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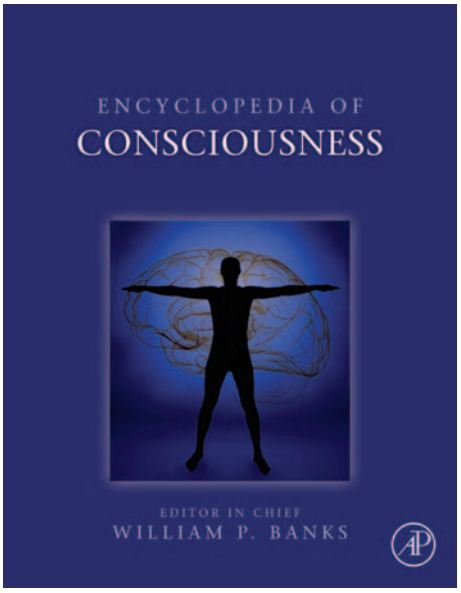

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Sleep: Dreaming Data and Theories

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Glossary

Bizarreness – Dream element that is highly improbable or impossible in waking reality.
Content analysis – Method that can be used to convert qualitative data into quantitative so that data can be expressed in numbers, frequencies, proportions, and statistically analyzed.
Random activation theories – A set of theories stating that dreaming is a random by-product of neurophysiological events taking place during sleep, and that dream content as such has no function.
Recurrent dream – A dream that occurs repetitively and has every time highly similar content or theme.
Reflective consciousness – A form of consciousness that allows us to think about, evaluate, and pass judgments about the contents of phenomenal consciousness.
Threat simulation theory – An evolutionary psychological theory of dreaming that states that the original function of dreaming was to simulate the threatening events of waking life to rehearse threat recognition and avoidance strategies.
Typical dream themes – Themes in dream content that are universal among humans.

Introduction

Sleep is a universal biological necessity all humans share. But what about dreaming? One problem in dream research is that researchers do not even concur on the definition of dreaming. In the 1970s, Frederick Snyder suggested that dreaming refers to the subjective conscious experiences we have during sleep, and consists of complex and organized mental images that show temporal progression or change. To Snyder, dreams were like stories or at least like scenes from a story. Static, simple, and unimodal dream imagery was later distinguished from full-blown dreaming, and referred to as sleep mentation. While these definitions do not state anything about the actual content of dreams, J. Allan Hobson's definition that dreaming is mental activity during sleep with most of the following features present – hallucinations, delusions, narrative structure, hyperemotionality, and bizarreness – emphasizes the qualitative features of dream content. Antti Revonsuo recently suggested that instead of strict definitions and categorizations, we should consider dream phenomena as a continuum. At the one end of the continuum resides full-blown dreaming, defined as complex, organized, temporally progressing, multimodal contents of consciousness during sleep that amount to a simulation of the perceptual world, and at the other end there is sleep mentation, that is, simple contents of consciousness during sleep that show a low degree of complexity and organization.

Another problem faced in dream research is that there is no objective physiological marker for dreaming. Thus, researchers have to rely on subjective reports when they study dreams. Majority of people can remember their dreams, although there is large interindividual variation in dream recall frequency. As Inge Stauch and Barbara Meier have shown, among others, some recall dreams every night, most of us frequently or every now and then, and for others, dream recall is a rare event. Dream recall seems to be highly independent of personality characteristics. Michael Schredl found that the most powerful predictor of recall is a positive attitude toward dreams. Regardless, according to several studies, there are people who state that they have never dreamed. When such people have been studied in a sleep laboratory, and have been woken up from rapid eye

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movement (REM) sleep – the most optimal stage of sleep for dreaming to occur – most can recall at least some dreams, but some do not. Also specific brain damage may obliterate dreaming altogether while REM sleep is preserved. Regardless, we do not know if these people dream or not, only that at least they do not recall their dreams. Consequently, dream recall, as well as the accuracy of recall, is a limiting factor in dream research.

Dreaming Data

Universality of Dream Themes

Numerous laboratory experiments indicate that most people experience dreams every night and several times per night, although not all of these dreams are normally recalled. Not only dreaming as a phenomenon seems to be universal but also the things people around the world dream about share many common themes, independent of the culture the people come from. Typical dream themes are dreams that contain the same general form over and over again across large numbers of people, even though the details of the dream may vary considerably.

In questionnaire studies, people have been presented with a list of various dream themes, and asked: "Have you ever dreamed of. . .?" The most common universal theme is that of being chased or pursued, reported by approximately 80% of dreamers. Being physically attacked or being frozen with fright are also common themes, as is falling from high places, or being on the verge of falling. Being trapped and not able to get out, being lost, or drowning, are also universally dreamed about. Sexual experiences or being naked in public is another well-remembered dream content, and many of us recall dreams about being late, or of school, teachers, or studying. Dreams in which we fly or soar through the air are also remembered by many of us, and in contrast to the previously mentioned themes, these kinds of dreams are usually positive.

Typical Dream Content

Questionnaire studies offer insights into the most common dream themes shared in different cultures, but a more detailed method for studying dream content is called content analysis. In content analysis, detailed dream reports are obtained immediately after awakening. Then, the elements present in dream reports are separated and classified, and specific proportions, frequencies, and percentages of different elements calculated. The pioneers of dream content analysis, Calvin S. Hall and Robert Van de Castle, developed in the 1950s and 1960s a detailed content analysis scale still widely used today, that is, the Hall and Van de Castle system. Their content analysis scale was groundbreaking in empirical dream studies, and since then, many different content analysis scales have been developed for various purposes.

