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IDEAS & PERSPECTIVES

SEARCH ACTIVITY OR CHAOTIC ACTIVITY IN DREAMS VS. WAKEFULNESS IN ANIMALS AND HUMANS

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Abstract

Search activity in the subsequent wakefulness is restored by the virtual activity in dreams based on the dominating DA brain system and this virtual activity is often chaotic. It is common for humans and animals. At the same time in wakefulness chaotic activity is not protective. It means that in dreams the activity by itself is more important than its belonging to the particular form. What is specific for humans is the polysemantic nature of human dreams based on the right hemisphere type of thinking that is solving the intra-psychic conflicts and overcomes repression as a particular human's type of renunciation of search.

Key words: *dreams; search activity; chaotic activity; right hemisphere*

1. INTRODUCTION

According to the search activity (SA) concept (Rotenberg & Arshavsky, 1979; Rotenberg, 1984; 2009) by search activity is understood activity designed to change the situation in the environment or the subject's attitude to it, in the absence of a definite forecast of the results of such activity, but with constant monitoring of these results at all stages of activity. Without an appropriate monitoring of the outcome of this activity it would be impossible to change a direction of search in the case of its inefficiency. The investigations performed on animals (Rotenberg & Arshavsky, 1979) have shown that search activity increases the subject's resistance to stress and prevents the development of somatic disorders caused by stress, while renunciation of search (that displays itself in the state of giving up and helplessness) decreases the stress resistance and predisposes subject to somatic disorders. It was confirmed in the investigations on humans (see Rotenberg, 2009).

According to the definition of search activity, it is obvious that certain types of behavior even being active do not correspond to search. For instance, stereotyped behavior includes a definite forecast of the results. On the other hand, panic (chaotic) behavior at the first glance may imitate search activity but the outside oriented panic behavior differs from it by the absence of the feedback between the outcome of activity and its regulation. As a result, during the outward oriented chaotic activity its outcome is not considered in a constructive way and cannot be used for the correction of the misdirected behavior. No line of activity can be traced up to its finish and as a result after numerous failures that do not stimulate subject

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to improve the direction of activity chaotic behavior in wakefulness is often displaced by renunciation of search (Rotenberg & Boucsein, 1993) because subject is unable to separate himself from the stable previous experience of failures.

2. CHAOTIC ACTIVITY IN DREAMS

It happens when chaotic activity is oriented outward, on the environment. However, it is one natural and normal mental state that is often characterized by chaotic activity, nevertheless, paradoxically, this mental state is usually not leading to the renunciation of search and giving up but, quite opposite, protects subject from the renunciation of search and restores search activity. This mental state is characterized by dream experience and usually accompanies REM sleep. The discussion of this paradox is the topic of the present article.

My recent review of the search activity concept (Rotenberg, 2009) contains references of articles that suggest most of dreams to be relatively structured with the preserved dreamer's self-control of his/ her behavior in dream (Purcell et al., 1993). According to Snyder (1970) and Vogel (2003) the typical dream of normal subjects is a clear, not bizarre, coherent and detailed account of a realistic situation with understandable content involving the dreamer and other people caught up in ordinary activities and preoccupations, and usually talking about them. Vogel (2003) stressed that most of dreams are vivid but without inappropriate or extraordinary intense emotions. These data are similar to data of Hall and van de Castle (1966), Domhoff (2003), Kahan (2003), who emphasized that dreams are consistent over time, continuous with past and present waking emotional concerns, and that self-reflection, decision-making and meta-attention are available in dreaming. Brain mechanisms responsible for error detection are active during dreams (Solms, 2003). According to Montangero (2003) benefit of dreaming is to maintain cognitive capacities such as encoding perceptions, making decisions, planning actions. All the above mentioned features of dream at least do not contradict the definition of dream as a particular form of search activity, and Mancia (2003) emphasized that dream production is not chaotic.

However, according to many other investigations normal dreams are chaotic (Vertes, Eastman , 2003; Fishbein, 2003). Hunt (2003) proposed that REM sleep state is a prolongation of the orientation response to novelty that starts in wakefulness although with the attenuation of reflective thoughts and volition. Such definition seems to be very close to my definition of chaotic behavior. Hobson et al. (2003) and Conduit et al. (2003) also emphasized that volitional executive attention control is greatly attenuated in dreams, at least in non-lucid dreams, and most dreams are not lucid.

