Master Degree Project

UNIVERSITY
OF SKÖVDE

1977

**THEORIES OF NIGHTMARES
IN COGNITIVE
NEUROSCIENCE AND
PSYCHOLOGY**

Master Degree Project in Cognitive Neuroscience
One year 30 ECTS
Spring term 2015

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Thesis title: *Theories of Nightmares in Cognitive Neuroscience and Psychology*

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The above noted work is submitted to the School of Bioscience at the University of Skövde, as a final year Master project toward the degree of Master of Science in Cognitive Neuroscience. The project has been supervised by Antti Revonsuo.

I, Emilia Chamorro, hereby declare that:

1. The above noted work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any other degree.

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Theories of Nightmares in Cognitive Neuroscience and Psychology

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Abstract

Dreaming is a complex, multimodal and sequentially organized model of the waking world (Metzinger, 2003). Nightmares are a category of dreams involving threatening scenarios, anxiety and other negative emotions (Hartmann, 1998; Nielsen & Levin, 2007). Dreams and nightmares are explored in this present thesis in the light of psychology and modern cognitive neuroscience as to their nature, function and neural correlates. The three main dream theories and their leading investigations are reviewed to evaluate their evidence and overall explanatory power to account for the function of dreams and nightmares. Random Activation Theories (RATs) claim dreams are biological epiphenomena and by-products of sleep underlying mechanisms (Crick & Mitchison, 1983; Flanagan, 1995, 2000a, 2000b; Hobson & McCarley, 1977). Mood regulation theories consider that the psychological function of dreams is to regulate mood and help with the adaptation of individuals to their current environment such as solving daily concerns and recovery after trauma exposure (Hartmann,1996; Levin, 1998; Stickgold, 2008; Kramer, 1991a, 1991b, 2014). Threat Simulation Theories of dreams present the evolutionary function for dreaming as a simulating off-line model of the world used to rehearse threatening events encountered in the human ancestral environment (Revonsuo, 2000a). With the threat-simulation system, threats were likely to be recognized and avoidance skills developed to guarantee reproductive success. TST consider nightmares to reflect the threat-simulation system fully activated (Revonsuo, 2000a). Supported by a robust body of evidence TST is concluded to be the most plausible theory at the moment to account as a theoretical explanation for dreams and nightmares.

Key words: Adaptation, bad dream, dream, function, idiopathic nightmare, Mood regulation Theories, nightmare, post-traumatic nightmare, RAT, recurrent dream, TST.

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Introduction

Dreaming is a natural and physiological phenomenon occurring during sleep (Revonsuo, Tuominen, & Valli, 2015). It is considered the most common type of altered state of consciousness (ASC) containing various subjective experiences such as sensations, perceptions and emotional content similar to waking life (Valli, et al., 2005). Because of the similarities to wakefulness, dreams are considered an important source of providing scientific insights into understanding and describing the nature of consciousness (Revonsuo, 1995; 1998). Thus, unlike waking reality where one is aware of conscious experience, to the dreamer the events occurring in dreams are not recognized as a concoction. It is upon awakening that the sleeper realizes the events experienced previously were not real. Similarly, nightmares are a category of dreams vividly experienced by the dreamer involving threatening scenarios, anxiety and other negative emotions (Hartmann, 1998; Nielsen & Levin, 2007).

Within the fields of psychology and cognitive neuroscience many theories and hypothesis have been proposed to clarify what dreams and nightmares are, their nature, function and neural correlates (Nielsen, 2011). However, there is still no convincing explanation for why they are experienced so commonly and if they are useful to the organism or not. Dream researchers keep trying to reach consensus in clarifiying conceptual confusions when describing mental states (Hobson, Pace-Schott, & Stickgold, 2000a). Nevertheless, they still disagree in elaborating useful concepts for this research field. Moreover, when it comes to measuring and quantifying empirical data of dreams as to content, form and frequency of occurrence, there is not yet a clear methodological standard that every researcher in the field follows consistently. The various instruments used seem to yield different results (Kahan & LaBerge, 1996; Robert & Zadra, 2008; Schredl, 1999, 2002; Sikka, Valli, Virta, & Revonsuo, 2014; Zadra & Robert, 2012). Data

yielded by studies should objectively reflect the subjective experience of the dreamer. Thus, the main problem dream research faces involves theoretical explanations of dreams and nightmares and finding a solution into how future guidelines of dream research should be directed. Theories worth considering as explanations for the nature and function of dreams and nightmares should contain a theoretical background that can be supported by empirical evidence. Researchers should reach a more unified understanding about the methodological standards that everybody should follow, to produce valid and reliable empirical evidence about dreams and nightmares.

There are three main goals in this present thesis. The first one is to describe in the light of psychology and modern cognitive neuroscience what dreams and nightmares are and why they are so commonly experienced. The second goal is to review the literature on the theories and empirical findings concerning definitions, occurrence, neural correlates and theoretical explanations of these phenomena. The third and last goal of this thesis is to discuss and evaluate the main current dream theories as to their strengths and weaknesses. This will include considering evidence for their overall explanatory power to account for the existence and nature of dreams and nightmares. Furthermore, their strengths and limitations will be contrasted as a guideline into how future research should be directed to achieve a successful clarification for these phenomena.

Theories of Nightmares in Cognitive Neuroscience and Psychology

This thesis will begin by elucidating the current concepts of dreams and nightmares. Next, these phenomena will be explored according to leading investigations in dream research. Furthermore, the three theories that will be discussed are the main ones in cognitive neuroscience and psychology which offer an explanation for both dreams and nightmares using the same underlying principles. These theories are: 1) random activation theories (RATs), 2) mood regulation theories, and 3) evolutionary perspective theories. The RATs conceive dreaming as an epiphenomenon. Researchers supporting this perspective consider dreams as by-products of underlying sleep mechanisms (Antrobus, 2000; Hobson, 1988; Hobson et al. 2000a; 2000b). The second approach claims dreams fulfill psychological functions by regulating emotional concerns and promoting well-being. In this theory nightmares are seen as a dysfunction of the healing process or mood regulatory mechanisms (Domhoff, 2003; Hartmann, 1995, 1996, 1998; Nielsen & Levin, 2007). The third and last approach that will be explored is evolutionary theories of dreaming. These last propose that dreams and nightmares serve a biological function (McNamara, 2004, 2008; Revonsuo, 2000; Valli & Revonsuo, 2007). In the final part of this thesis, overall strengths and weaknesses of each theory will be compared and contrasted to potentially direct future research.

Dreams and Nightmares: subjective experiences during sleep

Given the various fields of science involved in dream studies an agreement in describing and defining its main notions has been problematic (Pagel, et al., 2001). Therefore, an approach unifying a definition of the basic nature of dreaming (Revonsuo, Tuominen, & Valli, 2015) should be inclusive rather than exclusive (Pagel, et al., 2001). Pagel et al. (2001) propose that by including different concepts and a categorization system, findings from similar studies can be

objectively compared and integrated. In such a way, the main goal of explaining the

phenomenon with a systematic, normative and statistical approach will be succesfully reached

(Valli, 2008). Understanding experiential processes such as dreams and nightmares requires

studying its features and elaborating a concept that is clear and descriptive of the phenomenon

under investigation (McNamara, 2008).

Concepts of dreams and nightmares

Metzinger (2003) defines dreams as complex, mutimodal and sequentially organized

model of the waking world. He claims dreams satisfy important constraints of conscious

experience such as presentationality (the feeling of being in the world), globality (the world

dreamer is immersed and experiencing subjectively), and transparency (property of availability

of active mental representations). According to Revonsuo et al. (2015) dreams are an ASC

(altered state of consciousness) occurring during sleep where the dreamer finds himself

embodied and immersed in an experiential reality.

The concept of dreaming has undergone theoretical changes that may become beneficial

to dream research. According to Revonsuo et al. (2015) the main disagreement in dream studies

consists in defining dreams by content and function. However, the notion that dreaming is a

"simulation of the world" now serves to unify the basic nature of dreaming concept in the field

of consciousness studies (Revonsuo et al., 2015). By now, the idea of world simulation proposed

by Revonsuo (1995) is incorporated by many researchers (Domhoff, 2007; Feinberg & Keenan,

2005; Foulkes, 1999; Hobson, 2009; Metzinger, 2003; Nielsen, 2010; Windt, 2010), although,

perhaps not by using these same words, but incorporating the central idea nonetheless. Dream

consciousness consists of phenomenological differences and similarities with the waking world

(Hobson, 2009). Because of the similarities between them, dreaming is explained in terms of

alternative reality (Domhoff, 2007; Hobson, 2009; Metzinger, 2003; Revonsuo, 2000; Revonsuo et al., 2015;Windt, 2010).

