Running head: THE TST AND DREAM CONTENT ANALYSIS AFTER TRAUMA

The Threat Simulation Theory and Dream Content Analysis on Traumatized Subjects

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Examensrapport inlämnad av Rickard Redgård till Högskolan i Skövde, för Kandidatexamen (B.Sc.) vid Institutionen för kommunikation och information. Arbetet har handletts av Katja Valli.

31 maj –07

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Abstract

The present study set out to test some of the predictions made by the Threat Simulation Theory, which suggests an evolutionary source of dreaming (Revonsuo, 2000a). The qualitative content and frequency of threatening events in dreams were compared between traumatized Swedish subjects with experience of the tsunami-disaster in Southeast Asia in 2001 with Swedish subjects with no traumatic experiences. Only a few of the hypotheses were supported by the results. The results and unsupported hypotheses are discussed with focus on the Threat Simulation Theory, and alternative explanations are considered.

Keywords: threat simulation theory, trauma, function of dreaming, dream content

Table of Contents

Introduction

Dreams have fascinated mankind for all of recorded history and probably long before. The phenomenology of dreaming and its emotional impact on the dreamer have led people to ascribe distinctive meaning to their dreams, e.g. as messages from the gods or as predictions of the future. Some cultures have believed dreaming to be an alternative reality, granting access to the spirit world. Some modern theories have suggested that dreams have some form of psychotherapeutic function or that they are completely random by-products of REM-sleep (Farthing, 1992). Recently, the evolutionary psychological approach has lead to many new types of hypotheses regarding the biological function of dreaming.

The Phenomenology of Dreaming

Any conscious experience during sleep can be defined as "sleep mentation", but only a portion of all sleep mentation are considered "dreams". A dream is defined as a subjective experience during sleep that shows complex, organized imagery and temporal progression (Farthing, 1992). This experienced imagery does not have to be visual, but rather any kind of perceptual conscious experience. A subjective experience during sleep that fails to show either any forms of imagery, or show no temporal progression are not dreams and may instead be defined as "sleep thoughts" or sleep mentation.

Sleep consists of several physiologically distinct stages that occur in a cyclic pattern, namely REM (rapid eye movement) sleep and four NREM (non-rapid eye movement) sleep stages. Dreaming during REM sleep is more vivid and intense, but it is not confined to REM sleep alone. The physiological sleep stages are not the neural correlates of dreaming: dreaming can occur in any sleep stage, and any sleep stage can be without dreaming.

There is, however, a difference in the quality of dreams occurring during REM sleep and NREM sleep. Dreams that occur during REM sleep are typically longer, more "dreamy" and show more visually vivid, dramatic, emotional and bizarre contents, with more active participation from the dream Self. Dreams that occur during NREM sleep tend to be limited to simple imagery, or imageless conceptual thinking, and be more comparable to daydreaming (Farthing, 1992). However, if the length of dream reports is controlled for, these qualitative differences largely disappear (Cavallero & Cicogna, 1993; Cavallero, Foulkes, Hollifield & Terry, 1990; Foulkes & Schmidt, 1983). Moreover, Fosse, Stickgold and Hobson (2004) recently found that the quality of late night NREM dreams largely resemble early night REM dreams, suggesting that the complexity of dreaming increases in conjunction with the time spent sleeping, and that it is not related to specific sleep stages.

Dream Research and Consciousness Studies

Dreaming is the most frequently occurring altered state of consciousness, and therefore has a special role in the study of consciousness in general (Revonsuo & Valli, 2000; Valli, Revonsuo, Pälkäs, Ismail, Ali & Punamäki, 2005). The characteristics of dreaming itself constitute an important source of information about consciousness.

First, just the fact that dreaming exists as a subjectively experienced virtual model of the world during sleep raises questions about what physical and physiological phenomena are sufficient for conscious experiences to exist, and what are not necessary at all. During dreaming, the brain is cut off from sensory input and motor output and creates the hallucinatory dream world without any contact with the external world (Revonsuo, 1995). Therefore, the dreaming brain could be viewed as a "model system" for consciousness studies (Revonsuo, 2000c).

Second, the mechanisms working in waking consciousness and dream consciousness share the same ontology, making the phenomenon of "bizarreness" an interesting thing to study for learning about binding (Revonsuo, 1995). The concept of "binding" refers to the ability to form one single conscious unity out of several different sensory experiences (Gaulin & McBurney, 2001). Bizarreness refers to how dream content is represented in strange ways or combinations: dream persons can have a different identity than in waking life, or no known identity at all; objects can appear in the wrong context or with strange characteristics, etc. These combinations come about when the brain simultaneously activates contents that are never activated simultaneously in waking life, following from a failure in binding waking life perceptions correctly. From studying these failures of binding in dreaming, we might learn a lot about how the binding system functions in waking consciousness (Revonsuo, 1995).

Finally, studying the function and evolutionary source of dreaming is important for studying the function and evolutionary source of consciousness. If it can be shown that dreaming, which consists of phenomenal experiences, has a biological function, then it must also be that consciousness, at least in part, has a biological function, as well. Therefore, theories on the function of dreaming might have important implications for theories on the function of consciousness (Revonsuo & Valli, 2000).

Theories on the Function of Dreaming

Why do we dream? Why don't we spend our nights in absence of any subjective experiences, completely non-conscious? The function of dreaming has long been regarded a mystery, but many theories have been put forward over the years to try to explain the possible functions it might serve (Revonsuo, 2000a).

Dreaming has no function.

Hobson and McCarley's (1977, cited in Farthing, 1992) theory on the function of dreaming is based on a definition of dreams that only takes into account those dreams that occur during REM sleep, focusing on the intensely emotional and bizarre features of dreaming. Their "activation-synthesis hypothesis" claims that dreaming is a by-product of certain neurophysiological events that occur during REM sleep. The primary stimuli include feedback from eye movements, discharge from the motor system, vestibular system activity and feedback from the autonomic nervous system.