Sensory modalities in dreams

According to studies conducted by, for example, Frederick Snyder, and Inge Strauch and Barbara Meier, all sensory modalities are present in our dreams. All dreams include visual experience, and auditory components are also frequent. Bodily sensations, such as kinaesthesia and touch, are less frequently reported, and smell, taste, and pain experiences are rare but possible. The specific sensory experiences are present in our dreams approximately to the same extent as in our waking reality.

The visual qualities of dream experiences were explored in an ingenious experiment by Allan Rechtschaffen and Cheryl Buchignani in the early 1990s. They had a selection of more than 100 photographs in which the visual features (such as chromaticity, saturation, illumination) had been altered. Immediately after awakening the subjects in a laboratory, the participants selected a photograph that most accurately matched the visual quality of their dream. The most often picked photograph was the one that had not been altered in any way, and the next ones chosen presented only slight variations from normal. Thus, the visual qualities of dreams closely resemble the way we perceive the world while we are awake.

Most, but not all, dreams are perceived in color. Only approximately 20% of dreams lack color, and are perceived achromatically, in black and white. Seeing in black and white every now and then is actually natural, because in low levels of illumination, we only detect shades of grey, not chromatic colors.

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The dream self

An element present in almost every dream is the dream self. Usually, we experience our dreams from the embodied first-person perspective, in a similar fashion that we experience our waking reality. The dream self most often possesses a body-image much like the one we have while awake, and we are positioned in the center of the dream world, actively partaking the dream events. In this respect, the dream self is not all that different from the waking self. Sometimes, however, we can have a camera-like perspective on dream events and observe the dream and even ourselves from a third person's point-of-view.

What is different between the waking self and the dream self are memory lapses, confabulation, and lack of insight into our own deficient cognition. The dream self often has a limited access to his or her autobiographical memory, suffers from transient amnesia, and is disoriented to time and place. While we may remember some facts concerning our lives correctly when dreaming, often we lose the ability to contemplate whether the events, persons, places, or objects in our dreams are possible. For example, we can meet dead friends and relatives without the realization that they have, in fact, died years ago. We can also create false memories in our dreams, and not be able to reflect on the peculiarity of the dream. For instance, we can confabulate characteristics for our known dream persons, which they do not have in reality, like a different hobby or profession. Sometimes we manage to create 'friends' or 'relatives' that we do not have in our waking reality, and we have no insight into the fact that these people do not exist in real life. In fact, we are often totally unable to reflect upon the credibility of our own beliefs in our dreams.

The lack of full self-awareness can extend to ourselves as well, although this is quite rare. Although the dream self in most dreams appears much the same as during wakefulness, there is a small proportion of dreams in which the self appears in an altered form. The milder variations include cases in which the dreamer is the same person, but appears in strange clothing or is of a different age, say, a small child in the dream. In a more distorted form, we can appear as a completely different person, sometimes of the opposite sex or different race. In very rare occasions, we can even transform into an animal, as in the following dream excerpt.

> I lived in a small house in the countryside, and I had several dogs. I let the dogs out, to roam free. They run into a nearby field, and then I saw the reason for this: a huge elk was standing in the middle of the field, with magnificent antlers. My dogs wanted to hunt down and kill the elk, and suddenly I was one of the dogs, the leader of the pack. I felt myself running on four legs through the hay, fast and strong. Then I realized that I and the other dogs were no longer dogs, but fierce wolves. Bloodlust was filling my mind, I could almost taste the raw elk meat in my mouth, and drool oozed between my sharp canines. The elk started to run away from us, and we followed, hunting in a coordinated fashion to bring down our prey.
>
> (First author's dream, reported 11 August 2007)

Other basic dream content elements

The dream self is not alone or passive in the dream world, but surrounded by other dream characters, actively taking part in events and social interactions. The Hall and Van de Castle content analysis system has revealed in numerous data samples that on average our dreams contain three other animate characters, which are usually human, but sometimes animals or fantastic or fictional characters. Approximately half of the humans in our dreams are persons known to us, and the other half consists of strangers and occupational characters, such as doctors or policemen.

The dream self is also an active participant in approximately four out of five dreams, and an uninvolved observer only occasionally. The dream self interacts with other dream characters and various social interactions take place in dreams. Interactions with other characters are more often aggressive than friendly. Almost half of our dreams include an aggressive component, and the dreamer is personally involved in most of these, more often being the victim than the aggressor. Males dream more often of direct physical aggression than females, and females of friendly interactions. Sometimes the positive interactions take on an erotic tone, although more often in men's than in women's dreams.

Events in which a bad outcome occurs to a dream character independent of anything the character does are called misfortunes. These are,

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by definition, negative events, consisting of mishaps, dangers, accidents, loss of possession, injuries and illnesses, falling, and death. Misfortunes are seven times more frequent in dreams than the opposite type of events, good fortunes. Moreover, the dreamer is personally involved in almost three quarters of misfortunes.

In a series of studies investigating negative dream content, conducted by the authors, it has been found that threatening events are frequently experienced in dreams. Approximately two-thirds of all dreams contain one or more event that threaten the well-being of the dream self or his or her significant others. The most common type of threatening events includes aggression, and failures and accidents are also common, whereas disease and illness are seldom encountered. Of the threats we face in our dreams, about half endanger our well-being in a way that would seriously affect future survival opportunities if the threats were to occur in waking life.