Revonsuo (2006) suggests that instead of defining dreams in terms of a strict definition it should rather be seen as a continuum. At one end of the continuum are genuine dreams with complex features that simulate the form and contents of dynamic perceptual world characteristics and at the other end, low complexity subjective experiences such as sleep mentations (Revonsuo, 2006). That is, experiences can be described ranging from simple images, unimodal static disorganized experiences where the fragmented perceptual content does not bind together to form a simulated world (Feinberg & Keenan, 2005), to full blown, complex, temporally progressing hallucinoid scenes where there is an interaction between the dreamer and the dream-world (Scarone, et al., 2008). Thus, experiences occurring during sleep-dream transitions in the continuum can be classified by the complexity of the subjective experience involved (Windt, 2010). As wakefulness approaches sleep or sleep approaches wakefulness hypnagogic and hypnopompic hallucinations may take place respectively. These hallucinatory states mix together features of waking perception and dreaming, and are experienced as perceptually vivid, visual, auditory or bodily feelings (Ohayon, Priest, Caulet, & Guilleminault, 1996). Terrifying hypnagogic hallucinations arise from REM sleep onset and this is why they may be aggravated by factors predisposing this stage of sleep. Narcolepsy is the most common factor; nonetheless, other factors may be involved as well. Withdrawals of medicines that suppress REM sleep, chronic sleep deprivation, and sleep fragmentation are also significant causes that affect hypnagogic hallucination episodes (Nielsen & Zadra, 2000)

Since REM sleep is activated in both hypnagogic and hypnopompic hallucinations, images are internally generated and a mixture of waking and dreaming experience follows

(Revonsuo, 2009). Because hypnopompic hallucinations occur in proximity to wakefulness, a vivid sense of reality may provoke an increased level of anxiety. A feeling of paralysis is commonly experienced causing them to be more disturbing than nightmares (Nielsen & Zadra, 2000). Additionally, the most common experiences identified by the sleeper are the feeling of falling into an abyss and vividly facing an acquaintance where one is about to be attacked (Ohayon et al., 1996).

Sleep paralysis and sleep terrors are also types of parasomnias or sleep disturbances that mix together some features of different sleep stages with wakefulness, resulting in unpleasant sleep experiences. They both resemble features with nightmares and bad dreams such as felt frightening arousals and manifested fear (Nielsen & Levin, 2007). Nevertheless, they will not be broadly discussed in the present thesis because they represent mental activity occurring during sleep that does not meet the criteria of dreaming properly (Hobson, Pace-Schott, & Stickgold, 2000b).

At the other end of the continuum, where full-scale simulations of the perceptual world happen (Feinberg & Keenan, 2005) dreams, bad dreams and nightmares occur. Nightmares and bad dreams are vividly experienced by the dreamer and involve threatening scenarios, anxiety and other negative emotions (Hartmann, 1998; Nielsen & Levin, 2007). According to the standard diagnostic text DSM V nightmares are disturbing, emotionally intense dreams that wake up the dreamer (American Psychiatric Association, 2013). If the negative dream does not manage to awake the sleeper, it does not meet the threshold for a nightmare and is consequently considered as bad dream (Blagrove & Haywood, 2006; Zadra, Pilon, & Donderi, 2006). However, not all dream researchers consider this division between bad dreams versus nightmares useful, especially when it comes to dream studies of children (Simard, Nielsen,

Tremblay, Boivin, & Montplaisir, 2008). According to Spoormaker, Schredl, & van den Bout (2006) the awakening criterion is not related to the increased distress of nightmares. In a study conducted by Blagrove, Farmer, and Williams (2004) it was demonstrated that the negative tone of frequent bad dreams was a better index of low well-being when compared to the frequency of nightmare distress to well-being. This suggests that even though a bad dream does not manage to awaken the dreamer, it may still be intense and as negatively toned. The classification of nightmares and bad dreams according to standardized diagnosis manuals (e.g. DSM IV, V) consider the division merely for clinical distinction. A bad dream in this sense represents a dream with mild negative content. Additionally, according to clinical diagnosis, nightmares contain strong negative emotionality. By the means of this thesis, the distinction between bad dreams and nightmares will be considered only in cases where the study explored includes this clinical classification criterion. Contrariwise, since in research the dream content of both can be equally negative and with no emotional variances, they will be considered nightmares as most of dream researchers do (e.g. Simard et al., 2008).

Nightmares are categorized into two subgroups: Idiopathic Nightmares (I-NM) and Post-traumatic nightmares (PT-NM). I-NM are caused by unknown factors (American Psychiatric Association, 2013) and according to Nielsen and Zadra (2011) they are the most common form of disturbed dreaming. Though other researchers may argue that all nightmares do not necessarily disturb sleep, and the notion of "disturbed dreaming" presupposes that nightmares cannot be a functional form of dreaming (Revonsuo, 2000b). I-NM are commonly associated with nightmare chronicity. People reporting them have a life long history of frequent nightmares (Berquier & Ashton, 1992). PT-NM they are typically related to Posttraumatic Stress Disorder (PTSD) and are claimed to contain increased affect load and increased trauma severity when

compared to nightmares and bad dreams (Levin & Nielsen, 2007). Since PTSD criteria include

re-experiencing the traumatic event in nightmares or through flashbacks (American Psychiatric

Association, 2013), PT-NM are usually considered the re-experiencing of that event

(Spoormaker et al., 2006). Still, they may not be exclusive to PTSD (Germain & Nielsen, 2003;

Nielsen & Levin, 2007).

Domhoff (1996) suggests a repetition dimension in dream contents. He proposes that

dreams in general have a repetition dimension (e.g. recurrent dreams in children and adults), and

this dimension is just strongest in post-traumatic dreams. This kind of dreams can vary along a

continuum ranging by their intensity manifested by repeatedly reproducing overwhelming

experiences. They can be found on one side of the continuum. Further along the continuum,

recurrent dreams characterized by content repetition can be found. Most recurrent dreams

manifest as consequence of a conflict in a similar way that traumatic dreams activate as a

consequence of traumatic experience. Lastly in the repetition continuum, recurrent themes occur.

In this category the dream series preserves the main theme. However, there is a content variation

(Domhoff, 1996).

Zadra (1996) also agrees that repetition themes differ from recurrent dreams. These last

ones have an identical dream content through out the whole dream. He claims most recurrent

dreams have a negative content and are usually activated by stressful periods (Zadra, 1996).

Measurements of dreams and nightmares

Even though dream research experimental methodology has no method 100% accurate at

the moment. Many studies have shown that when measuring dream frequency or dream content

results may vary depending on the method of assessment (e.g. dreamer vs judges scoring the

same dream report or retrospective vs prospective questionnaires) (Kahan & LaBerge, 1996;

Robert & Zadra, 2008; Schredl, 1999, 2002; Sikka et al., 2014; Zadra & Robert, 2012). The most common measurement techniques applied to asses dream recall frequency (quantitative) and dream content (qualitative) are retrospective questionnaires, lab awakenings, and dream diaries or dream logs (Schredl, 1999).

Retrospective questionnaires in different forms (binary, nominal, ordinal, and open-ended choices) are traditionally used to assess nightmare frequency (Robert & Zadra, 2008). It is considered the simplest and most cost-effective method (Valli, 2008) which relies on estimates about dream and nightmare frequency provided by the participants (Schredl, 1999). In questionnaires participants are usually required to answer how many dreams or nightmares they had in the last week, 2 weeks, and so on (Zadra & Donderi, 2000b). According to Schredl (2002) questionnaires are commonly implemented in large samples for they are not time-consuming. With this method, dream recall is obtained in its natural form as it is not affected by measurement procedures (Schredl, 1999) such as focusing attention in dreams and producing longer and more detailed dream reports. However, one main disadvantage they present is the lack of precision of measuring dream occurrence and dream content due to memory bias of the dreamer after awakening (Schredl, 1999; Zadra & Donderi, 2000b). In other words, retrospective questionnaires have limited access to reveal the detailed quantity and quality of dreaming (Valli, 2008). According to Zadra and Donderi (2000b) nightmare frequency may also be underestimated with retrospective self-reports (obtained in various time lapses after dreaming experience occurred) when compared to daily dream logs (obtained upon awakening) because sometimes the questions formulated are not well understood by the participants.

Dream reports obtained from laboratory awakenings are the most expensive approach to assess dream recall as it requires equipment to measure physiological parameters such as

polysomnography containing EEG (Electroencephalograph), EOG (Electrooculography), ECG (Electrocardiogram), respiration and heart rates (Schredl, 1999). However, they are necessary to understand the underlying mechanisms of dreaming. By this means, it is also possible to collect data and know during which stage of sleep dream experience is produced (Domhoff, 1996). This method is characterized by collection of systematic and detailed dream content recall upon the participant's awakening (Valli, 2008). The major disadvantage of this approach lies in the unfamiliar setting of the lab, the uncomfortable EEG electrodes, and nocturnal interruptions by the experimenter (Schredl, 1999). As consequence this may have a negative impact on the data collected as subjects tend to incorporate in their dreams elements related to the lab environment (Domhoff, 1996). However, recordings of dream recall upon awakenings conducted in the lab decrease memory bias of retrospective measures (Shredl, 1999). Participants become more focused on their dreams and consequently more aware, leading to provision of more detail in the dream descriptions (Beaulieu-Prévost & Zadra, 2005).

Dream diaries have supplanted retrospective questionnaires as they are a more standard estimation for nightmare frequency (Levin & Nielsen, 2007). Participants can report their dream recall at the privacy of their home (Valli, 2008). This suggests that no lab intrusions are incorporated to dreams (Domhoff, 1996). In this approach, participants are asked to complete every morning after awakening a detailed report of their dream recall (Schredl, 1999). With dream logs, participants can also increase the reported dreaming frequency significantly (Schredl, 1999). According to Levin and Nielsen (2007) an advantage of this method of measurement is that they typically contain a definition to make a distinction among the types of dreams under investigation. However a pitfall is that physiological correlates cannot be measured. Thus, in addition to the dream diaries, researchers now incorporate the Nightcap.

According to Ajilore, Stickgold, Rittenhouse and Hobson (1995) the Nightcap is an ambulatory measurement device that detects small eye movements distinguishing them in REM (Rapid eye movement) and NREM (Non rapid eye movement) stages of sleep. An advantage of this portable equipment is that data can be collected in a personal computer and spontaneous awakenings can be programmed at desired time lapses. The Nightcap has proven to be a reliable system for detecting sleep onset latencies during day time naps or at night sleep (Cantero, Atienza, & Hobson, 2002).