How is it possible to integrate these contradictions? From my point of view it means that dreams may be either chaotic or not chaotic and it does not determine the main function of dream – the restoration of search activity.

The failures in dreams caused by chaotic activity as well as the inability to use these failures as lessons for the subsequent behavior are not dangerous in the virtual reality of dreams, and the process of search, chaotic or not chaotic, is most important.

I am not going to repeat here all arguments for the proposition that prescribes to REM sleep and dreams the main function of the restoration of search activity. These arguments have been already discussed in details in many publications (see for instance Rotenberg, 2009). As it was emphasized there, patients with mental and psychosomatic diseases are characterized by the functional insufficiency of REM sleep, decreased dream reports after awakenings in REM sleep, and this functional insufficiency determines the lack of the restoration of search activity in the subsequent wakefulness and the development of the diseases.

It is important to emphasize that healthy subjects and patients with psychosomatic and mental disorders (depression, anxiety, neurotic disturbances) display different correlations between some variables of dream reports and physiological variables of REM sleep (Rotenberg, 1988). In healthy subjects both eye movement density (EM) and heart rate (HR)

in REM sleep correlate positively with the value of subject's activity in dreams, while positive emotionality in dream reports has no correlation with the objective physiological variables. At the same time in patients subject's activity in dreams correlated only with the heart rate, but not with EM's while EM intensity correlated positively with the positive emotional content of dreams and heart rate correlated negatively. In patients positive emotionality in dreams displays an insignificant tendency to correlate negatively with subject's activity in dreams, and such tendency together with the abovementioned opposite correlations of these psychological features with HR means that in patients activity is at least not accompanied by positive emotional experiences in dreams, and often is accompanied by negative emotions, while in healthy subjects it may be accompanied by any type of emotions.

This difference seems to be very important. I would suggest that in healthy subjects the virtual activity in dreams is pleasant by itself, even if dream events presented after awakenings are estimated by the dreamer as negative. It means that even dreams that contain dangerous and threatening situations (and such dreams appear very often) implicitly include positive emotions related to the subject's activity in dreams, activity by itself, like it happens also in wakefulness in the process of acute struggle with negative events ("agitation of fight"). This struggle can take a form of fight and flight.

It means that it is difficult to speak about pure negative affect in dreams of healthy subjects. My suggestion is based also on data of the domination of the brain monoamine (DA) activity in REM sleep. In healthy subjects wakefulness is characterized by the combination of activity of the noradrenergic (NE), serotoninergic (5-HT), acethylcholinergic (Ach) and dopaminergic (DA) systems. Ach system provides brain with a general predisposition to any type of activity, NE and 5-HT are responsible for partial cortical inhibition, for discrimination between relevant and not-relevant information, for increase of signal-to-noise ratio that makes neuronal activity task oriented and determines the highly structured and organized, non-chaotic activity. For search activity in wakefulness it is especially important. (see Rotenberg, 2009) DA system is very prominent in highly motivated activity, in reward, reinforcement, novelty and sensation seeking, exploratory behavior, attractive aversive behavior – it means, in all types of behavior that are combined with emotional excitement, but in wakefulness it is combined with the high activity of NE and 5-HT systems, that makes the behavior more organized and transforms chaotic activity into search activity.

Being combined with the typical for the REM sleep decrease of NE and 5-HT activity, DA activity predispose subject for the unlimited chaotic search oriented in different directions that is more flexible, less organized and less goal directed than in wakefulness. DA supports the pure pleasure feeling caused by activity itself. This feeling is common for SA and Ch. It corresponds to the statement of Solms (2003) that DA agonists increase the frequency, vivacity and duration of dreaming. Due to the domination of DA system subject in dream is less self-reflective than in wakefulness and less critical to the outcome of his/ her search activity because, as I have already emphasized, these outcomes are not important in the process of the virtual search activity.