The dreams in themselves are created by the forebrain's attempt to match images and movements to this random internal activity, called "isomorphism". The images are usually taken directly from memory with no greater meaning behind them than to match the internal activity. For example, the dreamer's eye movement can correspond to various movements in the dream, e.g. watching someone jump up and down or a car driving from left to right. Fast eye-movements can also be responsible for the overall high tempo of a dream, whereas slower eye-movements correspond to a lower tempo of a dream. In sum, Hobson and McCarley (1977, cited in Farthing, 1992) don't assign any function to dreaming itself, however, they do believe the underlying REM sleep physiology is functional.

A major problem with this theory is that it only takes into account the intense and emotionally charged dreams found in REM sleep, even though dreaming occurs in all sleep stages. What follows from this is that the theory predicts dreams to be highly emotional and bizarre. These characteristics are, however, by no means defining characteristics, but are rather rare. Most dreams are more mundane and structurally coherent. Further, although evidence regarding the correlation between phasic physiological events and the general amount of dream activity is largely positive, the evidence for the correlation between more

specific physiological events and dream events (e.g. eye-movement corresponding to dream-movements) is largely negative (Farthing, 1992).

Foulkes's (1985, cited in Farthing, 1992) theory, too, describes dreaming as a type of by-product. Foulkes believes that dreams are created from the same system that is responsible for narrative production and imagination in waking life. This dream-production system, the form of which it takes during sleep, creates the dream images from a diffuse mnemonic activation, using both semantic and episodic memories. It combines completely random memories with the dreamer's knowledge of narratives, i.e. how to construct a linear chain of events over time, or script knowledge, i.e. how a plausible and common sequence of events might play out in a typical situation, like going to the restaurant, taking a bath, etc., with knowledge about the world, i.e. what things look like, how they move, etc, in a way that creates a comprehensible and most often plausible dream. These dream images, or symbols, as Foulkes calls them, have no deeper meaning in themselves, but are only representing their waking life counterparts.

By saying that dreams are the result of a more or less random mnemonic activation, Foulkes ignores the fact that some dream images are not very random, at all. Day residues and current concerns are more often represented in our dreams than what would be expected from a random selection of memory traces. Emotionally charged memories, e.g. after traumatic experiences, seem to be especially over-represented (Farthing, 1992).

Dreaming has a psychological function.

Freud (1900/1965, cited in Farthing, 1992) believed that dreaming was "the royal road to the unconscious" (Farthing, 1992, p.289) and thought that studying dreams could uncover the unconscious sources behind many neurotic symptoms and thereby prove useful in their treatment. He meant that dreams carry two types of content: manifest content and latent

content. In the manifest, or superficial, content, objects and events took the form of symbols that represented the latent, or hidden, content. According to Freud (1900/1965, cited in Farthing, 1992), the unconscious, or "Id", has desires that we cannot fulfil in our everyday life. Carrying out such a desire could e.g. be punished by society, because such behaviour is not tolerated. If the action would go by unnoticed, and we would avoid punishment, we would still feel guilty and anxious over what we have done. All of these desires create a strong energy that needs to be released in one way or another. Neurotic symptoms provide one outlet, while dreaming provides another.

However, the very knowledge of these desires creates anxiety for us, so we can't dream about them directly. Should the desires be shown to us directly, the resulting anxiety would cause us to wake up. The preconscious, or "psychic censor", is responsible for masking our desires as symbols in the dreams, as which they can be admitted freely to consciousness without causing stress or anxiety (Freud, 1900/1965, cited in Farthing, 1992). Freud thus believed that dreams are psychologically motivated, i.e. that dreaming has a psychological function.

The major problem with Freud's theory is that it is too vague, and is therefore not properly testable. The manifest dream content can be interpreted to represent different latent content depending on who is doing the interpretation, and consequently there is no way of telling what the correct latent content really is. Also, there is no direct way of falsifying the claims made by the theory since it is not precise enough to predict any specific outcomes. In contrast, it is flexible enough to explain all possible outcomes. A scientific theory has to be able to predict specific outcomes, not only explain them in retrospect (Farthing, 1992).

Hartmann (1996) bases his theory of dreaming on the claim that dreaming makes connections. Just as the waking brain consolidates and integrates new memories into the broader narrative, the sleeping brain connects new memories with older ones. This connecting

dream function was developed for the ancestral human when traumatic experiences were much more frequent than today, when the recovery-process had to be working constantly. During sleep, the new traumatic memories were integrated into other memory traces in order to diminish the emotional strength of the traumatic memories. This can be seen in the content of present-day dreams in individuals with traumatic experiences. First, the dreams replay the event more or less as it was experienced, but as time passes, the dreams start to integrate other elements and environments, although forever keeping the most dominant emotion that was experienced during the event as the central theme. In most cases, the connections made by integrating unrelated dream themes will eventually resolve the trauma, but in some cases the connecting mechanism fails and the dreamer is stuck with repetitive dreams that depict the experienced event more or less as it was experienced, through which post-traumatic stress disorder (PTSD) may develop. All dreams utilize the function of making connections, although it is much easier to discern in trauma, which can be seen as a paradigmatic case of dreaming (Hartmann, 1996). In sum, although Hartmann gives the function of dreaming an evolutionary source, he doesn't put much emphasis on it. The function itself is of psychotherapeutic nature, designed to help the dreamer resolve traumatic experiences.

Similarly as Freud's theory, Hartmann's theory on dreaming is essentially untestable. The central function for dreaming is to resolve traumas carried by the dreamer. Sometimes this succeeds and sometimes it does not succeed. There is no way of predicting what the outcome will be, given the information present before the recovery-process begins. The theory only explains why there sometimes is a correlation between dream images depicting a traumatic event and the mental health of a dreamer who has experienced a traumatic event. However, there is no evidence that supports the notion that dreaming about the traumatic event itself reduces the trauma. If the two are seen to diminish together, it can

only be said to be correlational, at best. It could be that the dreams reduce the trauma, but it could also be that the dreams only reflect the reduced trauma.