After collecting the data, it is necessary to describe the quantity and quality of dreaming as accurately as possible. To produce statistical outcomes, verbal reports (qualitative data) have to be transformed into quantitative data (Valli, 2008). This is carried out by dream content analysis (Hall & Van de Castle, 1966). The most common dream coding system utilized for content analysis is the Hall and Van de Castle system (1966). These normative studies show cultural, gender and individual differences among dreams and are based on dream reports of American college students compared to other population groups (Domhoff, 1996). This method shows many advantages over other coding systems: reliability, categories are psychologically relevant and standardized forms (Domhoff, 1996).

Even though the Hall and Van de Castle coding system comprises many categories, by the means of this thesis the most relevant to bad dreams and nightmares will be discussed more in depth. Similarly, the current version of this method elaborated by Domhoff (1996) will be more often referenced.

Phenomenological level of description

In this section a qualitative description of dreams and nightmares will be presented to provide an approach into what dreams are made of. Also, the typical themes that usually appear

in dreams and nightmares, their characteristics and the way they interact among each other. Emotionality and other dream features such as bizarreness will be explored as well.

Dreams and nightmares must present a minimal set of phenomenological characteristics to be categorized as so (McNamara, 2008; Windt, 2010). The stereotypical features dreams present, briefly summarized, are the following: delusion, narrative structure, hyperemotionality, bizarreness, hallucinatory perceptions (Hobson, 1988, 2001; Hobson et al., 2000a; Windt, 2010) and cognitive deficiencies (Pagel et al., 2001). Even though nightmares have similar features as dreams such as the ones described above, they present their unique characteristics as well.

Dream form and dream content

According to various studies of dream content that have been conducted globally there is a consistency in which people of different countries and with different cultures dream similarly (e.g. Hall & Van de Castle, 1966). Certain types of characters, social interactions, objects and activities are present in dreams cross-culturally and remain consistent over the years (Domhoff, 1996).

Dream-self, reflectiveness and sensory modalities. The dream-self is an internally generated representation of the dreamer in the dream (Revonsuo, 1995). The dream-self is present in almost every dream, however, the focus of attention is not directed to the self but instead to the environment and the events happening around (Revonsuo & Salmivalli, 1995). According to Revonsuo (1999) the subject dreaming experiences himself as a body-image in an spatially extended world where he has different encounters with objects, people and any kind of events may happen around him. In this perspective of phenomenology a dream is like an offline model of waking consciousness where the subject feels surrounded by the presence of a world (Metzinger, 2003). That is, characterized by the feeling of being immersed in a multimodal

experiential reality (Revonsuo, 1999). Dreams are experienced as lived in present time (Windt, 2010). As suggested by Metzinger (2003) dreams are such as the "presence of a world".

Hobson et al. (2000a) claim dreams are characterized by a lack of self-reflection. When one is inside a dream, it is not possible to control actions or the focus of attention (Hobson et al., 2000a). For example, one can assume that when the sleeper is dreaming, he loses the ability to decide where and when to go or what to do. It is unusual to choose the script of what is said or the scenario where a dream takes place. Altering the aforementioned features of the dreaming-world by selecting places, persons or objects of interaction is unlikely to occur.

In this phenomenological state, reflecting upon thoughts and emotions as it usually happens in wakefulness becomes unlikely (Hartmann, 1998). That is, the ability to consciously decide decreases in dream-life (Hobson, 2000). Metzinger (2003) suggests that due to the disorientation feature of dreams and the bizarre thought, cognitive processes such as working memory becomes severely impaired. In this same way, abstract thinking and metacognition are rarely found in dreams (Hartmann, 1996; Hobson, 2009). Hartmann (1996) conducted two studies where dreaming of the three R's (reading, writing and arithmetic) was almost absent. He claims that even though these are activities clearly important and usual in the waking life, they play a minor role in dreams. In the first study (Hartmann, 1996) 456 dream reports yielded zero dreams where reading and writing were activities the dream-self carried out. An activity related to calculating was mentioned only in one of the dream reports. However, the dream scorers claim it was not specified as "calculating", thus unreliable. Moreover, the second study (Hartmann, 1996) collected data from 240 subjects and requested to answer "never" or "hardly ever" encountering the following activities in a dream: reading, writing, typing and calculating. Data reflected an 84%, 92%, 92%, and 95% respectively. Supported by these findings, he stresses the

notion that while dreaming, activities that involve rapid and serial focus are not likely to be present. These data suggest that the dream production mechanism selects what to represent in dreams (Valli & Revonsuo, 2006). In other words, dream content is not just randomly organized, but certain activities and encounters are more common than others. Revonsuo (2000a) stresses that since in our ancestral environment reading, calculating and activities that are part of the modern world were absent in the EEA, they are not present in dream-life, as simulating them does not contribute to a successful reproduction.

Contrary to the aforementioned findings, a comparative study (Kahan & LaBerge, 1996) between waking and dreaming conditions was made to assess the presence of particular types of cognition and metacognition. A sample of 43 subjects provided detailed descriptions of their waking lives and dreams using a questionnaire and dream reports that measured occurrence of specific cognitive and metacognitive activities. The findings demonstrate that even though there may be a relative difference in the frequency in which certain events such as internal commentaries and self-reflection occur in wakefulness and dreaming, these activities are present in both states. "Continuity" between waking cognition and dreaming can be observed. However, it is highlighted that when the same dream reports are scored by third-persons, the manifestation of them in dreams becomes less evident than when the dreamer scores his own dream reports (Kahan & LaBerge, 1996). These results point out that even though some types of metacognitions such as reflective consciousness and other higher order cognitions are less common in dreams when compared to waking state, they are not absent nonetheless (Kahan & Laberge,1996). Data from a similar study indicated that public self-consciousness is more reported in dreams than in waking cognition (Kahan, LaBerge, Levitan, & Zimbardo, 1997).

As mentioned before, there are similarities between the cognitive mechanisms that operate in wakefulness and dreams (Okada, Matsuoka, & Hatakeyama, 2005). For example, the way one perceives in waking state resembles how senses are involved in the dream-world (Zadra, Nielsen, & Donderi, 1998). Sensations produced in the internal realm of dreams are so realistic that they are hard to distinguish from the ones perceived while awake (Valli, 2008).

Although dreams contain perceptual experiences mostly in the visual modality (Hobson et al, 2000a) and more than half (50.4%) are seen in color rather than black and white (Okada et al., 2005), dream content is not limited to one sensory modality. According to Metzinger (2003) other experiences such as perceiving pain, odors or taste may also be experienced, though rarely. Zadra et al. (1998) investigated by home dreams the prevalence of olfactory and gustatory sensory modalities. Their results indicate that 34.7% of the total male subjects recalled having experienced sensations of smell and taste. Women, on the other hand, reported 40.9% of these sensations. Asimilar study conducted by Okada et al. (2005) investigated vividness in the various modalities. Their findings indicate there is less frequency of cutaneous, gustatory and olfactory sensations. Subjects responded "always" experiencing the sensations as follows:cuteneous (9.2%), gustatory (4.9%) and olfactory (2.8%). Moreover, consistent with other studies (Strauch & Meier, 1996) the visual modality was the most common, present "always" in almost 70% of the dream reports. In the same data category as "always"experiencing a sensory modality, kinesthesic (59.1%) and auditory (43%) were the next common sensations (Okada et al., 2005).

Themes. The most common themes people dream of are similar across various cultures with few gender differences. One example of this falls into the repetition dimension described by Domhoff (1996) in which he includes typical dreams. He claims typical dreams are commonly shared cross-culturally such as finding money, flying, losing one's teeth, appearing poorly dressed in public or the feeling of falling through space. When reported through questionnaires where participants are asked to indicate the presence of a specific theme in dreams, the most prevalent theme is being chased or pursued (Domhoff, 1996; Nielsen et al., 2003; Robert & Zadra, 2014; Schredl, 2010). According to Nielsen et al. (2003) the most prevalent themes reported when asked which theme is most frequent in their dreams are falling (82%) and sexual experiences (77%). However, there is a gender and age difference in sexual encounters as they are more prevalent in men than in women (85% vs. 73%) and present in higher frequency in populations above 18 years old (Nielsen et al., 2003). Other typical dreams reported in retropective questionnaires that are also negative include killing someone, someone having an abortion, being unable to find something (e.g. toilet), snakes and insects, failling an examination, among others (Zadra et al. 2003).

Misfortunes by definition are any harm, adversity, or danger happening to the dreamer character as a consequence of circumstances out of the control of the dream-self (Domhoff, 1996). The dreamer is personally involved in misfortunes seven times more frequently than in good fortunes, which are good things happening to the dreamer (Domhoff, 1996). Zadra, Desjardins and Marcotte (2006) studied recurrent dreams and compared their results with Revonsuo and Valli (2000). In the first study (Zadra et al., 2006) 19% of all threats in dreams are accidents and misfortunes, and in the second (Revonsuo & Valli, 2000) 22%.

The majority of themes found in dream content are negatively toned. And this may suggest the content of dreams is rather similar to the content of nightmares, bad dreams and recurrent dreams. A high percentage of nightmares (72%) and recurrent dreams contain a life-threatening event for the dreamer (65%) (Zadra et al., 2006). According to Revonsuo and Valli (2000) who assessed the dream content of 592 home dreams with the Dream Threat Scale, two thirds of dreams contained at least one threatening event where the dreamer confronted it appropiately. Most threats (more than 60%) encountered by the dream-self were likely to be experienced in real life, whereas only a 4% of reported threats were bizarre fantasies (Revonsuo & Valli, 2000).