Some scientists are using the term "seeking" when they are speaking about the behavior that we are calling "search activity". However they do not discriminate "seeking" with feedback (SA) from "seeking" without feedback (CH). As a result they come to the conclusion that DA system by itself is responsible for "seeking" in general (Panksepp, 1998; Zellner et al., 2011) while in wakefulness it is responsible for search activity only in combination with 5-Ht and NE. As a result these authors come to the conclusion that the process of drug addiction also includes "seeking activity" as a central mechanism. From my point of view search activity is opposite to the hedonic drug addiction that blocks SA because prevents the change of the situation or of the subject himself and his view on the situation.

If search in REM sleep is chaotic, if it starts from the very beginning, from the "clean page", if the process of SA is more important for the REM function than the outcome of this activity, and if failures in dream activity are not critical for REM sleep function until subject is able to change the direction of this activity in a very free way, chaotically, what makes REM

sleep functionally insufficient, as it was shown in patients with mental and psychosomatic disorders (Greenberg,1977, Rotenberg,1988)? I suggest that until the process of chaotic search is still going on, even without the successful achievement of desired outcome (like solving some virtual tasks in dreams), REM sleep as a biological state reminds functionally sufficient. It became insufficient only if the process by itself stops or does not start at all.

3. HOWEVER, HOW IT CAN HAPPEN?

I suppose that there are following reasons: 1. An extremely high emotional tension caused by learned helplessness (when the situation by itself seems to be dangerous for the subject on the real or virtual level) may prevent the appearance of sleep together with REM sleep or cause exaggeration of awakenings from REM sleep thus disturbing its function. 2. If the level of DA activity in REM sleep for some reasons is decreased the chaotic search in REM sleep may be not flexible enough and became frozen. Such deficiency of REM sleep DA function was demonstrated in schizophrenic patients (see Rotenberg, 2008) and it is very possible that the same happens also in other mental and psychosomatic disorders.

These reasons of the inability of REM sleep to perform its compensatory function can be principally relevant both for human and animals. However in natural conditions (not in conditions of the special artificial investigations, not in the condition when subject cannot avoid the punishment dangerous for life) in animals these reasons, especially the first one, have a very low chance to be strong enough to cause REM sleep deficiency. In natural conditions, after animal displays renunciation of search and is unable to continue the goal-directed behavior, it has no reasons to stay in wakefulness. To fall in sleep in this condition is a very natural outcome, of course if animal has already avoided the direct danger for its life and is not suffering from the continuous punishment like it happens in the artificial conditions of experimental learned helplessness.

In contrast to humans who may be stimulated to stay awake by moral and social values, by feeling guilty, by the intention to support his/ her self respect, by worries about the outcome of the present frustration in the far future, by virtual imaginations, and often do not allow themselves to go to sleep – animals are more free to start sleeping in conditions that at that moment are not directly dangerous for survival but do not allow to continue active search, for instance, after numerous failures in the process of goal-directed behavior or in the situation that blocks search activity (for instance, being in the restricted space). Consequently, the chance of REM sleep DA activity to exhaust is very low. REM sleep is a natural biological mechanism predisposed to compensate renunciation of search that periodically appears, and disappears after REM sleep.

4. DREAMS AND IMAGE THINKING

Humans in comparison to animals have an additional feature of dreams that display strong advantages, however this feature may be destroyed more easy than REM sleep features common for animals and humans. It is the polysemantic nature of dream images based on the functions of the frontal lobe of the right hemisphere (see Rotenberg, 1979, 1985, 1993, 2004) .

I suggested in these publications, that the difference between two strategies of thinking related to the frontal functions of the left-and right hemispheres is reduced to opposite modes of organizing the contextual connections between elements of information. Left hemisphere frontal pole so organizes any sign material (whether symbolic or iconic) as to create a strictly ordered and unambiguously understood monosemantic context. The formation of this context requires an active choice from the many real and potential connections between the multiform objects and phenomena of a few definite connections that would facilitate an ordered analysis, building a pragmatically convenient but simplified and

relatively restricted model of reality that includes probability forecasting and cause-and-effect relations.

In contrast, the function of the symmetrical structure of the right hemisphere is the formation of an integral, but ambiguous, polysemantic context, based on a simultaneous capture of an infinite number of connections between objects and phenomena. In such a context, the whole is determined by the interconnections between its elements that interact with each other on many semantic planes simultaneously.