We also have a full range of emotional experiences in our dreams. Negative emotions are more frequently experienced in dreams than positive emotions. In the classic Hall and Van de Castle study of home-reported dreams, of the over 700 emotions explicitly mentioned in the 1000 dream reports of college students, 80% were negative and only 20% positive. Later, Frederick Snyder, and Inge Strauch and Barbara Meyer have acquired similar results in REM dreams collected in laboratory, indicating that two-thirds of emotions in dreams are negative. They also found that the most commonly reported negative emotions are fear and anger. Furthermore, dream emotions are almost always appropriate to the dreamed situations – a finding compatible with the results indicating that the events in our dreams are often unpleasant. There are, however, a couple of more recent studies that have found a more balanced sample of positive and negative emotions in dreams. Thus, dream emotions deserve further investigation.

Reflection

Reflective consciousness involves the ability to focus on some particular aspect of the content of consciousness and pass a judgment over it. The traditional view has it that dreams are devoid of reflective consciousness and self-awareness. This traditional view may now be changing. During dreaming our ability to critically reflect upon the events we witness is diminished, but it is not completely wiped out. Already in the early 1980s, McCarley and Hoffman found that in 16% of 104 REM dreams the dreamer explicitly noticed some bizarre feature of the dream. That is, reflective awareness of something not being quite right was present, at least for a fleeting moment.

More recently, David Kahn and J. Allan Hobson divided reflective thinking in dreams into two distinct components. The first component, reflecting on the dream event itself, that is, thinking about the event, is fundamentally deficient, and very different from waking state thinking. We take the dream event for granted, and do not question whether this event is likely or even possible in the waking realm. The second cognitive component, however, thinking and reflecting within the event, within the dream scenario, is similar to our thinking while we are awake. Even though we take the confabulatory dream event itself as real, we can think, pass judgments, make decisions, and guide our behavior the way we do while we are awake. For instance, the dreamer can protect her baby in the dream from dangers in appropriate and reasonable ways, but fail to realize that she does not have a child in waking reality. In sum, while we may not realize that the overall dream event itself is impossible or improbable compared to waking life, we act and think in the situation the same way we would if we were awake.

Bizarreness

Our sleeping brain combines dream elements in a novel, creative, odd, sometimes absurd way that is impossible or highly improbable in the waking realm. These dream oddities are referred to as bizarreness. J. Allan Hobson categorized dream bizarreness into three distinct forms: incongruity, discontinuity, and vagueness. Incongruity refers to mismatching dream features appearing together, for example, meeting your dead grandmother in your kitchen. Discontinuity comprises the sudden appearance, disappearance, or transformation of dream elements, and vagueness refers to uncertainty or ambiguity of a dream element, for instance, recognizing the dream character

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as a familiar person but not being able to specify who exactly the person is.

A few content analysis studies on bizarreness have been conducted. In one study by Antti Revonsuo and Christina Salmivalli, the frequency of bizarre elements was compared to the frequency of corresponding nonbizarre, normal-appearing elements. It was found that most dream elements are, in fact, nonbizarre, and not distorted in any manner. When bizarre features were present, they were more often incongruous than discontinuous or vague. A similar study has been conducted with dream characters by Revonsuo and Tarkko, investigating whether dream people are more often intrinsically distorted (internal bizarreness) or appear in a wrong context (contextual bizarreness). About half of the human characters in dreams were found to be bizarre, and two-thirds of these were contextually bizarre while the remaining one-third internally bizarre.

Bizarreness is an intriguing phenomenon as it reveals how the unity of consciousness is disrupted in dreams. If we were to figure out what are the underlying mechanisms in how the brain fails to bind together information during dreaming, we might learn about how the unity of consciousness is created by the waking brain. This is called the binding problem: we do not know how the brain mechanisms account for the unified perceptual world we take for granted.

Absent dream content

Self-awareness and the ability to reflect on the nature of dream events are flawed during dreaming. In dreams, we lack insight, that is, we take for granted the reality of dreams and fail to understand its hallucinatory characteristic. This may be explained by the specific pattern of brain activation during REM sleep: the dorsolateral prefrontal cortex where the neural mechanisms necessary for full self-awareness are believed to reside is very active during wakefulness, but deactivated in REM sleep.

There are also some specific dream contents that are almost nonexistent or at least very rare. These include such activities as reading, writing, calculating, and using a computer. The absence of these dream contents seem striking, as they are activities that we engage in daily, sometimes several hours a day. Thus far, there is no all-exclusive explanation as to why elements so frequent in our waking lives do not enter our dreams.

Bad Dreams, Nightmares, and Recurrent Dreams

Occasional nightmares are commonplace; almost everyone has experienced one or more dreams that contain anxiety or outright fear. A nightmare is a dream which causes a strong unpleasant emotional response in the sleeper, typically fear or horror, and awakens the dreamer, while bad dreams are defined as very disturbing dreams that do not awaken the dreamer. When asked retrospectively how often we experience bad dreams or nightmares, we have the tendency to underestimate the prevalence of these unpleasant dreams. Antonio Zadra and Don Donderi compared retrospective estimates with systematic dream diaries, and found that bad dreams and nightmares are more common than we tend to think. And for some of us, they are more frequent than we would like. Approximately 5% of men and 10% of women report frequent bad dreams and nightmares, that is, one or more per week. Also, children, especially between ages of 3 and 6, frequently experience bad dreams or nightmares.