Zadra, Duval, Begin and Pilon (2004) conducted a study where they collected data from 15 adult women through dream logs. Almost one third of dreams contained physical aggression, 12% ominous mood, 10% failure/helplessness, and 9% interpersonal conflicts. Robert and Zadra (2014) reflect similar findings where physical aggresion and interpersonal conflicts are the most frequent themes reported in nightmares. Nonetheless, failure/ helplessness, health related concerns and worries were also present. In the bad dream category, the most common theme was interpersonal conflicts (Robert & Zadra, 2014).

According to Schredl (2010) who explored nightmare topics by retrospective questionnaires the typical themes found in nightmares are falling (40%), being chased (26%), being paralyzed (25%), being late (24%) and the death of a close relative (21%). Gender differences were found. Men reported themes such as war, terror, and job loss whereas women, reported more commonly sexual harrassment, a close person disappearing or dying, and losing teeth or hair falling out (Schredl, 2010).

Even though questionnaires are frequently used to measure qualitative and quantitative

dream features, because of their time consuming characteristic, dream logs are a more reliable

instrument as the information collected is not as biased by memory. Since dream narrative is

provided immediatey after awakening real dream themes, emotions and other type of content can

be systematically coded and memory intrusions avoided. For example, falling is often reported

in retrospective questionnaires but rarely appears in dream diaries. This may happen because it

is an experience with emotional saliency, though easily remembered but, not reported in dream

reports because it usually happens in hypnagogia (state between wakefulness and sleep) and not

during dreaming state.

Dream characters and social interactions. Generally characters appear in dreams as they do in

waking life. Human characters are present in dreams the majority of the time (more than 90%)

(Domhoff, 1996) and they are usually known by the dreamer (almost 50%) (Kahn, Pace-Schott,

& Hobson, 2002). Dreams may also contain animals, however in a very low prevalence (4-6%)

compared to children's dreams where animals constitute approximately half of the dream

characters (Domhoff, 1996). On average, men and woman dream of 2.4 and 2.8 characters per

dream respectively (Domhoff, 1996). Noteworthy, according to Domhoff (1996) and Schredl et

al. (1998) is that males dream mostly about male characters (67% and 62% respectively), while

females dream about both genders equally (Domhoff, 1996; Schredl et al., 1998).

The typical way of interacting between characters is verbal. Thus, physical interactions

are also possible but in a lower prevalence (Schredl, Sahin, & Schäfer, 1998). More than half of

overall interactions tend to be aggressive. That is, where one character of the dream has the

intention to harm another dream character (Domhoff, 1996), regardless of type of aggressiveness

(physical/verbal and towards dreamer or by dreamer) (Schredl et al., 1998).   According to the

Hall and Van de Castle scoring system, there is at least one aggressive interaction in every dream reported. Concerning age and gender differences, aggressiveness is more common in teenagers than in young adults (Domhoff, 1996) and in general, men's dreams are more aggressive than women's dreams (21.7% vs. 11.9%) (Schredl et al.,1998). Schredl et al. (1998) report a higher degree of physical aggression for men than women in their dreams (16% vs. 5%). However, aggression directed inwardly to the dream character is present in 0% of their dreams as to a 4% in women.

Friendliness is also a way of relating between characters, but the prevalence is rather low when compared to aggressiveness. Contrary to aggressive interactions, women have more friendly social encounters than men (42% vs. 38%) (Domhoff,1996). In nightmares this data remains consistent. According to Robert and Zadra (2014) 21.4% of men's interactions are friendly, whereas almost 40% of women's dreams contain these kinds of interactions. For women, friendly encounters are more likely to happen in indoor settings than outdoors where most men's dreams occur. Dream settings for both male and female are usually familiar (Domhoff, 1996). According to McNamara (2008) it is when unfamiliar settings and unknown characters appear in dreams that they turn into nightmares. Another gender significant finding is sexual interactions occurring in dreams (Nielsen, et al., 2003). In this case, men report approximately 6% and women 3% (Schredl et al., 1998).

Similar to dreams, the most common way of interaction in bad dreams and nightmares is aggressive and conflictive. According to Robert and Zadra (2014) the proportion of nightmares (48%) containing physically aggressive interactions was higher when compared to the proportion of bad dreams (21.3%). Interpersonal conflicts are the most common interactions in bad dreams (34.6%) and the second most common in nightmares (21%).

Emotions. Since emotions are subjectively experienced, the measurement of them has been a challenge to science. Hall and Van de Castle (1966) in the scoring system of content analysis identified the adjectives that represented specific emotions contained in dreams in order to assess them and quantify them (Domhoff, 1996).

A variety of emotions are present in dreams and nightmares (Robert & Zadra, 2014; Schredl, 2010; Zadra et al., 2004;Zadra, Pilon, & Donderi, 2006). More than 50% of bad dreams and 35% of nightmares contain different emotions such as fear, anger, sadness, frustration, among others (Robert & Zadra, 2004). It is suggested by many studies that most dreamed emotions are negatively toned (Domhoff, 1996; Merritt et al.,1994; Stickgold, Pace-Schott, Williams, & Hobson, 1994; Zadra, Pilon, & Donderi, 2006). Positive emotions are present at a very low rate (Robert & Zadra, 2014). According to the Hall and Van de Castle scoring system only 20% of normative dreams contain positively toned emotions, whereas the rest are negative (Domhoff, 1996). For example, in recurrent dreams this notion is also consistent and the majority (85%) of them contain a negatively toned emotional content (Zadra, 1996). According to Robert and Zadra (2014) only 4.2% of nightmares and bad dreams contain positive emotions. Merrit et al. (1994) obtained results through reported emotions in dreams and 68% of them were negative. That is, anxiety/fear, anger, sadness, and shame/guilt overall ratio was higher than the frequency of joy/elation and affection/eroticism according to their categorization. Their dream reports showed a tendency of the negative emotion to shift from bad to worse. An initial 58% of negative emotion in dreams increased to a final negative emotion of 76% (Merritt et al., 1994). Apprehension (fear, anxiety, guilt and embarrassment) which is the most prominent emotion was present in almost 36% of the various dream contents. In the Hall Van de Castle scoring system on the average, there were 0.35 emotions per dream report in the sample, which means that many

dream reports describe no emotions at all (Domhoff, 1996). Conversely, Merrit et al. (1994) and Sikka et al. (2014) who compared self-rated results with third-person ratings, obtained in self-ratings 3.6 emotions per dream and 7.24 respectively. However, when rated by external judges the results were similar to Hall Van de Castle scores (Domhoff, 1996). Sikka et al (2014) reported 0.31 emotions per dream report while Hall Van de Castle's 0.35 emotions per dream. With these findings, it is suggested that when an instruction of reporting the emotion in a dream is specifically required (Merritt. et. al, 1994) or when judged by self-rating instead of external scorers (Sikka et al., 2014) emotionality in dreams becomes more evident. In line with these results, Merrit et al. (1994) found 95% of dreams are emotional. These findings support the hyperemotionality characteristic of dreams which in contrast to Hall Van de Castle is not so evident as only one third of dreams are claimed to contain an emotion (Domhoff, 1996). Gender differences may be found when it comes to emotionality. Claimed by Schredl et al. (1998) dreams of women depict more emotion per dream than dreams of men.

It is clear by the definition of nightmares and bad dreams that a negative emotion will likely prevail. However there may be differences between the emotionality of both. In a study (Zadra, Pilon, & Donderi, 2006) a sample of 90 participants was divided into two categories. The first category (40% of sample) reported at least one nightmare and one bad dream in a four week period. The second group (32% of sample) reported at least one bad dream but no nightmare. The mean emotional intensity of nightmares and bad dreams in the first group was 7.95 (SD=1.51) and 7.24 (SD= 1.15) respectively. In the second group, where participants did not report experiencing any nightmare, the emotional mean of bad dreams was 7.06 (SD= 1.54).These results indicate nightmares are significantly more intense than bad dreams (Wilcoxon signed-rank test= 3.13; p < 0.005) (Zadra et al., 2006).

In this same study, a comparison of the intensity of emotions was also made between nightmares and bad dreams. The most common reported emotion in both groups was fear: 70% and 56% respectively (Zadra et al., 2006). These results support the aforementioned studies where fear (apprehension) is depicted as the most common emotion in normative dreams (Hall & Van de Castle, 1966; Merritt et al.,1994). For the nightmare group the second most common known emotion reported was frustration (7%) and for bad dreams sadness (11%). Anger was also reported but in a decreased ratio (Zadra et al., 2006).

Zadra et al. (2004) and Robert and Zadra (2014) found a mean emotional intensity of fear ranging between 62 and 65 percent approximately is present in nightmares and 45% in bad dreams (Robert & Zadra, 2014).

Sadness is the second most reported emotion in both nightmares and bad dreams. However, bad dreams contain higher emotional intensity in sadness and other emotions such as anger, confusion, digust and frustration.

Bizarreness. Bizarreness in dreams can be described as incongruity (mismatching features), discontinuity or uncertainty (vague features) of thoughts and feelings of the dreamer in the dream plot. This term denotes the presence of improbable events, characters, or objects and the interactions taking place inside a dream (Hobson,1988). This feature of dreams occurs when the binding of different information sources combine in an uncommon manner in order to produce phenomenal representations (Revonsuo, 2006). In other words, when bizarreness is a present feature of dreams, the unity of consciousness has been disrupted and this means that the dreaming brain has failed the task of binding information (Revonsuo, 1999, 2002, 2006). In the Hall and Van de Castle scoring system unrealistic elements scale, such features are described by different sets of criteria. For example, unusual activities the dream-self and other dream characters are involved in, unusual things happening, distorted objects and shapes and metamorphoses such as changing into an object or into someone else (Domhoff, 1996).