The right frontal lobe produces the much broader net of associations than the left frontal lobe (Chiarello et al., 1990, Chiarello, 1998, Beeman et al., 1994). According to Federmeier and Kutas, 1999, the right hemisphere is integrative and incorporates information directly into the initial context while left hemisphere processing is predictive: new information is compared with the definite expectations.

The advantage of the right frontal lobe strategy of thinking manifests themselves only when the information itself is complex, internally contradictory and basically irreducible to an unambiguous context.

The ability to integrate different experiences and amount of a very broad information from the polydimensional world and to form a polysemantic context helps the subject to avoid unresolved intra-psychic motivational conflicts and to find himself as being integrated into the very complicated world of human interrelationships (Rotenberg, 2004). This integration is the most important feature of the subject's mental health, emotional balance and well being, it is the predisposition to the creativity and the successful adaptation to the environment. Here is the main difference between humans and animals, and it is not surprising that the right frontal lobe is the last structure of the human brain to be matured (Saugstad, 1998), it means, it is the most developed part of the brain.

In my previous publications I have often used dreams as an example of the polysemantic context (see Rotenberg, 2004, 2007). The verbal reports of dreams are usually less impressive and have less subjective meaning than the vivid images of dreams, and not only for those who are listening for these reports, in comparison to the dream viewer, but surprisingly even for the viewer himself. It happens because the impression evoked by dreams is caused by the numerous (and often contradictory) interrelationships between dream images that cannot be comprehensively expressed by the verbal report that is following the rules of the monosemantic context. The crucial role of the right hemisphere in dreams was confirmed by many investigations (see for example Joseph, 1988).

However, it would be an oversimplification to conclude that all dreams experiences are characterized by the domination of the right frontal lobe activity and by polysemantic context. Some investigators are coming to the quite opposite conclusion. Greenberg and Farah (1986), have shown that dreams are characterized by the domination of the left hemisphere. McCornick et al. (1997) have discovered dream reports in REM sleep in right hemispherectomized patients, and dream contents were similar to those in control subjects. These data correspond to data of Hoppe (1977), that split brain subjects are able to report dreams, though more rarely than healthy subjects. Because only a left hemisphere is capable of making a verbal report, it means, that at least some dreams are produced by the left hemisphere that is separated from the right hemisphere.

We have shown in this article that REM dreams may be chaotic or not chaotic, and in both cases they perform their function because to be chaotic or not is less important than to display search activity. However, to be related to the right or left brain hemisphere is not the same for the dream function. Only the polysemantic context created by the right frontal lobe is able to integrate numerous contradictive impressions coming from the polydimensional world, to solve inner contradictions and conflicts, to help subject to feel himself to be integrated in the world, especially in the social world of human relationships. It is the highest human's mental skill and if it is present in dreams it opens a new particular way of search activity – a search for integration and for solving contradictions. This way of search activity is absent in animals, and it is a very important additional adaptive advantage of human dreams.

If for some reasons the access to the polysemantic context is not available, or if the polysemantic context is functionally insufficient (Rotenberg, 2004) dreams may not disappear totally but they lose their special human's advantage and display only the same much more simple search activity that characterizes dreams of animals. In this condition human's dreams became less adaptive. Nevertheless sometimes even in these conditions dreams do not lose their restorative functions, however I suppose only if the tasks in front of the person are not very complicated. In such conditions human dreams can successfully use the same skills as they are using in animals.

Of course, we cannot collect the contents of animal's dreams. However, according to the investigations performed by Jouvet and Delorme, 1965, and Morrison, 1982, it is possible to make some suggestions. When locus coeruleus alpha in the brain stem is artificially destroyed and muscle tone does not drop during REM sleep, animals display in this sleep phase active behavior without awakening as if they participate in their own dreams. This behavior looks out as orienting behavior, or as a fight with a virtual objects, or as a flight from these objects. Thus in any case this behavior contains search activity. It is possible to speculate that animal's dreams represent the direct goal-oriented wish fulfillment, like in wakefulness, however being not restricted by real conditions and obstacles as well as by probability forecast that has to be taken into consideration during wakefulness.