The most common themes of bad dreams and nightmares are those of being pursued or attacked, being stuck in slow motion and unable to move, being naked in public, being late or unprepared for class, or scenes of falling, drowning, or death. Sometimes the dream may be recurrent, that is, the same theme keeps on repeating while the detailed content of the dream changes. Repetitive dreams, in contrast, refer to dreams that are identical in actual content. Research has shown that most recurring and repetitive dreams are described as being unpleasant.

Some people seem more prone to nightmares than others. A personality measure proposed by Ernest Hartmann, thin and thick boundaries, correlates with nightmare frequency. Thin boundary people are open, trusting, and vulnerable, whereas thick boundary people do not let anything rock their world. People who rate high on thinness of boundaries report more nightmares than people with thick boundaries.

While most nightmares have no apparent cause, psychological stress seems to precipitate nightmares.

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Extreme psychological stress, for example, exposure to a traumatic event, may trigger posttraumatic nightmares. These nightmares often repeat the traumatic event or depict some aspects of it. In a worst-case scenario, posttraumatic dreams may become chronic and last throughout life, but usually posttraumatic nightmares disappear as the person recovers from the trauma. Some repetitive and recurrent dreams can also be traced back to physiological causes, such as high fever or a need to urinate.

Differences in Dream Content

A wide range of cross-cultural studies on dream content reveals that the content analysis scale developed by Hall and Van de Castle provides similar results in most of the cross-cultural samples of dream reports studied. Thus, the formal features of dreams are alike all around the world, independent of culture. The small variations in dream content from culture to culture seem to relate to unique cultural patterns, and become understandable in terms of what is known about the culture. For example, the dreams of hunter-gatherer Mehinaku Indians living in the Amazon often include wild animals and hunting themes – elements present in their everyday lives.

Male and female dreams are also very much alike. The main differences are that men twice as often as women dream of direct physical aggression. Also, sexual themes are two to three times more common in men's than in women's dreams. These gender differences also seem to be cross-cultural and reflect the small but universal differences between the sexes.

Children's dreams as opposed to adults' dreams contain more aggression. Children also dream more about animals. The younger the child, the more often the animals are wild and exotic, and as the child matures, domestic animals start to dominate the dreams.

Dream content is powerfully modulated by real-life events that cause high levels of psychological stress. Posttraumatic nightmares are commonly reported by both children and adults who have experienced threatening real-life situations. The content and nature of posttraumatic dreams and nightmares are affected by several variables, for example, the number of deaths or the extent of loss experienced, the degree to which the event in question has been personally witnessed, the perception of personal threat or threat to significant others, the prominence of specific traumatic imagery, the phase of recovery, the specific meanings attributed to the event, the individual experience, and personality. The higher the degree of personal threat involved, the more probable is the occurrence of posttraumatic nightmares.

The effect of trauma has been studied in different populations, for example, veterans of war and children living under military rule. Veterans frequently report posttraumatic dreams depicting actual events experienced during the war. Traumatized children's dreams are also qualitatively different from nontraumatized children's dreams. More aggression, more persecution, and more negative emotions are present in traumatized children's dreams.

Theories of Dreaming

To this day, we know quite a lot about the form and content of dreams. But why do we dream in the first place? This question has puzzled both laymen and researchers for ages, and several different types of theories have been suggested to explain dreaming. How do these different theories manage to explain the form and content of dreams?

Psychoanalytic Theories

In psychology, the highly influential views of dreaming were presented by Sigmund Freud and Carl Gustav Jung. Freud's idea was that the manifest content of dreams, dreams the way they appear, is only a reflection of the latent or hidden content of dreams that needs to be disguised in order to protect the sleeper. If we were to become aware of our subconscious wishes, often of sexual or aggressive nature, the anxiety provoked by these wishes would awaken us. Thus, anxiety-provoking subconscious wishes are transformed into the manifest content of dreams, and we can only access the true latent content with dream interpretation techniques.

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For Jung, our nightly dreams were not trying to hide anything from us. He believed that our dreams were trying to communicate with us, but that the language of dreams, the images and symbols, made dream messages difficult to understand. He treated dream images as symbols, which have meaning in and of themselves. Jung believed the unconscious was purposely trying to speak to us, in order to bring forth a sense of wholeness and added meaning to our lives.

Jung divided the unconsciousness into personal and collective. Collective unconsciousness is the part of the psyche that retains and transmits the common psychological inheritance of mankind. Archetypes are symbols that occur in mythology, fairytales, and religions, and take the form of mythological or primordial images. Archetypes reside in and form the collective unconscious, and are shared by all mankind. According to Jung, dreams have a compensatory function; for example, when the dreamer is troubled, he or she will dream of archetypal images, dreams whose aim is to right an imbalance in the psyche of that individual.

At the time Freud and Jung formulated their theories, very little was known about the form and content of dreams. They based their ideas on unsystematically collected, small samples of dreams reported by only few individuals, not on the statistical properties of dreams in representative, systematic samples of dream reports. Thus, today Freud's and Jung's theories are not considered to be scientifically valid explanations for the form and content of dreams, or why we dream, although these theories are influential in personality psychology.

Random Activation Theories

The random activation theories (RATs) are a cluster of views that state that dreaming is a by-product of neuronal activity during sleep, that is, nothing but a nonfunctional REM-sleep-related epiphenomenon. The RATs suggest that random neuronal activation during REM sleep erratically activates memories, and the brain then synthesizes or constructs dream content based on these randomly activated memories. The specific activation pattern is determined by the neurophysiological and neurochemical processes occurring during REM sleep. The form and content of dreams is thus seen as a functionless side effect of sleep-related brain activation, serving no purpose whatsoever on its own.