Dreaming has an evolutionary function.

The starting point for the evolutionary theories on dream function lies in modern evolutionary psychology, in which dreams are analysed from the perspective of the environment of evolutionary adaptedness (EEA). Evolutionary psychologists assume that it takes thousands, sometimes hundreds of thousands, of years for adaptations to evolve and spread through entire populations, and therefore, the present-day human probably carries the same adaptations as our ancestors did. In order to find the function behind dreaming as a biological phenomenon it is necessary to systematically analyse large samples of dream reports from many different populations. Cross-cultural samples from "normal" populations would be needed, as well as samples from "special" populations, such as contemporary hunter-gatherers, children, traumatized individuals and frequent nightmare sufferers. If some dream content characteristics tend to pop-up across different populations, they can probably be described as traces of the original biological function of dreaming (Valli & Revonsuo, in press).

There are many evolutionary theories that claim the function of dreaming to lie in simulations of social interaction, as rehearsal of social perception and social skills (Valli & Revonsuo, in press). About half of the characters we meet in our dreams are known to us (Domhoff, 1996), and 81% of all known characters evoke an emotion in the dreamer, the most common ones being caring and joy. Together with appearance and behaviour exhibited by the character, the feelings evoked by the character are regularly used to establish its identity (Kahn, Pace-Schott & Hobson, 2002). This shows how dreams often include human

characters and how they give plenty of opportunities to practice social interactions (Valli & Revonsuo, in press).

Brereton (2000) has suggested that the simulation of not just social interactions but also the very awareness of others, and of their internal mental states, eventually led to the emergence of self-awareness. Nielsen and Germain (2000) points out that many selection pressures acting in the ancestral environment were of social nature and that it would have been reasonable to think that social, cognitive and emotional skills were rehearsed during dreaming to assist the adaptation of these waking life traits. Stronger interpersonal relationships could have resulted in stronger defences against predators and better cooperative problem-solving skills. Franklin and Zyphur (2005) have suggested that the rehearsal of social interactions and practice solving of complex situations in dreaming gave the dreaming individuals better social skills, which gave them access to better resources and mates. Kahn and Hobson (2005) have pointed out the importance of awareness of other people's thoughts in human nature, and how we also spend a great deal of time in our dreams thinking about what other dream characters are thinking. The way we think and react in dream events tend to be very realistic in comparison to how we would think and react in a comparable waking life situation. Kahn and Hobson thus imply that the mechanisms of dreaming that allow awareness of other people's thoughts could have made it easier for us to anticipate the intentions of others while we are awake.

The function of dreaming suggested in social simulation theories in general have been criticised for not being cost-efficient. Practice of social interactions with no real danger or threat attached to them is performed in waking everyday life, and thus it remains unclear why evolutionary selection would have favoured such a simulation (Valli & Revonsuo, in press). The little evidence present on social interactions in dream content tends to point towards the highly aggressive nature of interactions (Domhoff, 2006). Is this aggressive

nature of social interactions actually preparing us to interact with people in our waking life in a reasonable way? More specific hypotheses on what type of dream content should be expected to be found is needed to do further research on social interaction theories, and a cost-benefit analysis is needed to explain why natural selection would have favoured such simulations (Valli & Revonsuo, in press).

Revonsuo's (2000a) Threat Simulation Theory (TST) suggests that the dream consciousness has evolved as an organized and selective simulation of the world, which is specialized in the simulation of various threatening events. Only waking life experience of threatening events can fully activate the threat simulation system. First, the threatening experience is stored in long-term memory, and during sleep, the dream production mechanism selects memory traces with highest saliency and creates simulations of threatening situations within the dream consciousness. Simulated threats by the fully activated threat simulation system are perceptually and behaviourally realistic, and rehearsal of the skills needed to avoid these threats in the dream consciousness can lead to enhanced performance in waking life regardless of whether the rehearsal is explicitly remembered or not. In EEA, the threat simulation system gave the dreamer a venue to practice threat recognition and avoidance without the risks that would necessarily follow from doing it in real life. Because of the internal practice's beneficial effect on survival skills and reproductive success, the treat simulation system was opted for natural selection (Revonsuo, 2000a).

The theory is heavily based on analysed dream content. A study by Domhoff (1996) showed that different kinds of negative emotions are far more frequent in dreams than positive emotions. Similarly, aggression is a more prominent dream content characteristic than friendly interactions, especially in children's dreams, which also contain far more animal aggressors than adult dreams. Another study by Nielsen et al. (2003) showed that the most common dream theme was that of being chased or pursued, and a study by Robbins and

Houshi (1983, cited in Valli & Revonsuo, in press) showed that the most common theme for recurring dreams and nightmares was that of being chased or attacked.

Some criticism has been put forth regarding TST's claims, most noticeably concerning the compatibility between threat simulation as a function and the amount of people suffering from PTSD, and the general testability of the theory. The criticism against TST will be further developed in the discussion.

Previous studies on TST.

In order to test some of the predictions made by TST, Revonsuo and Valli (2000) devised a set of scales for analysing the content of dreams and distinguishing threatening events from other events mentioned in dream reports. They collected a total of 592 dream reports from 52 subjects and found out that 66.4 percent of all dreams contain a minimum of one threatening event. The average number of threats per dream was 1.2, which seems to indicate that threatening events are over-represented in dreams compared to waking life. Different forms of aggression were contained in 42 percent of all threatening events. Failures, accidents and misfortunes were also frequent, while catastrophes and diseases were rare. The most frequently threatened dream person was the dream Self, followed by people significant to the dream Self. Twenty-two percent of the threatening events were life threatening or physically highly severe, 17 percent were psychologically, socially or economically severe and 61 percent were only mildly threatening. In those cases where the dream Self actively reacted to the threatening event, the reaction was almost always of a relevant and appropriate nature. Also, life threatening events were significantly more likely to cause the dream Self to react to the situation. Overall, the results obtained in this study support the predictions of TST. However, the subjects were all Finnish students who are likely to have not experienced any traumatic events, thus not having a fully activated threat simulation system.