Many dream researchers consider dream content is mostly bizarre (Hobson, 2002; Hobson et al., 2000a, 2000b). However, various studies on content analysis report data that contradict their research (Domhoff & Schneider, 1999; Revonsuo & Salmivalli, 1995; Strauch & Meier, 1996;). In a study conducted by Revonsuo and Salmivalli (1995) a content analysis was elaborated to measure the different kinds of bizarreness that may be present in dream content and the occurrence of them. It was also probed whether dreams are mostly bizarre or non-bizarre using waking life activities as a baseline to compare both states. The data obtained indicate bizarreness is not a feature of dreams that is randomly distributed. In fact, the representation of the dream-self, contrary to what one would assume, is rarely incongruous. However, supporting the notion that memory is highly impaired during dreams (Hartmann, 1996; Hobson, 2009; Hobson & Friston, 2012) mental functions such as cognition (35%) and language (31%) yielded

incongruous features (Revonsuo & Salmivalli, 1995). Another category that is usually vague

(8%) and discontinuous (13%) in dreams is the immediate environment where the dreamer is

immersed (place). Bizarre elements were present in 19% to 22% approximately, meaning that the

vast majority of dream content was not found bizarre (Revonsuo & Salmivalli, 1995). In line

with these findings, Merritt et al. (1994) and Domhoff and Schneider (1999) also reported a

study where the content of dreams is mainly organized rather than bizarre, as of 200 dream

reports, only 15.8% of the total content appeared bizarre in the first study and less than 10% in

the second. Another study depicted similar data where 9.7% of bizarre elements were present in

dream in overall categories (Hobson, Hoffman, Helfand, & Kostner, 1987).

Bizarreness as a feature of dreams has been commonly compared by clinicians to the

hallucinatory state of mental disorders in psychiatric populations (Limosani, D'Agostino,

Manzane, L., & Scarone, 2011). It has been mentioned above that dreams can be defined as

hallucinations where the dreamer has a sense of immersive spatiotemporal experience similar to

waking reality (Metzinger, 2003; Revonsuo, 2006; Windt, 2010). According to Windt (2010) it is

the comparison of dreams to waking reality that allows conception of them as a hallucinatory

state. Studies have probed that the dreaming brain may be a useful experimental model for

psychosis as bizarreness in control and schizophrenic dream reports may be compared (Scarone,

et al., 2008). However, researchers that consider dreaming as a healthy, organized and realistic

phenomenon that carries out a function may disagree with this comparison (Domhoff, 2007;

Hobson, 2009; Revonsuo, 2000). But, according to Revonsuo (1999, 2002, 2006) bizarre dream

phenomena are an important feature that may reveal the neural constituents of successful binding

together of conscious experience.

Sensory input and motor output

Dreams can occur independently of sensory input and motor output. Perceptual inputs by themselves are not enough nor necessary to produce dream experience (Revonsuo, 1995). According to Metzinger (2003) dreams have three important features: output blockade, input blockade and internal signal generation. The first one is characterized by a motor inhibition where there is no control of external behavior (Hobson et al., 2000; Metzinger, 2003). That is, caused by the inhibition of spinal motor neurons which avoid behavior to be generated during REM (rapid eye movement) sleep (Metzinger, 2003). Metzinger (2003) claims the second functional feature settles in the inability of the dreamer to perceive the external environment. He stresses sensory signals can rarely be processed. Thus, no external stimuli are associated to dreams. The last one, internal signal generation, consists of the brain processing a collection of stimuli that are generated internally as if they were external inputs and creates an alternate realm (Metzinger, 2003).

These features are what make the dreaming brain so appealing for consciousness studies. According to Revonsuo (1995) dreams are an appropriate model of consciousness because it suggests it may happen regardless of the presence of sensory input and motor output. Thus, they are seen as a pure form of conscious experience (Revonsuo, 1995).

Quantitative level of description

Prevalence and frequency of nightmares

The different populations and the varieties of already accepted definition criteria for nightmares make it a complex task when it comes to identifying frequency and prevalence. Zadra and Donderi (2000b) suggest there is a marked underestimation of nightmares in retrospective reports when compared to normative dreams. However, nightmare rates may as well be increased

as most authors fail in distinguishing nightmares from bad dreams in their studies. Since bad

dreams are about four times more frequent than nightmares when assessed by dream logs,

substantial increase in data may be observed (Zadra & Donderi, 2000b). Another additional

factor that produces different nightmare rates is dependant of measuring frequency by

retrospective questionnaires rather than prospective daily dream logs (e.g. Blagrove et al., 2004).

Approximately 5% of adult population report suffering from nightmares according to the

statistical manual DSM V (American Psychiatric Association, 2013). Levin (1994) conducted a

study by retrospective self-reports where 83% of the overall sample reported having nightmares

at least once a year, 15% at least once a month and 5% one nightmare or more weekly.

Approximately 2%-8% of the population report having a nightmare at least every week and 8%-

30% report one or more nightmares per month (Blagrove et al., 2004; Levin, 1994; Nielsen &

Zadra, 2000; Schredl, 2010; Stepansky, et al., 1998; Zadra & Donderi, 2000).

Many published studies indicate nightmares are more prevalent in women than in men

(Blagrove et al., 2004; Levin, 1994; Nielsen, et al., 2000) and also more prevalent in young than

old populations (Levin & Nielsen, 2007). Blagrove et al. (2004) obtained results that support

gender differences. This group of researchers conducted a study where they collected data

through retrospective questionnaires and two-week dream logs. Questionnaires data show a

significant difference between genders where women depict a higher nightmare value in

comparison to men (1.79 vs. 0.70) (Blagrove et al., 2004). Nielsen (1994) assessed a large

sample of students from various demographic origins over four years. He suggests that women

are 50% more likely to report nightmares once a month or more than do men. He also claims

women's nightmares show more realism, vividness and they are more affected by them than

males (Nielsen, 1994).However, Nielsen and Levin (2007) who probed 111 independent studies in their meta-analysis, stress this gender difference is not found in children or older populations.

In the statistical manual DSM IV it is reported that 10%- 50% of children between the ages 3 and 5 suffer disturbing dreams 3-4 times more prevalent than other populations. The prevalence rates decrease with age (Nielsen et al., 2007). Supported by a study with a sample of 60 children (5-11 years old) nightmares are highly frequent in children (Mindell & Barrett, 2002). According to children's responses to retrospective questionnaires, the prevalence of nightmares when asked if they have ever experienced a nightmare was 75%. Conversely, when their parents responded to the nightmare questionnaire a lower prevalence was reflected (49%). If one compares the obtained rates with adult nightmare prevalence, there is a significant difference between them. According to parent's rating 17 % of the children sample has one or two nightmares per week and when reported by children the prevalence rate increased to 26% (Mindell & Barrett, 2002). When compared to the prevalence of 2%-8% in adults (Blagrove et al., 2004; Levin, 1994; Nielsen & Zadra, 2000; Schredl, 2010; Stepansky, et al., 1998; Zadra & Donderi, 2000) one can observe that there is an increased prevalence in children. Moreover, it it worth mentioning that according to Levin and Nielsen (2007) it is likely that children's nightmare frequency is underestimated in various studies as they are typically rated by their parents.

Nielsen, Stenstrom, and Levin (2006) conducted an internet based study with 24,102 respondents where gender and age differences were found. Female participants reported more frequent monthly nightmares than did male participants. Also, female nightmare frequency increased in the ages 10-19 to 20-39 and then decreased at ages 50-59. In males, the frequency was maintained between ages 10-39; but, also decreased between ages 50-59 (Nielsen et al.,

2006). Nielsen et al. (2000) suggest gender differences in nightmare frequency arises in adolescence. In their study (Nielsen et al., 2000) out of a 610 children sample at the age of 13 girls reported disturbing dreams "sometimes" or "often"more regularly than did boys (37% vs. 25%). Noteworthy, at the age of 16 this difference was more robust (40% vs. 20%) (Nielsen et al., 2000).

In a comparative study (Salvio, Wood, Schwartz, & Eichling, 1992) between students and elderly popuation (60-70 years old) results reflected that nightmare frequency indeed decreases with age. The 2 week dream logs depicted 25.5% of elderly participants reporting at least one nightmare per month, whereas 46.8% of young students reported at least a nightmare per month. Annual measurements were calculated between students and elderly population indicating a nightmare frequency of 1.2% versus 9.3% respectively (Salvio et al., 1992).

Relationship between Sleep and Dreaming

Physiological correlates of sleep and dreaming

Dreams emerge from the physiological state of sleep (Sándor, Szakadát, & Bódizs, 2014). Therefore, there is a clear existence of a relationship between both that designates sleep as the substrate of dreaming. Sleep is the state where changes in the forebrain (Hobson et al., 2000a) and other networks occur in order to produce dreams. However, even though this connection has been well established and supported by a robust body of evidence the neural correlates of dreaming are not completely clear. Neural mechanisms of sleep have been studied by neuroimaging techniques such as MEG (magnetoencephalography), EEG , fMRI (functional magnetic resonance imaging) and PET (positron emission tomography) demonstrating which brain areas activate during this state (Esposito et al., 2004; Maquet, et al., 2005; Miyauchi, Misaki, Kan, & Fukunaga, 2009). But, this evidence has not proven to be consistent in

explaining how the areas involved in sleep physiology account for the dream generator

mechanism. In other words, neuroimaging techniques have shown the brain activation areas

during sleep, but the question lies in how these areas are involved in accomplishing the task of

producing dream experiential consciousness.