The biggest problem of RATs is that they cannot explain why the form of dreams is so well organized. If memories are randomly activated and then dream content is constructed based on them, should not our dreams consist of chaotic and flash-like mental images and sensations? The RATs do not manage to specify why or how the brain creates such a rich and coherent world analog or world simulation during sleep that we experience as dreams. Even if we accept that random activation could lead to organized dream constructs, we should not be able to pinpoint any over- or underrepresentation in any dream contents that would be similar for all individuals, such as the presence of realistic dream self, the distribution of sensory modalities, or the prevalence of negative emotions in dreams.

Continuity Hypothesis

The continuity hypothesis (CH) states that there is a continuum between waking experiences and experiences within dreams in a way that dreaming reflects waking life experiences. Several studies actually demonstrate this. Up to 65% of dream elements can be linked to waking experiences, and isolated spatial or temporal features of memories have been found to occur in approximately one-third of dream reports. However, exact episodic memory replays are present only in about 1% of dream reports. It has also been demonstrated that episodic memories are depicted in dreams most likely on the subsequent night, and again about a week later.

In contradiction with CH, many such activities that we engage in our daily lives, such as writing, reading, calculating, and using a computer, are almost absent in dreams. In fact, the specific predictions and hypotheses of CH have not been described in a clear manner. The most general form of CH seems to predict that the frequency and nature of any real events will be correlated with the frequency and nature of similar dream events in subsequent dream content. On the basis

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of findings that some elements are almost absent in dreams, whereas others, like negative emotions and events, are overrepresented in dreams compared to waking reality, the CH does not seem to be the most reliable explanation for the form and content of dreams. Furthermore, CH does not claim anything about the possible function of the continuity between dreaming and waking, but, as it has been demonstrated that some waking life experiences are incorporated into dream content, rather states the obvious. What is lacking here is the specification for why some autobiographical memory elements are more likely to be incorporated into dream content than others.

Psychological Healing Function of Dreams

One influential view within clinical dream theories, supported by many esteemed researchers such as Ernest Hartmann, Rosalind Cartwright, and Milton Kramer, states that dreaming maintains psychological balance. Dreaming is seen as functional because it somehow enhances the individual's coping capabilities to his or her current concerns, solves current waking life problems, and promotes psychological well-being, and even helps to recover from traumatic experiences. Dreaming helps us to psychologically adjust to any current life stressors that consume psychic energy.

It is assumed that the process of dreaming makes connections in the memory networks more broadly than focused waking cognition, and this making of connections is guided by the dominant emotional concern of the dreamer. Negative emotional memory traces in long-term memory mark situations that cause a psychological imbalance, and these traces need to be integrated with other material in the memory networks in order to be neutralized. When the neutralizing process is successful, the emotional concern will disappear. Consequently, the psychological healing theories explain why negative emotions are incorporated into dream content.

The clearest examples mentioned in the context of the psychological healing function of dreams are posttraumatic nightmares. Traumatic experience is stored into long-term episodic memory, and it is the dominant emotional concern for the dreamer. Therefore, in posttraumatic nightmares, the emotional content of the traumatic event is repeated over and over again until the traumatic memories are integrated in the memory networks and the trauma is resolved. If the integration process is not successful, posttraumatic dreams may persist for years after the original trauma. In fact, chronic posttraumatic dreams are interpreted as a failure of dream function.

Even though the psychological healing theories are intuitively appealing, some difficulties explaining empirical findings have emerged. To begin with, even though a strong correlation exists between first experiencing a traumatic event and later dreaming about it, there is no evidence that dreaming about the trauma somehow causally contributes to psychological recovery. The currently available empirical evidence on the healing or mental health function of dreams is correlational at best, and recent findings imply that posttraumatic dreams depicting terrifying dream images, even integrating them with other memory traces, do not lead to recovery or psychological healing. Thus, the changes in dream content from nightmarish posttraumatic dreams to normal dreaming may only reflect the recovery process that as such goes on independently of dreaming.

Evolutionary Functions of Dreams

The most recent types of theories put forth to explain the form, content, and function of dreaming originate from an evolutionary biological or psychological perspective. The closest physiological correlate to dreaming, the REM stage of sleep, is energetically costly, and natural selection does not retain costly characteristics unless they provide advantages. Thus, natural selection would not have favored REM sleep and dreaming unless the benefits overran the costs that went into producing them.

The questions asked by the evolutionary psychological dream function theories are as follows: Why did the human brain evolve so as to be equipped with an automatic, involuntary program that generates complex subjective experiences during sleep? Is it conceivable that dreaming about particular contents in the ancestral world was functional in the biological sense – that somehow our ancestors had better chances of surviving because they regularly dreamed during the night,

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and especially because they regularly dreamed about particular things? When we expose dreaming to an evolutionary analysis, and if we find that dreaming may have increased ancestral survival rates and production of offspring, then we would understand why the human mind is a dreaming mind in the first place.

The sentinel function

Perhaps the first theory to explicitly present an evolutionary biological approach to sleep and dreaming was presented already in the 1960s by Frederick Snyder. He had noticed that REM sleep is unique only for mammals (although later identified also in birds), and suggested that REM sleep provided early mammals with a selective advantage over the reptiles that dominated the planet when mammals evolved. While long periods of sleep allowed early mammals to minimize metabolic requirements, it also rendered them vulnerable to predators. The selective advantage of REM sleep was to guard the safety of the sleeping animal. First, REM sleep increases the activity level of the brain and prepares the animal for a brief awakening that takes place after each REM period. If during the awakening danger is detected, the activity level of the brain is already high and the animal is prepared for immediate fight or flight. Snyder called this the sentinel function of REM sleep.