Valli et al. (2005) and Valli, Revonsuo, Pälkäs and Punamäki (2006) set out to test the hypothesis that experience of traumatic events in waking life should activate the threat simulation system to a higher degree than without experience of waking life traumatic events. They used a scale similar to that devised by Revonsuo and Valli (2000), and analysed a total of 763 dream reports from 187 Kurdish and Finnish children (Valli et al., 2005), and 1348 dream reports from 299 Palestinian children (Valli et al., 2006). The Kurdish and Palestinian children were divided into trauma group and control group, based on their personal experience with traumatic events. It was shown that children with experience of severe traumatic events reported more dreams, and that their dream reports contained more threatening events than the dream reports by children without, or with less, experience of traumatic events. Compared to the dream reports of non-traumatized children, the dream reports of traumatized children contained more often life threatening or highly physically severe threats, the threats were more often aggressive and had more severe consequences. These results support the hypothesis that experience to traumatic events further activates the threat simulation system, as proposed by TST.

Current Study

Purpose and hypotheses.

TST predicts that personal exposure to traumatic events will fully activate the threat simulation mechanism in dreaming, which will lead to frequent threatening events in dreams. Therefore, the experimental group, having experienced a highly traumatic event, should show more frequent threatening events in their dreams than the control group, not having experienced a severe traumatic event. The threatening events should also be depicted as more severe for the experiment group than for the control group.

The current study set out to collect dreams from people that had come in direct or indirect contact with the tsunami disaster in Southeast Asia in 2004, i.e. people who had either personal experience from the disaster or people who knew someone who had personal experience of the disaster. The dreams were analysed with regard to frequency and quality of threatening events.

Method

Subjects

The subjects consisted of 12 Swedish, adult females, divided into experimental group and control group. The experimental group consisted of 6 subjects with personal experience of the tsunami-disaster in Southeast Asia in 2004. Subjects were recruited through advertisements in e.g. newspapers, radio and TV, as well as from various help-organizations, such as The Red Cross and Children's Rights in Society (BRIS). The control-group consisted of 6 subjects that had no personal experience of the disaster nor knew anyone who did, and were matched with the experiment group by age, gender and level of education. The mean age of subjects was 40.2 years (SD = 6.5, range = 29 – 50).

Data Collection Procedure and Material

The subjects that responded to the advertisements were given information about the study and participation. First, to test the suitability of participants, they were asked to write a dream-diary for three days, as well as a description of what they experienced during the tsunami-disaster, and to include any bad dreams they might have had directly following the disaster. They were also asked to sign an informed consent. Second, the suitable subjects were

asked to keep a dream-diary for three weeks, which was, at the end of the three-week period, handed in either digitally through a website that masked the sender's identity and prevented the experimenter from knowing the identity of the participants, or through snail-mail with an enclosed franked envelope. The material consisted of 295 dream reports, averaging 24.6 reports per subject (SD = 20.7, range = 6 – 51), of which 22 reports were recalled as experienced directly following the disaster.

Data Analysis Procedure

The analysis procedure was carried out in two stages: 1) The identification of threatening events in dream reports, and 2) the classification of the identified threats with regard to their content (see Table 1). Two judges carried out both stages independently of each other. Before starting with the first stage, the two judges practiced identifying threats in dream reports from previous study-material, in order to gain a certain degree of experience.

Statistical Analysis

In testing whether the trauma group and the control group differed in the age of subjects, number of reported dreams, length of reported dreams, and number of threatening events in dreams, the non-parametric Mann-Whitney U test was used. In the comparison of differences in the quality of threatening events between groups, Pearson's Chi-Square Test (χ^2) was conducted. To evaluate the inter-rater agreement, percent agreement was used in the identification of threatening events, and Cohen's Kappa Coefficient Test was conducted for threat classification.

Table 1

The Dream Threat Scale

Threat identification criteria
Objective threat: An event in a dream where, if the event were real, the physical or mental well-being of any person would be endangered or where any person's physical resources or territory would be jeopardized (i.e., any event that would be considered threatening if it should really occur in the waking life). Such an event may be directly witnessed by the dreamer reporting the event or only indirectly heard about in the dream.
Subjective threat: An event in a dream that is interpreted or emotionally experienced by the dreamer (i.e., the dream self) to be somehow dangerous. Any event in which the subject reports the feeling of danger or threat even if no objective threat (as defined above) is reported to accompany this feeling.

Name of the category	I The Nature of the Threatening Event	II The Target of the Threat	III The Severity of the Threatening Event for the Self	IV Participation of the Self in the Threatening Event	V Reaction of the Self to the Threatening Event	VI Consequences of the Threatening Event to Self	VII The Source of the Threatening Event
Aim of the category	What kind of a threatening event is in question?	Who or what is being threatened? (may receive several scores)	How risky for the self would the threatening event be if it happened in real life?	Does the dream self participate in the course of events?	How does the dream self react to the threatening event?	What kind of losses does the dream self suffer in consequence?	What is the likely source of information for the threatening events?
Content of the category	1. Escapes and pursuits 2. Accidents and misfortunes 3. Failures 4. Catastrophes 5. Disease 6.1. Psychological aggression 6.2. Threat of physical aggression 6.3. Direct physical aggression 7. Nature of threat cannot be classified	1.1. Self 1.2. Persons significant for the self 2.1. Territory of Self 2.2. Resources significant for the self 3.1. People not significant for the self 3.2. Resources not significant for the self	1. Life-threatening event 2. Socially, psychologically or financially severe threat 3. Physically dangerous event 4. Minor event	1. The dream self is active 2. The dream self does not or cannot actively participate in the threat	1. Possible and reasonable action 2. Physically impossible but efficient action in the dream 3. Physically possible but irrelevant action 4. No reaction, reaction not possible or not reported	1. No losses or damage to self 2. Minor losses or damage to self 3. Severe losses to self 4. Consequences not adequately reported	1. Personal life: realistic threat 2. Media: realistic but unlikely threat 3. Fiction- or fantasy-based threat 4. Source of threat cannot be classified

Note 1: Modified from Valli & Revonsuo (in press)

Results

Reliability

The threat identification agreement was good between the raters, 79.3%. Similarly, the threat classification agreement levels were strong, ranging from $\kappa = 0.989 - 0.798$ (see Table 2 for detailed κ values). All p values were significant ($p < 0.001$).