REM (rapid eye movement) and NREM (non-rapid eye movement) are two distinct types

of sleep that can be distinguished in terms of polysomnography by detecting electrophysiological

signs (Hobson et al., 2000a). After the first observations of REM and its correlation to dreaming

(Aserinski & Kleitman, 1953), research was directed during the following years into approaching

REM sleep as an isomorphism of dreaming (REM sleep equals dreaming). Subsequently, this

notion was challenged by studies demonstrating dream recall can also arise from NREM sleep

stage (Antrobus, 1983; Foulkes, 1962). Currently, the controversy of whether dreaming can

occur independent of REM sleep and viceversa seems to be settled (Bosinelli, 2000; Nielsen,

2000; Solms, 2000) . Moreover, there is a rather clearer perspective as to distinguishing

phenomenological qualities of mental imagery from both REM and NREM stages.

Supporting REM sleep and dreaming as two phenomena dissociated from each other,

Solms (2000) lesion studies demonstrate that brain stem lesions can eliminate REM but not

dreaming. Contrary to this, lesions located in other areas (e.g. parieto temporo-occipital junction

and ventro-mesial quadrant of frontal lobe) may abolish dreaming while REM is kept intact

(Solms, 2000). This evidence suggests brain activation areas observed during REM cannot

account for neural correlates of dreaming precisely. Although they may be activated during

dreaming state, they must not be taken for granted as neural correlates of dreams since REM and

dreaming may coexist independent of each other.

Another ongoing argument that derives from sleep mentation recall reports is whether REM and NREM dreams are dissimilar and produced by two independent dream generator mechanisms; or if they can be explained by a single dream generator (Esposito, Nielsen & Paquette, 2004; Hobson et al, 2000; Nielsen, 2000;). In the two-generator model REM/NREM sleep mentation recall arises from qualitatively different imaging generation systems. Whereas, the single generator perspective proposes a set of images may account for sleep mentation recall regardless of the stage of sleep where it is produced (Nielsen, 2000).

Nielsen (2000) in his review of REM and NREM sleep claims there is a close correlation between REM and dreaming. Yet, as mentioned above dreams can occur in the absence of REM (Hobson et al, 2000a; Nielsen, 2000; Revonsuo, 2000a; Solms, 2000; Zadra & Donderi, 2000a). Nielsen (2000) proposes a third model reconciliating the two aforementioned models. In this alternative model, the existence of covert REM sleep processes during NREM sleep is claimed. To clarify, Nielsen suggests that there is REM in NREM sleep stage and this explains the presence of dreams in this last mentioned. According to Nielsen (2000) the NREM sleep mentations containing dream-like features can be explained by the covert REM in NREM suggested by this model.

Nielsen (2000) summarizes 35 different studies of sleep mentation recall in both REM/NREM before and after Foulkes (1962) proposal of NREM sleep mentation. After 1962, 21 REM studies reflected data where dream recall ranged between 60-93% and 25 studies indicated NREM sleep mentation recall of 23%- 75% (Nielsen, 2000). These findings are robust support for dream research in considering both stages as correlations of dreams. However, it is worth noting that REM sleep stage does indeed have properties that make it interesting for dream research. To illustrate, during this phase fully realized dreams with vivid visual imagery and

bizarreness ensue (Crick & Mitchinson, 1983; Hobson et al., 2000a). Dreams tend to be longer, more animated and more emotional when compared to NREM dreams (Hobson et al., 2000).

Now that the relationship between dreams and the underlying mechanisms of sleep have been explored, it is important to address the link between nightmares and REM sleep. According to McNamara (2008) commonly nightmares occur in REM regardless of the age. In healthy adults suffering from nightmares, that is, nightmares that are not triggered after any traumatic event, they occur at the extreme end of the REM sleep continuum. This is caused by the extension of small periods of REM to large periods. Consequently, subjects experience elevated sleep time in REM and an inhibition of SWS (slow wave sleep) causes more nightmares (McNamara, 2008). A study (Wamsley, Hirota, Tuker, Smith, & Antrobus, 2007) investigated circadian and ultradian influences on dream features and their results support McNamara's (2008) claims that post-deprivation recovery sleep compromises the regulation of REM by prolonging these periods and contributing as a factor of frequent nightmares.

Neural correlates of dreaming

Since the late 1990s, functional neuroimaging techniques available in neuroscience were incorporated to dream research field allowing the observation of the brain in different sleep stages. With this contribution, it was possible to produce a functional brain map and distinguish activated and deactivated areas during REM and NREM sleep. Another contribution of great impact that took place in this same time was the examination and CT (computerized tomography) scans observation of neurological patients with dreaming alterations (e.g. Maquet et al., 1996). In other words, for the first time scientific research had insights into the neural substrates that support dream phenomenon (Maquet, et al., 2005).

As mentioned in the section above, the exact neural correlates of dreaming have not yet been pinpointed. However, data obtained in various studies has suggested brain areas correlated to wakefulness are similar to those correlated to the dream generator (Esposito et al., 2004; Fox, Nijeboer, Solomonova, Domhoff, & Christoff, 1996; Maquet, et al., 2005). Significant differences between sleep and wakefulness brain activations are also crucial evidence for dream features (e.g. REM deactivations of dorsal pons and mesencephalon, cerebellum, thalami, basal ganglia, basal forebrain/hypothalamus, prefrontal cortex, anterior cingulate cortex and precuneus) (Maquet at al., 2005). The main differences between REM/NREM and the selective cerebral activations observed through PET scans and fMRI are as follows: 1) during REM limbic and amygdalar locations show high activation whereas dorsolateral prefrontal cortices have increased activation (Maquet, et al., 2000). 2) During NREM thalamic functions remain dormant whereas secondary association areas in temporal and parietal lobes are active (Hofle, et al., 1997). The consequences of brain structure's activations and deactivations in dreaming will be explained in what follows.

Maquet et al. (2005) elaborated a meta-analysis study of 207 PET scans of 22 young male during awake resting state, SWS and REM sleep. In their study, they concluded the main relationships between active and inactive brain structures and dream features. Their findings are also consistent with other studies. The first conclusion reached is the activation of posterior cortices such as occipital and temporal are correlated to the perceptions present in dream content (Maquet et al., 2005). Domhoff and Fox (2015) in their recent review suggest the lingual gyrus (medial occipital lobe) as a secondary visual area may explain the abundant visual imagery contained in dreams. Similarly, the activation of the caudate nucleus may account for enhanced sensorimotor qualities of dreaming (Domhoff & Fox, 2015). Alpha power in REM/NREM has

also been claimed to accomplish an important task in visual imagery of dreams in blind and

sighted subjects (Bértolo, et al., 2003; Esposito et al., 2004). Esposito et al. (2004) propose

Alpha power decreases during stage 2 and REM sleep indexing presence of sleep mentation

(cognitive elaboration). This group of researchers conducted a study where the EEG was

analysed in terms of different bands (three Alpha sub-bands). Their results indicate that recall of

sleep mentation is inversely correlated with Alpha power, particulary middle Alpha power (9.5-

11.5 Hz) (Esposito et al., 2004). In other words, decreased Alpha power is associated with

higher sleep mentation recall.

The second conclusion claimed is amygdalar complexes activations (orbito-frontal cortex

and anterior cingulate cortex) explain emotional features (Maquet et al., 1996; Maquet, et al.,

2000). Amygdala activations and medial frontal cortex indicate the presence of social and basic

emotions which lead to social cognition ample in dreams (Phan, Wager, Taylor, & Liberzon,

2002; Phelps, 2006; Ruby & Decety, 2004). Given the high emotionality of dreams and

nightmares, brain activation in this area plays an important role. This is especially because the

amygdala is known to handle negatively toned emotions and related responses (e.g. fear,

aggression, defense, flight or fight, or autonomic ativity response) contained in dream-life. Thus,

this may explain frequent REM fear responses from the dreamer (Phan, Wager, Taylor, &

Liberzon, 2002; Sah, Faber, De Armentia, & Power, 2003). The central nucleus of the amygdala

regulates responses such as freezing, startle, release of stress hormones, threat displays among

others (Sah et al., 2003), which one could suggest intimately correlates to the fear present in the

majority of nightmare content. Now, the central nucleus activation at the same time induces

autonomic responses that project in the brain stem (e.g. nuclei in midbrain, pons, hypothalamus

and medulla) (McNamara, 2008). The parts of the brain stem associated function as follows: grey

matter (mediates startle, anastesia, vocalizations in threat responses and cardiovascular changes), parabrachial nucleus (mediate pain transmission) and nucleus of solitary tract (vagal system regulation) (McNamara, 2008).

The third conclusion from the meta-anaysis study (Maquet et al., 2005) is highly active mesio-temporal regions (hippocampus, amygdala, parahippocampal gyrus, lincus and dentate gyrus) indicate aspects of memory content in dreams. Lastly, they established there is a hypoactivation of the prefrontal cortex (Maquet et al., 2005). This low activity may account for dream characteristics such as alterations in logical reasoning, waking and episodic memory, and executive functions (Maquet et al. 1996; Maquet, et al., 2000). Because of scarce activity in prefrontal areas during REM sleep there is a lack of orientation as they control contextual and episodic memory (Maquet et al., 2005). Limited self-focused metacognitive evaluation is also consequence of decreased activation in the right dorsolateral prefrontal cortex (Schmitz, Kawahara-Baccus, & Johnson, 2004). The ventral parietofrontal area in charge of attention is deactivated as well, suggesting explicatory reasons for dreams to be less sensitive to external stimuli compared to wakefulness (Maquet et al., 2005). Another deactivated brain area during REM that is noteworthy is the inferior parietal cortex which carries out the task of first and third person perspectives in waking life. Since this area is dormant during REM sleep, in dreams there is difficult ability to distinguish between these first and third person levels of descriptions (Ruby & Decety, 2001, 2004). Domhoff (2015) suggests these low levels of activation in areas responsible for executive, attentional, and primary sensory motor networks is what makes possible the embodied simulations of the real world in dreams.

