during sleep remains incompletely closed during REM sleep for a long period of time. Therefore, the excitation coming from the cortex and reflecting the result of the visceral information analysis can "activate" the images formed in wakefulness and start the development of fantastic plots through associative links in the consciousness system. It is possible that stronger impulses coming from any organ suppress other afferent flows, and further transform into dreams associated with this organ (Berezina, 2015).

Ivan Nikolaevich Pigarev's visceral theory of sleep, not being alone in the field, does not contradict modern ideas on the same issue. Meanwhile, in a sense, this theory can serve as a scientific basis for developing a direction specialized in the early diagnosis of the disorders or their dynamics according to the nature of the development and the course of dreaming activity.

According to modern ideas about the neurophysiological and mental mechanisms underlying the dream activity, dreams are not only a reflection of the human mental health, but also of the somatic state, including both general and individual states of organs and systems.

Results

According to the World Health Organization, about 30–40% of sleep disorders are indicators of neurological and mental diseases (Aleksandrovsky, 2000; Avakumov, 2009). Sleep pathology, along with autonomic regulation, general sensitivity, and activity disorders, is one of the earliest and most stable signs of a mental disorder. Patients note an increase in the frequency of dreams, the appearance of unusually vivid dreams; less often a loss of the ability to dream is observed (Kalinchuk, Antsyborov, 2020; Nigam et al., 2021). Moreover, the work of T. A. Sviridchenkova (2013) shows the relationship between dream images and a predisposition to such neurotic states as anxiety, neurotic depression, and asthenia. It allows one to consider the possibility of using dream analysis as a preliminary diagnosis of neurotic states whose clinical symptoms have not yet manifested in wakefulness.

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Dream activity in neurological disorders

Sleep disorders, quantitative and qualitative changes in dreams, are recognized as one of the consistent symptoms of neurotic states (Wayne, Hecht, 1989, Karvasarsky, 1990; Kalsched, 2017; de Cortiñas, 2013).

Clinical diagnostic analysis of dreams in neurotic disorders in children and adolescents, performed by E. A. Korabelnikova (Golubev, Korabelnikova, 1996; Korabelnikova, Golubev, 2000), identified its features in different types of neurosis compared to healthy peers.

Compared to healthy patients, in the compensation stage, in patients with neuroses, a positive affect was less observed after awakening after dreams. They showed a higher frequency of negative emotions in dreams, a prolonged retention of dreams in memory, and their incompleteness. The phenomenon of lucid dreaming (dreams within dreams) was observed more often.

In the stage of subcompensation of a neurotic disease, dream activity intensifies: dreams became obsessive and painful for the patient, awakenings were often accompanied by a feeling of relief; and the frequency of feelings of fright, fear, anxiety, and aggressive manifestations appearing in dreams increased, as well as the perception of individual colours (channelling of colour perception) (Korabelnikova, Golubev, 2000).

In the decompensation stage, the intensification of dreams was replaced by the oppression (low frequency, rare connection between awakenings and dreams). The authors associate the fact that lucid dreaming occurs in the early stages of a disease and disappears in the stage of exacerbation of a neurotic disorder with the adaptive mechanisms of dreams (Korabelnikova, Golubev, 2000). In their opinion, the phenomenon of lucid dreaming contributes to the elimination of the neurotic effect on the psyche created by dreams themselves. This is confirmed by the feeling of relief that occurs during the transition from dreaming to wakefulness at the stages of compensation and subcompensation in patients. Patients in the stage of decompensation likely have no distinction between sensations and experiences associated with a dream and an emotional state in wakefulness.

Dream activity in somatic diseases

Changes in dream activity are observed in somatic diseases as well: patients have difficulty falling asleep, they experience frequent night awakenings, there are complaints of emotional dreams and nightmares (Kalinchuk, Antsyborov, 2020). Cardiovascular patients often have nightmares. Upon awakening, they often experience fear of death, which may be the result of impaired blood circulation to the brain during sleep. With obesity, respiratory diseases, patients often dream scenes of suffocation, there is a feeling described as “stone on the chest” (Zhuchkov, Timoshenko, 2019; Berezina, 2015). Patients suffering from migraine are more likely to experience a feeling of fear and suffering during sleep (DeAngeli et al., 2014). They often have dreams in which they can taste and smell, which may reflect the special sensitivity of taste and olfactory analyzers in this disease (Lovati et al., 2014).

Dreaming about a disease can be a preliminary step towards the onset of its symptoms. The study by Burk et al. (Burk, Wehner, Soo, 2020), carried out in 163 women with suspected breast cancer, has shown that 64% of the respondents remember their dreams and 5,5% of the women dreamed of the word “cancer” before the appearance symptoms and diagnosis.

Dreams as harbingers of illness

Currently, the prevention of neurological and somatic diseases is complex and difficult to implement, as the mechanisms of their occurrence and course are still unclear, and technologies and methods for early diagnosis have not been developed (Pyatin et al., 2021). More and more researchers are coming to the conclusion that dreams can be harbingers, somewhat a "signal system" of somatic, neurological, and mental disorders (Pichugina et al., 2017).

The only limitation of using dream activity analysis as an objective tool lies in the fact that dreams are mental activities that occur during sleep. This makes them difficult to study through scientific observation and experiment.