Table 2: Inter-rater classification agreement

	Nature of threat	Target of threat: Self	Target of threat: Significant Others	Target of threat: Significant Resources	Target of threat: Insignificant Others
Kappa (κ)	0,943	0,917	0,989	0,908	0,981
p	<0,001	<0,001	<0,001	<0,001	<0,001

	Severity of threat	Possibility for Self to react	Participation of Self in threat	Reaction of Self to threat	Realism of threat
Kappa (κ)	0,918	0,841	0,876	0,901	0,798
p	<0,001	<0,001	<0,001	<0,001	<0,001

Subjects and Material

The control subjects were matched with the experimental subjects by age, gender and education, thus no differences were observed between groups. The traumatized subjects

reported more dreams (M = 28.0, SD = 11.8, range = 14 – 46) per subject than the control group subjects (M = 17.5, SD = 15.5, range = 6 – 47), but due to small sample size, this difference did not reach statistical significance (p = 0.11). The traumatized subjects' dreams were slightly longer (M = 209 words, SD = 133.5, range = 12 – 1533) than the control subjects' (M = 135 words.1, SD = 38.3, range = 10 – 559), but the difference was not statistically significant.

The Frequency of Threatening Events

Altogether, the raters identified 232 threatening events, on which 184 they originally agreed upon. After discussion, 28 threats were accepted to further analysis, whereas 20 were omitted. Thus, altogether 212 threatening events were accepted to content scoring, 146 from the trauma group, and 66 from the control group. Even though the absolute number of threats per group seems to differ, when the higher number of dream reports from traumatized subjects is taken into account, the differences disappear. Thus, the mean number of threatening events per dream report did not differ between the trauma group (M = 0.77, SD = 0.33, range = 0.31 – 1.1), and the control group (M = 0.82, SD = 0.46, range = 0.29 – 1.3).

The Quality of the Threatening Events

The nature of the threatening event.

The distribution of the nature of the threatening events, i.e. what type of threat was in question, in dream reports by the experiment group and control group is shown in Table 3. The traumatized subjects reported significantly more accidents and misfortunes than the control group, but less failures ($\chi^2 = 12.9$, df = 5, $p < 0.05$). Although not statistically significant, a relative difference could be seen when combining sub-categories of escapes and

pursuits with sub-categories of aggression (1, 6.10, 6.20 and 6.30). The trauma group reported a sum of 42.6% events of that nature, whereas the control group reported a sum of 33.3%.

Table 3: The nature of the threatening event

	Exp. group			*Cont. group*		
Sub-category	Frequency	Valid Percentage	Cumulative Percentage	Frequency	Valid Percentage	Cumulative Percentage
1,00	36	24,7	24,7	13	19,7	19,7
2,00	33	22,6	47,3	7	10,6	30,3
3,00	36	24,7	71,9	29	43,9	74,2
4,00	7	4,8	76,7	1	1,5	75,8
5,10	4	2,7	79,5	4	6,1	81,8
6,10	9	6,2	85,6	5	7,6	89,4
6,20	8	5,5	91,1	2	3,0	92,4
6,30	9	6,2	97,3	2	3,0	95,5
7,00	4	2,7	100,0	3	4,5	100,0
Total	146	100,0		66	100,0	

The target of the threatening event.

The distribution of the targets of the threatening events is shown in Table 4. Since the category is inexclusive, i.e. more than one score can be assigned to each threat, the total percentage point here exceeds 100. There were no significant differences regarding the target of the threatening event between the trauma group and the control group. However, the trauma group's dream reports contained relatively more insignificant people and resources

than the control group's dream reports (33,6% vs. 19,7%). Also, there were no differences between significant others and insignificant others within both groups.

Table 4: The target of the threatening event

Sub-category	*Exp. group*			*Cont. group*		
	Frequency	Valid Percentage	Cumulative Percentage	Frequency	Valid Percentage	Cumulative Percentage
1,10	100	68,5	68,5	48	72,7	72,7
1,20	38	26,0	94,5	14	21,2	93,9
2,10	0	0,0	94,5	0	0,0	93,9
2,20	1	0,7	95,2	5	7,6	101,5
3,10	42	28,8	124	12	18,2	119,7
3,20	7	4,8	128,8	1	1,5	121,2
Total	188	128,8		78	121,2	

The severity of the threatening event for the dream self.

The distribution of the severity of the threatening events for the dream Self is shown in Table 5. The difference was not significant ($\chi^2 = 5.8$, df = 2, p = 0.056), but threatening events depicted in dream reports by the trauma group showed a tendency to be more life-threatening than in dream reports by the control group.

Table 5: The severity of the threatening event for the dream self

Sub-category	*Exp. group* Frequency	Valid Percentage	Cumulative Percentage	*Cont. group* Frequency	Valid Percentage	Cumulative Percentage
1,0	35	24,0	24,0	8	12,1	12,1
2,0	11	7,5	31,5	11	16,7	28,8
3,0	5	3,4	34,9	2	3,0	31,8
4,0	95	65,1	100,0	45	68,2	100,0
Total	146	100,0		66	100,0	

The participation of the self in the threatening event.

The analyses of the possibility for the self to react to, the participation of the self in, and the reaction of the self to the threatening events did not show any differences between trauma group and control group.

The realism of the threatening event.