Why do we Dream? Dream and Nightmare Theories

The function of dreams and nightmares, if there is one, has become a subject of interest to many scientist in dream research (Hartmann, 1996; Levin & Nielsen, 2007; Revonsuo, 2000a). However, different fields of expertise attempt to explain it differently. The three main fields explored in this present thesis are the psychological field (Hartmann, 1996; Kramer, 2014 Nielsen & Levin;), the evolutionary perspective (McNamara, 2008; Revonsuo, 2000; Valli, 2008) and ephiphenomenal approaches or random activation theories (Antrobus, 2000; Crick & Mitchison, 1983, 1995; Flanagan, 1995, 2000a, 2000b; Hobson, 1988, 2009; Hobson, Pace-Schott, & Stickgold, 2000a). In this section, a brief introduction to the main theories of dreams and nightmares and their main developers and supporters will be explored.

Random activation theories (RAT)

In the late 1970s, two Harvard University psychiatrists Hobson and McCarley developed a neurobiological model whose main purpose was to explain the dreaming brain (Hobson & McCarley, 1977). The Activation Synthesis Hypothesis (Hobson & McCarley, 1977) claimed that dreams are a by-product of neurochemical changes in the brain during REM sleep. The random activations of these biochemical changes, which originate in the brain stem, were put together by the forebrain in an attempt by the brain to make sense of the noise generated. Since the limbic system located in the forebrain becomes active, emotions, sensations and memories are also involved. Consequently, according to the Activation Synthesis model dream imagery was formed containing amygdalar and hippocampal produced features (Hobson,1988; Hobson & McCarley, 1977). It was suggested the dream generator was localized in the brain stem and it activated when sleep processes activated as well (Hobson, 1988; Hobson & McCarley, 1977; Hobson et al., 2000).

Hobson (1988) in his book stresses that most dreams contain bizarre features and the mechanisms explaining their unusual operating properties are due to aminergic neurons. Aminergic REM off neurons employ a modulatory and inhibitory influence in the brain. And it is when the modulatory activity ceases in REM sleep that the brain cells become randomly active and free of restraint from external stimuli and internal inhibition. According to him, this model answered inquiries such as where are dreams originated, why they are so strange and hard to remember, and what is their purpose to occur (Hobson, 1988). However, as to the purpose they serve, they concluded dreams are just left overs of biologically functional mechanisms underlying REM sleep state (Hobson, 1988; Hobson & McCarley, 1977). Later on, however, Hobson (1992) updated the previous model based on neuroimaging findings and integrated a three dimensional state space and the psychological and neurobiological correlates of those dimensions (Hobson et al., 2000a). In the AIM (Activation-input Source-neuromodulation model) NREM was also considered and both REM and REM stages of sleep were conceived as interactions between aminergic and cholinergic neurons that may operate in areas other than the brain stem as well. By means of this model, dreams result from processes of arousal having an effect on input-output blockades of forebrain structures. The formal aspects of dream content are because sensorimotor and limbic brain regions attempt to produce a coherent experience out of random disorganized inputs originated in the brain stem (Hobson, 1994; Hobson et al., 2000a).

Agreeing that dreaming is a consequence of random brain activations, Crick and Mitchison (1983, 1995) proposed a model of "reverse-learning" that also correlated to REM sleep. As RAT theorists, they claim that during REM sleep a series of impulses called PGO (ponto-geniculo-occipital) waves appear in the brain. They originate in the pons and spread through the thalamus to the neocortex where sensory and motor cortical neurons are affected.

Because of this, dreams, which are conceived as bizarre intrusions, contain daily residues and mixture of different incoherent features with particular emotional tone (Crick & Mitchison, 1983, 1995). Their main claim is that the brain network, just like any other net, has a limit when it comes to stored information it can manage. When it gets overloaded it starts misbehaving, and thus, the network needs to be tuned by removing parasitical modes. An automatic process (reverse-learning) accomplishes this reduction of mixed inputs-outputs by gradually weakening associations and adjusting synaptic weights making the storage more efficient (Crick & Mitchison, 1983,1995). In their original paper, they elaborate a slogan saying that "We dream to forget" (Crick & Mitchison, 1983), meaning that during dreams obsessive behaviors caused by net overloads end up being cut off during REM. After this disposal, unwanted behaviors are no longer produced.

Flanagan, who is currently a professor of philosophy and neurobiology, is one of the main advocates of RAT theories. However, he claims that Hobson and McCarley (1977) and Crick and Mitchison (1983, 1995) now lack support of their theories (Flanagan, 2000b). For instance, Hobson (1988) suggests dreams consolidate memory. For this, Flanagan (1995, 2000a, 2000b) argues that one rarely dreams about things that should be remembered, and this makes a memory function of dreams not conceivable. According to him dreams are self-expressive, in the sense that they reflect things activated by the mind such as concerns, emotions, worries and memories (Flanagan, 2000b). Flanagan's proposal that dreams are a spandrel of sleep and that active sleep mechanisms in the brainstem simultaneously activate emotional centers of the brain (because of their proximity in location) is in line with the aforementioned (Crick & Mitchison, 1983; Hobson & McCarley, 1977) RAT theorists (Flanagan, 1995, 2000a, 2000b).

Additionally, it is suggested that since most basic emotions are negative, it is not a surprise that dream content is mainly negative as well (Flanagan, 2000b). In the memory network, the most salient traces are those recently activated which correspond to daily memory residues. That explains why one usually dreams of more recent memories rather than old ones and mostly with a negatively toned content. According to Flanagan (2000b), after a positive emotional experience, the "positive affect" program will activate in the same way that the "negative affect" program activates following a negative experience. The activation of the "negative affect" program results in threat-related dreams. In other words, one can assume that this last activation program produces nightmares.

According to Flanagan (2000b) the affect programs contained in the forebrain operate by the original evolutionary context. Therefore, the presence of animal creatures and unknown characters in dreams is common, as they are woven into narratives of dream content in the effort of the brain to make sense of the random activations. Moreover, Flanagan also stresses the possibility of the affect program containing pre-loaded scenarios with threatening content such as creatures and situations. This information is thus put together creating dream or nightmare phenomena (Flanagan, 2000b).

Briefly, RAT theories' main claims explain dreams as a by-product or epiphenomenon of sleep processes that attend to random activated information of emotional and memory networks (Antrobus,1991, 2000; Crick & Mitchison, 1983, 1995; Flanagan, 1995, 2000a, 2000b; Hobson & McCarley, 1977). REM sleep serves biological functions while dreaming on its own does not. Lastly, nightmares are also explained as by-products of sleep processes that obtain their negative tone by the activation of negative affect programs. In other words, they do not serve any independent function.

Mood regulation theories

The notion that dreams serve a psychological function by regulating mood and helping the adaptation of the individual to his waking life is not novel. Since "The interpretation of dreams", Freud alleged that repressed instincts find ways to be expressed in dream-life. This way, dreaming emotions and thoughts were processed in the mind to resolve recent and past conflicts (Freud, 1900/1954). Although Freud's theory and methodology have now been widely discarded, Freudian ideas are still at least indirectly present in some clinically inspired modern theories of dreaming. These theories often focus on the role of emotional processing during dreaming (like Freud did) and assume (like Freud did) that the dream attempts to calm down too strong ("unacceptable") emotions and preserve the continuity of sleep. Mood regulation, solving daily concerns and recovery from trauma exposure are functions of dreams that will be explained in this section (Hartmann,1996; Kramer, 1991a, 1991b, 2014; Levin, 1998; Stickgold, 2008). However, before exploring theories that offer psychological explanations for dreams and nightmares, it is necessary to contextualize the usage of the term "adaptation". Since, it would be misleading to assume it as a fixed concept when referring to two completely different notions (psychological and biological adaptations). In this section, the term "adaptation" is specifically related to the individual's psychological adaptation to his current environment or life situation. That is, an adaptation serves the function of promoting the individual's well-being (e.g. behavioral changes). Now, in a psychological perspective, "functions" are conceived in relation to behavior and mental life as active adaptations to the immediate individual's environment (VandenBos, 2007). Later on, a clarification of these terms in the evolutionary context will be made.

Emotional processing is one of the most highlighted roles of dreaming. According to Mood Regulation Theories its function is to modulate and transform emotions by expressing the affective concerns of the dreamer (Hartmann, 1996, 1998; Kramer, 2014; Nielsen & Levin, 2007). Hartmann (1996, 1998) suggests that dreams provide a context to the dominant emotion of the dreamer by making broader connections in the networks of the mind. The model he proposes constitutes of a net of simple units and connections between units where a flow of excitation (thoughts, fantasy, dream images) represents either recent experienced memories or old ones (Hartmann, 1996). Put simply, memory is the totality of the connections in the net determined by the strenghts between them. Hartmann (1996) claims that in dreams, these connections are broader (hyperconnectivity) than in waking life, which explains memories in dreams having more generic and combined features. According to Hartmann (1996) making connections is not a random process. Contrary to this, it is guided by the dominant emotion or concern of the dreamer. Emotions take the role of determining which connections are to be made in order to yield dream images related in some sense to the emotional concern of the dreamer. It is by combining this information to similar memory scenes in the net that the recent trauma gradually plays a smaller role in the dreamers life (Hartmann, 1995,1996). The 'quasi-therepeutic' function of dreaming is explained through metaphors (explanatory methaphor) that aid the individual in coping with future traumas, stressful situations and daily problems (Hartmann, 1996). Similar to other theories, dreaming relates to REM stage of sleep. According to Hartmann (1995) this stage of sleep represents a safe place to make connections for restorative and adaptive roles.