Information about a dream can only be obtained from a subjective report, which has a number of disadvantages: upon awakening, memories of a dream may be preserved to varying degrees or completely absent, the subject can make adjustments to the plot of the dream in order to hide their personal experiences or immoral, aggressive scenes, which may receive a negative assessment from the other person, and the last is the difficulty to verbalize experiences, which in a dream are more often visual and emotional in nature. Therefore, most modern research is aimed at studying the general neurophysiological mechanisms of dreams without considering their content. K. Bulkeley (2017) identifies three promising directions in the study of dreams: neurobiological studies of the activity of the brain-mind system during sleep (for example, in lucid dreams); systematic analysis of large collections of dream reports from different groups of people; and psychotherapeutic studies of the "personal" component woven into dreams of each person.

Discussion

There is still no consensus on the nature and purpose of dreams. Several theories claim that dreams are an accidental byproduct of rapid sleep and do not serve any natural function. However, dreams appear organized and selective. As practice shows, their form and content are not random. They reflect not only the mental state, but also the somatic state of the body. During dreams, the brain constructs a complex model of the world in which some elements are underrepresented, while others are excessive, compared to wakefulness. During dreams, an encounter with the "self" occurs (Shkuratov, 2014).

The content of dreams is constantly modulated by the events of awakening. As A. Revonsuo (Revonsuo, 2001) suggests, it is modulated by events of threatening nature with subsequent processing of threat perception and its avoidance. Therefore, dream activity is closely related to both the mental and physical state of a person. Despite the obvious limitations of using dreams as a diagnostic model, there are objective models that determine the relationship of dreams with the somatic state of the body. This indicates the prospects for the use of dream analysis in cases with patients of various disease profiles, including oncological patients who have undergone massive treatment.

Patients with malignancies are a complex category in dire need of both physical and psychological rehabilitation. However, due to impaired cognitive functions, their general mental state, it is sometimes difficult or impossible to use universally accepted questionnaire methods to diagnose their physical, neurological and psychological status. The use of dream analysis in oncological patients at the stages of rehabilitation can provide additional data on the dynamics of both neurological functions and the psychosomatic state. This data is necessary for clarification the diagnosis and corrections to the ongoing rehabilitation measures.

Conclusion

Thus, dream activity has a close relationship with both the mental and physical state of a person. Dreams can be harbingers in somatic, neurological and mental disorders. It determines the relevance of using their analysis for the early diagnosis of diseases associated with these disorders. The conclusions obtained on the basis of the results of the dream analysis can be of a recommendatory nature for the diagnostics specification.

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Author Contributions

Zinaida Igorevna Berezina reviewed the content of the article;
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Ekaterina Fedorovna Komarova wrote the theoretical part of the article;
Yulia Yurievna Arapova wrote the theoretical part of the article, worked with references;
Tatiana Panteleevna Protasova worked with references.

Author Information

Zinaida Igorevna Berezina – Dr. Sci. (Psychology), Associate Professor, Vice-Rector of Postgraduate Education; Head of the Department of General and Clinical Psychology, Rostov State Medical University, Rostov-on-Don, Russian Federation; WOS ResearcherID: ABA-9278-2020, SPIN-code: 3859-3932, AuthorID: 280259; ORCID: https://orcid.org/0000-0002-3787-2019, e-mail: fpk_pps@rostgmu.ru

Oleg Ivanovich Kit – Corresponding Member of the Russian Academy of Sciences, Director General of the N.N. Petrov National Medical Research Center of Oncology, Rostov-on-Don, Russian Federation, WOS ResearcherID: U-2241-2017, SPIN-code: 1728-0329, AuthorID: 343182, ORCID: https://orcid.org/0000-0003-3061-6108, e-mail: onko-sekretar@mail.ru

Ekaterina Fedorovna Komarova – Dr. Sci. (Biology), Professor of the Russian Academy of Sciences, Head of the Department of Biomedicine (and Psychophysiology), Dean of the Faculty of Clinical Psychology, Senior Research Scientist, Rostov State Medical University, Rostov-on-Don, Russian Federation, N.N. Petrov National Medical Research Center of Oncology, Rostov-on-Don, Russian Federation, WOS ResearcherID T-4520-2019, SPIN-code: 1094-3139, AuthorID: 348709; ORCID: https://orcid.org/0000-0002-7553-6550, e-mail: katitako@gmail.com

Yulia Yurievna Arapova – Cand. Sci. (Biology), Senior Lecturer of the Department of Biomedicine (and Psychophysiology), Rostov State Medical University, Rostov-on-Don, Russian Federation, WOS Research ID: ABE-5228-2021; SPIN-code: 8454-0547; AuthorID: 208953; ORCID: https://orcid.org/0000-0002-4300-6272; e-mail: to.juli.arapova@gmail.com;

Tatiana Panteleevna Protasova – Cand. Sci. (Biology), Senior Lecturer of the Department of Biomedicine (and Psychophysiology), Rostov State Medical University, Rostov-on-Don, Russian Federation, WOS ResearchID: ABE-7089-2021; SPIN-code: 4542-3581; AuthorID: 760427; ORCID: https://orcid.org/0000-0001-6364-1794; e-mail: protasovatp@yandex.ru

Conflict of interest information

The authors have no conflicts of interest to declare.