The distribution of the realism in the threatening events, i.e. what the most probable source for the dream content is in relation to the dreamer, is shown in Table 6. Although not statistically significant ($\chi^2 = 5.7$, df = 2, p = 0.057), the traumatized subjects tended to report more threatening events with bizarre elements, while the control subjects reported more realistic threats.

Table 6: The realism of the threatening event

Sub-category	*Exp. group* Frequency	Valid Percentage	Cumulative Percentage	*Cont. group* Frequency	Valid Percentage	Cumulative Percentage
1,00	81	55,5	55,5	48	72,7	72,7
2,00	34	23,3	78,8	7	10,6	83,3
3,00	25	17,1	95,9	9	13,6	97,0
4,00	0	0,0	95,9	1	1,5	98,5
5,00	6	4,1	100,0	1	1,5	100,0
Total	146	100,0		66	100,0	

Discussion

The purpose of the present study was to test some of the predictions made by TST (Revonsuo, 2000a). The frequency and quality of threatening events in dream reports were compared between a group of traumatized subjects and a control group. TST suggests that the function of dreaming is threat simulation and predicts that personal experience of highly threatening situations will lead to the threat simulation system becoming fully activated. People with very little or no experience to threatening situations should have a poorly activated threat simulation system in comparison. If the predictions made by TST are correct, the traumatized subjects should report more frequent threatening events in their dream reports than the control subjects. The threatening events reported by the traumatized subjects should also be more severe than the threats reported by the control subjects. Further, to support the hypothesis that mental rehearsals during dreaming enhances the dreamer's threat avoidance

skills, the traumatized subjects should more often react to the threatening events than the control subjects.

The Frequency of the Threatening Events

The traumatized subjects were predicted to report more threatening events per dream report than the control subjects, as the threat simulation system would have a higher degree of activation after exposure to threatening situations in waking life. The trauma group reported more frequent threatening events, however, when taken into consideration that the trauma group consisted of more subjects than the control group, the resulting difference is negligible. These results do not seem to support the prediction made by TST. On the contrary, since the control subjects were Swedish adult females, raised with no particular threats in the environment, these results rather seem to indicate that, even if there is a threat simulation system that produces dreams depicting threatening events for rehearsal, the system does not show different levels of activation depending on traumatic experience. However, in the studies by Valli et al. (2005; 2006) there were significantly more frequent threatening events in dream reports by traumatized subjects than by non-traumatized subjects.

The Quality of the Threatening Events

The nature of the threatening event.

There were significantly more occurrences of accidents and misfortunes in traumatized subjects' dream reports, as well as a relatively higher amount of threats depicting different forms of aggression and pursuits. These results both give support to TST, as traumatized subjects are predicted to report more occurrences of threatening events that were present in the ancestral environment. Even though the system constantly incorporates new

information from our daily lives, it is based in the ancestral environment where specific types of threats were more common than others. Aggression and pursuits could be traced to hunting highly dangerous animals, as well as protecting oneself, significant others and resources from other ancestral humans, and accidents and misfortunes were probably common in the unprotective and harsh environment. Being late and failing to carry out a certain task were probably not as important and severe as they would be considered to be in modern times. Catastrophes were surely highly severe but perhaps not common enough to earn frequent simulations. Disease, illness and medical problems should be expected to earn frequent simulations as they were probably very common and severe in the ancestral environment, but perhaps it is too difficult a threat to rehearse avoidance from. The frequency of accidents and misfortunes might also be a result of the traumatized subjects in the current study being traumatized by an uncontrollable natural event in the environment, as opposed to unnatural events, e.g. abuse, assault, imprisonment and war. The amount of aggression is similar to that found by Valli et al. (2005), however, in their study, the amount of accidents and misfortunes in the trauma group were significantly lower than in the control group.

The target of the threatening event.

There was no significant difference regarding the targets of the threatening events. The traumatized subjects did, however, report a relatively higher amount of insignificant persons and resources as targets than the control subjects. The higher frequency of insignificant persons and resources in itself does neither support nor criticise TST. If the higher frequency of accidents and misfortunes could be explained by the nature of the traumatized subjects' experience, the higher frequency of insignificant others as targets might similarly be explained as an influence of the catastrophic nature of that traumatic experience, which affected many more insignificant than significant others.

What is more interesting is that there was no difference in frequency of significant others and insignificant others within the trauma group, nor within the control group. TST predicts that simulations of threatening events affecting significant others should be more frequent due to the need for the dream Self to rehearse protection of significant others. If a dream character is carrying partly the same genetic make-up as the dream Self, or if the dream character in some way can benefit the reproduction of the dream Self, it would be in the best interest for the dream Self to learn how to protect these individuals in order to get a bigger chance of passing on its own genes in waking life. This result does seem to support TST. There was a significantly increased frequency of insignificant others reported in the threatening events of the trauma group, compared to the control group, in the study by Valli et al. (2006), comparable to the present study, although, there were also significantly increased frequencies of significant others reported in the studies by Valli et al. (2005; 2006), which was missing in the present study.

The severity of the threatening event.

There was a tendency for the threatening events reported by the trauma group to be more severe than those reported by the control group. There was a higher frequency of life-threatening events in the traumatized subject's dream reports. These results, although not statistically significant, give support to TST. As the threat simulation system becomes more activated, through waking life traumatic experiences, TST predicts that the simulated threats will become increasingly severe. Interestingly enough, the frequencies of minor threats and physically severe threats were basically the same for both groups, indicating that only socially, psychologically and financially severe threats were affected by the increased activation of the threat simulation system, and modified to make room for a higher number of life-threatening events. Why the minor threats were not decreased instead of the socially,

psychologically and financially severe threats is unclear, since the latter must be of higher importance to rehearse. Valli et al. (2005; 2006) reported more severe threatening events for trauma groups, in general, which is in accordance with the indications of the present study.

The participation of the self in the threatening event.