The sentinel theory as such does not state anything about dreaming, but Snyder also proposed that nonhuman mammals dream during REM sleep. The nature of their dream imagery is modulated by the latest estimate of expected danger at the time of waking up. If the available evidence from the environment predicts approaching danger, the dream will prepare the animal for fight or flight. If no dangers are in sight, then the dreams will preserve continuity of sleep with pleasant dreams. Thus, the evolutionary function of dream content is to be predictive of and preparatory for the situation where the animal finds itself immediately after the currently ongoing REM dream.

Snyder's theory places the function of dreaming to the context of REM sleep evolution. This makes his theory difficult to test, as we know nothing of what ancient mammals dreamed about, not even whether they dreamed at all. This applies to modern mammalian species as well. What we do know from human studies is that external stimuli, such as sounds, smells, or tactile experiences, are detected by the sleeping brain as activity in specific sensory cortices increases when stimuli are presented, but that the stimuli are not easily incorporated into dream content. Thus, if incorporation is infrequent, how would the animal brain be able to predict approaching danger from external environmental cues?

The costly signaling theory

Patrick McNamara suggests that costly REM features affect dream content, and, through producing hard to fake emotional signals, increase fitness by facilitating courtship displays or cooperative social interactions. The costly signaling theory (CST) builds on the concept that first emerged in the context of sexual selection theory presented by Robert L. Trivers. Sexual selection theory suggests that some traits have evolved because the more resources the organism has to allocate for the production of a particular trait, the more honest is the advertisement of 'having good genes. When members of the opposite sex can enhance their fitness by selecting mates who possess good genes, they will favor individuals displaying costly, honest, and hard to fake signals.

REM sleep involves high metabolic costs for the organism. The costs result from physiological changes taking place during REM, such as high levels of brain activation, increases in cardiac and respiratory rates, paralysis of skeletal muscles, REMs and limb twitches, thermoregulatory lapses, changes in growth hormone release, and penile erections. According to CST, REM features influence dream content and affect the mood states and emotional displays of the individual during following wake periods, regardless of whether specific dream content is remembered or not. Dreams are an emotional burden, and this burden is the greatest after having a highly memorable negative dream that places the dreamer into a 'handicapped' position. If the individual is able to display appropriate and functional behavior despite the emotional burden that is carried into waking realm, the emotional signals emitted by the individual during wakefulness are honest and hard to fake, and consequently, she or he is more likely to be favored by other group members, for

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instance, selected as a mate or preferred over others in cooperative alliances.

The problem with the CST is that the theory does not specify how exactly behavior is affected by REM sleep and dreaming. The theory does not define what the external behavioral cues are, supposedly modulated by preceding REM sleep and dreaming, which the other group members can monitor and evaluate. Unlike typical costly features that play a role in mate selection (as the peacock's tail), the costly features of REM sleep and dreaming might not be as such directly observable. However, some directly observable characteristics must be highly and reliably correlated with REM sleep and dreaming so that by preferring these features, the costly features of REM sleep and dreaming would consequently be selected for, albeit indirectly. Furthermore, we should be able to verify that other group members actually find these behavioral cues desirable and that the cues affect favorably the selection of the individual as mate or cooperative party.

The psychological problem solving and creativity function

Ernest Hartmann, who has suggested a psychological healing function for dreams, has also proposed that the capacity of dreaming to form new connections within the neural networks of the brain might have served two functions useful for our ancestors. Hartmann's first evolutionary argument concerns the idea that dreaming, as a process making new connections, has a kind of psychological problem solving or psychotherapeutic function, especially in handling traumatic experiences:

> Dreams after trauma may appear to represent a rare situation and fortunately for many of is this is so. However…. one hundred thousand years or so ago, when the human brain was gradually developing to its present form, our lives were considerably more traumatic; the after-effects of trauma may well have been an everyday reality and the resolving of trauma a constant necessity.… (Hartmann, 1998: 158).

Hartmann's second evolutionary proposal is that the making of broader and wider associations during dreaming might have helped in bringing material together in new ways and this would have been useful to our ancestors in their waking lives. Dreams might have provided new innovations in exploiting resources and solving problems related to everyday life. This particular argument emphasizes the creative and problem-solving nature of dreams.

> . . .In other words, the functions of dreaming. . . may have been especially important for us at earlier times in our species' development. . .Only our dreams gave us a chance to do this – to make broader and wider connections, to integrate trauma or other new material, and also to bring material together in new ways that occasionally might have been useful to us in our waking lives. (Hartmann, 1998: 209)

In sum, Hartmann suggests, at least indirectly, that the evolutionary origin of the function(s) of dreaming is in the ancestral environment where life was dangerous, trauma resolution was required on a daily basis, and creative new ideas could have provided valuable selective advantage. Individuals who were able to regain emotional balance and well-being after trauma were better off than those who did not, and therefore the psychotherapeutic function of dreaming was selected for and became a universal feature of the human mind. Similarly, individuals with creative problem-solving dreams were better adapted to their environment and consequently left more offspring than individuals not having extra help from their dreams.

We have already dealt with the problems related to the psychological healing theories. In addition, empirical evidence on the creative and problem-solving nature of dreams is mostly negative. New and useful solutions to waking life problems are extremely rarely depicted in dreams. Thus, whatever the function of dreaming is, it does not seem to be the finding of creative, new, and useful solutions to problems faced in waking life. Therefore, these two suggestions for the evolutionary function of dreaming are not supported by the currently available empirical evidence.