Human dream contents are sometimes also simple enough and represent search activity oriented on the definite wish fulfillment. It happens more often in children although it can happen also in adults. However in adults dreams more often are complicated, and in order to understand their sense and messages it is necessary to perform a high-level professional psychological analysis that takes into consideration numerous relationships between people the dreamer is in contact with, as well as dreamer's general cultural background (something that is absolutely irrelevant in the case of animals), and even after such analysis we can never be sure that our interpretation is correct.

The content of dream is an outcome of a very complicated polydimensional and polysemantic inner world of the dreamer. In contrast to animals that have relationships and confrontations only with the outward world, man has complicated relationships with himself, has inner conflicts between different motives (for instance, egoistic and social, altruistic), and in order to solve these conflicts man needs to use a polysemantic way of thinking produced by the right frontal lobe (Rotenberg, 2004, 2007). Its function during wakefulness may be not sufficient enough for this task due to some problems of its development during onthogenesis. It may be also restricted by the extreme contribution of the left hemispheric logical (monosemantic) way of thinking that often dominates during wakefulness. In dreams this left-hemispheric control can be often avoided and polysemantic way of thinking starts to dominate. It is the additional advantage of human dreams that opens new ways of search for the solutions of inner problems, for integration of the traumatic events by connecting these events with other emotionally related material from the dreamer's life (Hartmann, 1996). Moreover, even the process of search for the solutions of such problems cannot start being not based on the polysemantic manipulation with information. In addition, the activation of the right hemisphere image thinking helps subject to became separated from the conditions that caused renunciation of search, to enter a "new world" where it is possible to start from the very beginning.

I have already mentioned that the domination of the right hemisphere polysemantic way of thinking is not obligate for dreams: after the brain splitting some patients are able to report dreams after awakenings in REM sleep. It means that the left hemisphere is also able to produce dreams that are monosemantic and relatively simple. Consequently, polysemantic manipulation with information is not the only one function of human dreams. Such dreams produced by the left hemisphere can contain search activity, as dreams of animals, and perform its function of the restoration of search activity in wakefulness. However, important features of dreams that help to solve inner conflicts are lost, at least temporary, in such dreams.

Extremely important investigations performed by Grieser et al. (1972) demonstrated the participation of REM sleep (dreams) in the psychological adaptation. It was shown in these investigations that REM sleep deprivation in healthy subjects causes effect opposite to the well-known Zeigarnik effect (see Zeigarnik, 1967). In this investigation subjects were given a series of tasks and they were not allowed to complete some of them. A long time later subjects were asked to recall the content of all these tasks, and investigator found that they remembered best the details of the tasks they had not been allowed to complete.

It is a normal and natural reaction on something that has a personal meaning but was not finished successfully. It is an important mechanism, allowing a person to learn lessons from past experience of failures. It was a failure that stimulated search activity and attention if a failure for the subject does not mean the crash of his/ her self-esteem and Self-Image, and stimulates subject for the farther attempts to seek for the solution of the task. It means that the failure is somehow integrated in the subject's view of the world.

However, after REM sleep deprivation subjects forget exactly those tasks that were not solved (Grieser et al, 1972). It was the outcome of the psychological defense mechanism – repression that protects subject from information that is intolerable for Self-Image. It means that dreams in REM sleep prevent repression that represents by itself the renunciation of search, but a very specific renunciation – the renunciation not only of attempts to realize the actual motives like the motive to overcome obstacles, but also attempts to integrate the emotionally traumatic information in the holistic picture of the world and in Self-Image.

When subject is dealing with the inner motivational conflict it is not enough simply to start a process of search activity in dreams for its restoration in the subsequent wakefulness, as it happens when all obstacles and failures are external for the subject. It is necessary to solve the motivational conflict, at least temporarily and on the virtual level, in order to overcome repression. Plutchik et al. (1979) have shown that repression dominates during passive behavior, and it corresponds with our finding (Rotenberg & Michailov, 1993) that repression correlates with the scale D (depression) of MMPI. After the functionally efficient dreams that help to avoid repression man is ready for the constructive search activity.

Thus, these investigations confirm our concept of REM sleep that compensates renunciation of search, and in addition emphasize a very specific, exclusively human's way of such compensation by integrating the conflicting motivations and information in the virtual domain of dreams.

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