For the categories "the possibility for the self to react to the threatening event", "the participation of the self in the threatening event" and "the reaction of the self to the threatening event" there were no differences between the trauma and control groups. These results do not support TST, as it predicts that, in order for the dream Self to gain any threat avoidance skills from dream rehearsal, the dream Self should actively participate in resolving the threat, as well as react in a reasonable and sufficient manner with regard to the nature of the threatening event. When the threat simulation system becomes more activated, the dream Self should become more active and the actions taken should become increasingly more reasonable and sufficient. Similar results were reached by Valli et al. (2005; 2006), which showed no differences between groups.

The realism of the threatening event.

There were no significant differences between trauma and control groups regarding the realism of the threatening events, however, there was a tendency for the trauma group to report more bizarre elements, in sum, than the control group, which reported more realistic events. These results are in direct contradiction with the predictions made by TST. According to the theory, simulations of threatening events should be highly realistic, and as the threat simulation system becomes more active, the realism should increase, even further. These

results indicate the opposite, that the threatening events simulated for the traumatized subjects had become more bizarre, following the traumatic waking life experience.

Summarized Support For TST

In sum, the present study gives mixed support for TST. Only one prediction got statistically significant support, namely that traumatized subjects should report more threats similar to those experienced by the ancestral human in waking life.

Two tendencies were observed: a higher frequency of life-threatening events reported by the trauma group, which supports TST, and surprisingly, a higher frequency of bizarre elements in the threatening events reported by the trauma group, which seems to be in direct contradiction with the predictions made by TST.

Further, two non-significant but relative differences were observed regarding the nature of the threatening event and the target of the threatening event. The trauma group reported more threatening events depicting aggressive situations and escapes or pursuits, which gives support to TST. The trauma group also reported insignificant persons and resources to be the targets of more threatening events than the control group did, which does not support TST.

Finally, the predictions that traumatized subjects should report more threatening events per dream report, participate more often and react more reasonably to the threatening events were given no support. The trauma and control groups showed no differences in these categories.

Alternative Interpretations

Alternative explanations to the threat simulation theory are possible, in light of the present study's results. Hartmann's (1996) theory of a psychological function for dreaming might be able to explain some of the findings. The central point of Hartmann's theory is that dreaming helps the dreamer cope with emotional and traumatic concerns. By incorporating unrelated memory traces to the traumatic memory, the emotional strength of the memory should weaken and eventually resolve the trauma. Although unrelated dream images are incorporated to the traumatic memory, the central emotion, or theme, is forever present. The higher frequency of life-threatening aggressive themes and events depicting accidents and misfortunes could be traces of the original traumatic memory, which has been diluted by unrelated dream images but still representing the central emotion, or theme. Similarly, the higher frequency of bizarreness might be explained by this incorporating process, which blends almost random images together. It is also possible that the increased frequency of insignificant others as targets is a trace from the original trauma, which had the traumatized subjects witnessing many insignificant persons being targeted by the disaster. However, just as TST, Hartmann's theory predicts an increased frequency of threatening dream events after trauma and is not able to explain this absent difference.

Hobson & McCarley's (1977, cited in Farthing, 1992) "activation-synthesis hypothesis" has difficulties explaining any of the present results, due to the supposedly random nature of dreams. If dreams are constructed randomly by matching memory traces with physiological events, there would be no noticeable differences between traumatized and non-traumatized subjects regarding e.g. the nature of threatening events or the target of the threatening events. However, it might be able to shed some light on the higher frequency of bizarreness by referring to the isomorphism mechanism. Perhaps there is more activity and

restlessness in the bodies of traumatized subjects due to stress and anxiety, which influences the dream production in a way that incorporates more bizarre elements.

Limitations

The present study.

First, the subjects were asked to write their dream reports at home, after regular awakening during the night or in the morning. Home-based dream reports result in much worse dream recall compared to e.g. dream reports made in laboratories with determined awakenings. Home-based dream reports are also biased, as most reports will probably be made after waking up from a vivid dream in REM sleep, making the resulting statistics of dream reports represent most heavily just one type of dreams from one stage of sleep. In a more controlled environment, like a sleep laboratory, awakenings can be made during any sleep stage, making the resulting statistics more representative of dreams in general.

Second, the subjects consisted of only females. Since the study was aimed at comparing traumatized subjects to non-traumatized subjects, the results, had they been significant to a large extent, should still be regarded as trustworthy. If the results show that there is a difference between traumatized females and non-traumatized females, that tells something about the function of dreaming, and it should not be completely disregarded. However, it is, in principle, possible that females have a distinctly different function of dreaming than males, or, perhaps more reasonable, that there are some minor or major characteristic differences in e.g. the nature or target of the threatening event. Maybe the dreams of male subjects are affected more by traumatic experience than the dreams of female subjects? Previous studies have shown that male subjects dream more often about aggression and direct violence than female subjects (Revonsuo & Valli, 2000; Valli et al., 2005;

Domhoff, 1996), and TST predicts an increased frequency of aggressive, and other ancestral-traced, threats in traumatized subjects. This gender difference in non-traumatized subjects might have implications for the collective differences in traumatized subjects. For this, and all of the above-mentioned reasons, the results of an all-female study should not be generalised to represent dreaming as a whole.

Third, although the subjects were asked to write down any dreams they could remember having had directly after the trauma, most dreams were reported almost two years after. As the effect of trauma on dream content is decreased more and more as time passes (cf. Hartmann, 1996), the results might not be fully representative of what the study was intended to measure. The few dreams that directly followed the trauma should be more representative, as the dream content would be more affected. However, since they were recalled from so long ago, many aspects and features of the dream content might have been forgotten or embellished.

Finally, the sample of subjects was very low, which made it difficult to get significant results. In some cases it was necessary to combine sub-categories in order to get a higher frequency and thus better results. Even though significant results were hard to obtain, because of the low frequencies, a comparison of percentage could still give an indication as to what kind of results might have been found significant with a larger sample.

The Threat Simulation Theory.