Simulation functions of dreams

Three different simulation function ideas have been suggested: that dreams are similar to play behaviors in mammals, dreams are simulations of social interactions, and that dreams are specialized in the simulation of threatening events. All these views are based on the claim that the dream experience is

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functionally constructed to resemble waking experiences, and therefore shows clear design features for a world simulation function.

Dreaming as play

There are indeed several similarities between dreaming and play behavior, but also a number of dissimilarities. Both seem to be limited, in their clearest forms, to mammals only. Both can simulate reality and rehearse different types of situations and interactions in a safe context. Both may exaggerate, transform, and display enormous variation of behaviors that are originally related to other contexts outside play. Both are energetically costly, biologically programmed behaviors that should therefore be in some way useful.

Unfortunately the adaptive functions of play are not entirely clear; thus, it is not possible to explain the functions of dreaming by saying that they are similar to the functions of play behavior. Most likely play has multiple functions, some of which might be closely related to the threat simulation function of dreams. There are forms of mammalian play that seem to be rehearsals of hunting behavior, aggressive encounters, or predator avoidance. Thus, playing and dreaming might have complementary functions in the rehearsal of behaviors: dreaming is perceptually more realistic than play, whereas play is motorically more realistic, involving actual execution of motor programs, muscular movements, and physical exhaustion.

Dreaming as social simulation

Another currently popular suggestion is that dreaming simulates human social interactions and rehearses social perception and social skills. Several slightly different versions of the 'social simulation hypothesis' have been proposed. The 'social mapping hypothesis' suggests that dreaming allows simulation of self, location, and awareness of others, including awareness of their internal mental states. Dreaming is thus suggested to have rehearsed the perceptual and emotional features required in successful social mapping in human evolutionary history, eventually leading to the emergence of self-awareness. Relatedly, David Kahn and J. Allan Hobson emphasize that awareness of what others are thinking and feeling is a robust aspect of human consciousness, and this aspect is maintained during dreaming despite the changes in chemistry and activation patterns of the brain during sleep. Thus, even though Kahn and Hobson do not explicitly express it, they imply that awareness of the minds of others ('theory of mind') during dreaming might have contributed to the ability to anticipate the intentions of others while awake. Dreaming about the intentions of others could prepare us for social encounters when awake. This idea leads us to another version of the social simulation hypothesis, suggested by several different researchers.

As many of the selection pressures faced by ancestral humans were posed by complex human social life, modeling human relationships, and interpersonal bonds, for example, family politics, attachment, love affairs, and status battles, might have had adaptive value. Interacting with other members of the group was an important selection pressure in the ancestral environment, and simulation of skills such as how to find a mate, build coalitions, and avoid conflict would have been useful. In dreams, it is possible to practice dealing with complex social situations, and because those most adept in their social environment were likely to have the best access to resources in their social group, simulation of social situations would have been selected for. Furthermore, strong family and group cohesion would have enabled organized defenses against predators and other enemies and enhanced survival and health of group members.

The social simulation hypothesis is to some extent compatible with what we know about the form and content of dreams. About half of the human characters in our dreams are persons familiar to us, and appearance, behavior exhibited by the character, and feelings evoked by the character in the dreamer are regularly used in the identification of the person. More than 80% of known dream characters evoke some kind of emotional response in the dreamer, most often affection or joy. A significant amount of time in dreams is spent wondering what other dream characters are thinking or planning. Thus, our dreams often represent human characters and give plenty of space for opportunities to practice social interactions. Nevertheless, aggression is a more common type of social interaction than friendliness, while sexual interactions are relatively rare in dreams. Thus, we get

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less practice in forming positive social bonds, such as making friends and allies, than in dealing with negatively toned social interactions. Even less time in dreams is devoted to mate selection and practicing how to form romantic relationships.

Although the social simulation hypothesis is consistent with the fact that other people and multiple social interactions are frequently present in our dreams, the hypothesis has some problems as an evolutionary psychological account of the function of dreaming. First, we get a lot of practice in (nonthreatening) social interactions during our waking lives, and this practice does not have high costs. Thus, it remains unclear why it would be advantageous to practice or simulate something like that further in our dreams. Second, there is a lack of studies on the detailed nature of the social interactions in dreams, and the ones conducted reveal the often aggressive nature of social encounters. Do we, in fact, interact with other dream characters in reasonable ways that might be considered useful simulations of or rehearsals for real-life social interactions? To back up an evolutionary hypothesis, a detailed description of the type of dream content and the conditions under which it occurs is required, as well as a cost–benefit analysis that should show why the dream simulation is likely to be useful for us (or was likely to be useful for our ancestors). It remains open whether the social simulation hypothesis will receive support from the more detailed analyses of dream interactions and cost–benefit considerations.

Dreaming as threat simulation

The third version of simulation function theories is the threat simulation theory (TST), proposed by Antti Revonsuo. According to him, to study the biological function of dreams we are required to make a systematic, detailed analysis of the content of dreams across a wide range of large data samples: in the 'normal' population, in cross-cultural samples, and in various special populations, especially hunter-gatherers, children, frequent nightmare sufferers, and traumatized individuals. If in this analysis some dream content characteristics tend to pop out here and there, again and again, those features probably are traces of the original biological function of dreams.