Most evidence support TST, though there are some common counterarguments: 1) Emotionally charged events are more easily remembered and are thus more frequently mentioned in dream reports. The high amount of threats and negatively charged dream events could simply be attributed to their emotional charge, not to their being over-represented. 2) The bizarre elements and disorganized dream might not allow simulations of realistic

threatening events. 3) PTSD and nightmares disturb sleep and are dysfunctional and can therefore not be regarded as good or functional for the dreamer. 4) Dreaming simulates so many other things, as well, that threat avoidance cannot possibly be its only function. 5) TST is in principle untestable, and thus can be neither falsified nor verified (Revonsuo, 2000b; Valli & Revonsuo, in press).

In response to the argument of emotionally charged memories being easier to recall than mundane ones, this is true not only for dream memories but also waking life memories. We have a tendency to forget about all those everyday events that we experience during the day and only remember those with greater emotional impact. If the frequency of experienced threats during dreaming is compared to the frequency of experienced threats during waking life, threats are much more frequent in dreaming than in waking life (Valli, Strandholm, Sillanmäki & Revonsuo, submitted; Valli & Revonsuo, in press).

Bizarreness has commonly been regarded as a frequent and defining feature of dreaming, however, it actually only affects a small percentage of dreams. Most dreams are well-organized with regard to dream people and objects, as well as the general setting and environment (Rechtschaffen & Buchignani, 1992; Revonsuo & Salmivalli, 1995). Since the threat simulation system only becomes fully activated after the dreamer has experienced real waking life threatening events, it is of importance to point out that dreams become more realistic and less bizarre after the dreamer has experienced traumatic events (Punamäki, 1997).

Although PTSD and frequent nightmares do disturb sleep, there are reasons to believe that the ancestral human did not suffer from these conditions in the same way as the modern human does. In the ancestral environment, life threatening situations were very common, and since they were in most cases connected to everyday events, they were most often experienced as familiar and predictable threats. The general level of stress and trauma in

the ancestral human was very high, from childhood to adulthood. The modern environment is, in one way, extremely protective and safe, but can also be extremely devastating and horrifying (e.g. wartime combat and imprisonment in concentration camps). The nature of some modern threats is probably even more terrifying than anything the ancestral human ever faced in the natural environment. Threats such as wartime combat and concentration camp imprisonment are highly unnatural threats with long periods of exposure to several stressful situations, e.g. sleep deprivation, imprisonment, torture and witnessing mass murder. The modern humans are used to very low levels of stress, compared to the ancestral human, and very infrequent threats, but when one goes from extremely protected to extremely threatened in an instant, the resulting trauma becomes much more devastating than what the ancestral humans probably ever experienced. Hunter-gatherer populations in modern times that are used to high levels of stress and threatening situations, similar to the ancestral human, support this theory. Despite their constantly threatening environment, they are in general unaffected by PTSD (Revonsuo, 2000b). This indicates that PTSD and sleep-disturbing nightmares are a result of the conflict between the ancestral mind and the modern-day society, and the threat simulation system having too much to work with.

It is possible to imagine dreaming having other simulative functions than threat avoidance, however, from an evolutionary perspective, threat simulation is the most plausible one. Simulations such as adjustment to novelty, social interactions, interpersonal understanding, motor functions and spatial learning have been suggested, however, they all involve little costs if they were to be practiced in waking life, as opposed to real threats that could often be fatal. Therefore, fitness benefits are higher from simulating threatening events with high costs if practiced during waking life, compared to other situations that have very little, or no, costs (Revonsuo, 2000b; Valli & Revonsuo, in press). TST is not, however, aimed at explaining the one and only function of dreaming as threat simulation. Revonsuo

(2000b) does not completely disregard any other possible functions of dreaming, e.g. social interactions, but the burden of proof is on those that propose these other functions to show how it would be beneficial from a fitness-perspective. TST is simply aimed at explaining threat simulation as one function of dreaming, which, as it seems, might very well be the only function.

To analyse the testability of TST one must first divide between testing the function of dreaming and testing the evolutionary source behind dreaming. The function of dreaming is unrelated, by its function alone, to its evolutionary source. We can test the predicted function without necessarily knowing anything about its source. If TST holds up, we should be able to find more frequent manifestations of threatening events than non-threatening events by analysing dream content, and the dreamer should react in a reasonable way as an attempt to avoid the threatening situation (Revonsuo, 2000b). The evolutionary source of dreaming is much more difficult to directly test, however. We can never know exactly what our ancestors dreamed about, but we can look at what kind of environment they lived in and what situations they frequently found themselves in. With increased knowledge about what selection pressures operated at the time, we can postulate increasingly specific hypotheses regarding what types of events should be most important for the threat simulation system to simulate, and thus we can assume what kind of dream content we should find also in modern times. Whether or not the threat simulation system led to greater survival skills and reproductive success is not directly testable either, as that would require large samples over several generations to be studied (Valli & Revonsuo, in press). However, we should, in principle, be able to test if frequent and intense dream threats increase threat avoidance skills, e.g. by enhancing threat recognition, lowering reaction times and priming the optimal behaviour response. We can also test the opposite, if the lack of threatening dream events decrease threat avoidance skills, e.g. by increases reaction time. Such studies would however require

knowledge about the exact neural and cognitive subsystems responsible for threat recognition and threat avoidance to know exactly what to measure (Revonsuo, 2000b; Valli & Revonsuo, in press).

Conclusions

The results derived from this study show that traumatized subjects dream more often about threats suspected to be common in the ancestral environment. The traumatized subjects' dreams include more accidents and misfortunes, as well as more aggressive threatening events. The results also indicate that the dreams of traumatized subjects are more severe, including more life-threatening events than the dreams of non-traumatized subjects. These results support the predictions of TST. Further, the results indicate that traumatized subjects dream about more bizarre and unrealistic threatening events than non-traumatized subjects. Traumatized subjects do not seem to participate more often to threatening events than non-traumatized subjects, nor do they seem to react in a more reasonable manner to the threatening events. These results do not support the predictions of TST. The present study suffers from some methodological limitations and overall the results give mixed support for TST and the results of previous studies.

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