The TST is based on currently available evidence of the systematically recurring dream content characteristics. As mentioned above, the major statistically significant features of dreams are biased toward representing negative elements. Negative emotions and aggression are prominent dream content characteristics, the universally most often reported dream theme is the dreamer being chased or pursued, and the most frequent themes of recurrent dreams and nightmares consist of the dreamer being chased or attacked. The TST interprets this evidence by suggesting that dream consciousness evolved as an off-line model of the world that is specialized in the simulation of various threatening events encountered in the ancestral environment. In the ancestral environment, a threat simulation system that selected memory traces representing life-threatening experiences from long-term memory and constructed frequent threat simulations based on them could have provided our ancestors with a selective advantage in practicing threat recognition and avoidance skills. During dreaming, threat coping skills could have been maintained and rehearsed without the risks of hazardous consequences that accompany threats in real situations. Due to its beneficial effects in enhancing survival and reproductive success, the threat simulation mechanism was selected for, thus propagating its own existence in the ancestral environment.

The predictions of TST have been empirically supported in several studies. Threatening events are frequent in normative dreams, the most frequent type of threat are aggressive encounters (varying in severity from verbal nonphysical aggression to escape and pursuit situations, and to direct physical aggression), the dream self is most often the target of the threatening event, approximately half of the threats pose a severe threat to the dream self, the dream self reacts to the threats in a relevant and adequate manner, and the source of the threat simulation is most often traced back to the personal experiences of the dreamer or to media exposure. Recurrent dreams and nightmares include more severe threat simulations; especially the dangerousness of events is exaggerated in these special dreams. Further, if we are exposed to traumatic events in our lives, our threat simulation system becomes highly activated. The more severe the

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trauma, the better the dream recall, the more threatening events dreams contain, and the more life threatening and severe the threats in dreams.

In sum, the dream content studies on TST have mostly supported the predictions of the theory, although it is too early to draw any definitive conclusions about the accuracy of TST. The typical counterarguments against the theory include the following: (1) perhaps the high amount of threat-related content is only the result of selective memory for emotionally charged content; (2) perhaps the bizarre and disorganized nature of dream content does not allow realistic simulation of reality or real threats; (3) posttraumatic stress disorder (PTSD) and frequent nightmares are dysfunctional and disturb sleep, therefore they cannot be regarded as good or functional for the individual who suffers from them; (4) dreaming simulates so many other things too that surely threat simulation cannot be the (only) function of dreams; and (5) the TST is in principle untestable, and thus cannot be falsified or verified.

To begin to answer this critique, even though emotionally charged dream content is easier to recall than mundane content, the same applies for our everyday memories. We tend to forget the ordinary events in our lives, and only remember those that had an emotional impact. When the frequency of threatening events experienced during a specific time period in the waking life was compared with threats simulated in dreams during the same period, it was clear that the dream world contains threats much more frequently than the waking life does.

Second, practically all dreams are well-organized simulations of a world including the self, other characters, objects, and a setting or an environment where the dream takes place. Bizarreness disrupts some parts or features of this otherwise coherent organized world, but although dreams include bizarre elements, bizarreness appears to be a relatively small deviation in the otherwise coherently organized dream experience.

Third, it is true that many severely traumatized individuals suffer from sleep disturbances due to terrifying nightmares. But there are also reasons to believe that ancestral humans did not suffer from the effects of PTSD to the same extent as some individuals in the present environment. The threats in the ancestral environment were frequent, and the ancestral humans were most likely adapted to higher levels of stress and trauma from early childhood on than most contemporary humans. Moreover, in the ancestral setting the threats were often related to everyday activities and thus predictable.

Fourth, although some researchers are willing to accept the idea that dreams are simulations of significant selection pressures, they disagree on what types of events are simulated in dreams. Rehearsal of skills such as adjustment to novelty, social interactions, interpersonal understanding, motor functions, and spatial learning has been suggested. Thus far, however, none of these suggestions have undergone a similar evolutionary cost–benefit analysis as the TST. The suggested alternative evolutionary functions involve little costs if practiced during waking hours, while real threats often result in fatal consequences. Thus, fitness benefits for simulating threats during dreaming are higher than for simulating situations that yield no costs if practiced during wakefulness.

Finally, the main concern faced by the TST is its empirical testability. This concern is not unique only to TST, but to all evolutionary psychological theories that infer cognitive mechanisms from the selection pressures operating in the evolutionary environment of the species. We will never be able to acquire data that would tell us what our ancestors dreamed about thousands and thousands of years ago. But the more we learn about ancestral life and threats in that environment, the more specific hypotheses we can draw concerning what types of events should be simulated in dreams, and thus, indirectly test whether contemporary dream content is compatible with ancestral selection pressures.

To sum up, the TST takes into account the selection pressures most likely present in the human ancestral environment. It proposes a plausible explanation for how dreaming of negative and threatening events might have provided a slight advantage to our ancestors in maintaining and enhancing their threat recognition and avoidance skills. By referring to a single threat simulation mechanism, it furthermore manages to explain a wide variety of dream content data that already exist in the research literature.

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Summary and Conclusions

Dreaming can be defined as a subjective experience occurring during sleep and taking the form of an organized, temporally progressing world simulation. Even though dream content is subjective and highly individual, some dream themes, such as being chased or attacked, falling, drowning, or flying, seem to be universal among humans. Detailed dream content studies also reveal many common underlying elements dreams are composed of. Regardless, we still do not know why people dream or if dreams serve any function. Numerous theories have been proposed to explain why we experience dreams, and some of them possess more explanatory power than others. Nevertheless, none of the theories posed are thus far accepted by all researchers in the field of dream science.

See also: Sleep: Implications for Theories of Dreaming and Consciousness.

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