As a clinician, Hartmann (1989) proposed a different personality dimension with characteristics explaining the degree to which different individuals tend to have different kinds

of contents and experiences in their dreams. According to him, "thin boundaries" is a personality trait that is associated with the tendency to have frequent and vivid dreaming. The main features of persons with thin boundaries are fluidity, which allow thought and feelings to merge; people with thin boundaries do not always distinguish unreality from reality, have vivid fantasies, no clear sense of self, and tend to be over-involved in relationships (Hartmann, 1996). "Thick boundaries", on the other hand, refer to the opposite end of the continuum of thin-thick boundaries. Subjects with "thick boundaries" are less likely to dream or recall them. They present the following personality traits: keeping perceptions, thoughts and feelings separately, tendency to be organized within time and space, usually thinking in black and white and having a solid or well defined sense of self (Hartmann, 1996). Other dream researchers seem to support this dimension, however, more focused in psychopathology traits of dreamers, especially when it comes to recurrent dreams (Zadra, O'Brien, & Donderi, 1997). Empirial evidence of dreams dealing with emotional concerns can be extensively found in his book "Dreams and nightmares: The new theory on the origin and meaning of dreams" (Hartmann, 1998). For example, he studied approximately 100 recurrent dreamers who described the repetitive themes of their nightmares had initiated in childhood and evolved along time (e.g. from a monster chasing them, to a human figure chasing them). None of the dreamers had previously any trauma that could explain these nightmares, rather a lack of separation between areas and processes in the mind (thin boundaries) (Hartmann, 1998). Hartmann (1998) then concludes that what to other individuals may be lacking importance and non-traumatic, for these other "thin boundary" characteristical people, was a defining impact in their dream lives. Another group of people that was also studied by Hartmann (1998), reported no traumatic event during their earlier years,

howewer, they claimed having nightmares when something in their current lives was painful and reminded them of childhood vulnerability.

In line with Hartmann (1989,1995, 1996), Kramer (1991a, 2014) as clinician and psychiatry professor, also emphasizes that dreams are responsible of reconciling emotional concerns. He proposes the Selective Mood Regulatory function of dreaming where he claims that during REM a surge of emotion arises (Kramer, 1991c, 1993, 2014). This way, the function of dreaming is acomplished by absorbing the emotional surge and protecting the dreamer from awakening (Kramer, 1991c, 1993, 2014). Kramer (1993) shows empirical evidence where mood was assessed in subjects before going to sleep and immediately after awakening. Results reflected that indeed mood improves over night and turns to more positively toned. Before sleeping, unhapinness, agressiveness, friendliness and others are experienced intensely. Upon awakening, this mood has improved (Kramer, 1991b). Recurrent dreams do not follow this pattern, and for that, they represent a clinical problem (Kramer, Schoen, & Kinney, 1987). According to Kramer et al. (1987) who conducted a study with Vietnam veterans, the emotional surge that arises in REM cannot be contained, thus they show poor sleep with more awakenings and spontaneous arousals. Control groups do not show awakenings and arousals. Kramer et al. (1987) suggest problems in their current lives such as preoccupations or marital relationship issues reactivate combat memories and recurrent dreams are triggered.

To recapitulate, according to psychological theories the function of dreaming lies on the emotional problem-solving and promotion of well-being in the subjects waking life or emotional recovery of a trauma. Dreams serve as an adaptation for the subject to cope with current stressors in his waking life. Theorists suggest that the content of dreams is not randomly activated. Rather,

its an orderly process that activates by salient memory traces of emotional preoccupations or trauma.

Nightmares as dysfunctionional dreams

Many theorists supporting the mood regulation theories of dreaming agree that nightmares are the failure of dream function (Kramer , 1991b; Levin & Nielsen, 2007, 2009; Nielsen & Germain, 2000; Nielsen & Levin, 2007; Nielsen & Zadra, 2000). In other words, nightmares are the consequence of unsuccesful emotional problem-solving (Kramer, 2014). This occurs because the integrative capacity of the individual is exceeded and REM sleep cannot manage to contain the surge of emotion (Kramer, 1991b). Nightmare sufferers are psychogically more troubled than non-sufferers. Particularly, people who have frequent nightmares have psychological problems in their waking lives (Levin, 1998; Levin & Fireman, 2002; Nielsen et al., 2000; Nielsen & Levin, 2007; Simard et al., 2008; Zadra & Donderi, 2000).

Supported by Hartmann's (1989) psychological boundaries proposal, Beaulieu-Prévost and Zadra (2007) conducted a meta-analysis study based on 33 quantitative studies to investigate the subject's attitude towards dreams and their boundary permeability. The results of the study demonstrate that dream recall frequency relates to marked personality dimension traits overlapping with personality and cognitive styles, which can be helpful to understand frequent nightmare sufferers (Beaulieu-Prévost & Zadra, 2007). Similar to the standard diagnostic text DSM V (American Psychiatric Association, 2013), many researchers consider nightmares as a form of dream disturbance that affects various spheres of the individuals's life (Levin & Nielsen, 2007; Nielsen & Germain, 2000; Nielsen & Levin, 2007, 2009; Nielsen & Zadra, 2000). To illustrate, emotional processes during waking life are directly affected by negative dream

content. After awakening, the distress can be so intolerable that it may alter the subject's mood

long after the nightmare is over (Nielsen & Zadra, 2000).

In the repetition dimension proposed by Domhoff (1996, 2000), the consequences are

more severe as they reflect no progress in containing daily emotional worries and healing of

traumatic events. This lack of progress repeats the pattern of the preoccupation and activates a

stating and restating of the conflict. However, the emotional experience still depicts unresolved

emotional conflicts (Domhoff, 1996, 2000; Nielsen & Zadra, 2000). The failure of the adaptive

function of dreams relates to the extent of the psychpathological severity of the dreamer (Nielsen

& Zadra, 2000), for example high levels of neuroticism, anxiety, depression, somatic

symptomatology, among others (Zadra et al., 1997). It is also associated with unsuccesful

regulation of dysphoric emotions such as the ones experienced in waking life by daily stressors

and personality traits which also mediate these emotional reactions (Nielsen & Levin, 2007). A

life-long history of nightmare prevalence prior to being exposed to a traumatic event may define

the how affected an individual may be in her life's well-being as it contributes to the

development of PTSD (accompanied by post traumatic nightmares) or other psychiatric related

disorders (Nielsen & Zadra, 2009).

Integrative model of nightmare production. In 2007, Nielsen and Levin as dream researchers and psychologists proposed a neurocognitive model of nightmares. The AND (Affect Network Dysfunction) model of nightmare production is based on recent neuroimaging findings, sleep physiology, PTSD, fear memory and the neurophysiological description of nightmare phenomena (Nielsen & Levin, 2007) AMPHAC (Amygdala, Medial Prefrontal cortex, Hippocampus, and Anterior cingulate Cortex) which will be explained in what follows (Levin & Nielsen, 2007). Nielsen and Levin (2007) put forward the suggestion that the AND model consists of cognitive and neural explanatory levels proposing an affective network where its perturbations produces different kinds of dysphoric dreaming such as PT-NM, recurrent dreams, among others. Nightmares are claimed to occur when there is an increase in the affect load producing fear extinction and fear acquisition mechanisms to be activated (Nielsen & Levin, 2007).

According to this model (Levin &Nielsen, 2007) nightmares are the dysfunction of the dream network that when processing successfully, accomplishes fear memory extinction. This process is supported by a neural level of organization where brain areas in charge of emotional process are intimately involved. According to Levin and Nielsen (2007) the main claim of their model is that the affect load determines the development of fear extinction memories but also help maintaining prior ones. When the affect load increases significantly, the fear extinction mechanisms activate and consequently nightmares are produced. Though, stressed by the authors, two processes have to take place for nightmare production: 1) affect load (consequence of experiencing emotions in daily basis), and 2) affect distress (disposition of negative emotion reactivity) (Levin & Nielsen, 2007).

In line with the AND model (Levin & Nielsen, 2007), Germaine, Buysee and Nofzinger (2008) claim the central role of amygdalar hyperactivation and deactivation of medial prefrontal cortex (MPFC) in influencing the regulation of REM and NREM sleep. Since these two structures are neurobiological correlates involved in fear response and PTSD these findings account as evidence of the model proposed by Nielsen and Levin (2007). In this same way Germaine et al., (2007) also highlight the neural correlates of fear conditioning and fear extinction which is support the AND model.

According to Germaine et al. (2008) in order for fear conditioning to take place, a neutral stimulus such as a light or a sound must be presented at the same time with an aversive, emotionally salient event (e.g. shock) that will produce a fear response such as freezing. The unconditioned stimulus, which is the neutral stimulus with the repetition of the association, will eventually produce the same fear response in the absence of the aversive stimulus. If the conditioned stimulus is presented continually, conditioned fear responses will be diminished thus extinct. Fear extinction does not eliminate the fear conditioned response, but instead, reflect new learnings (Germaine et al., 2008).

The AND model proposes fear extinction memories are preserved during dreaming when the following three processes take place: 1) element activation (increased availability of fear memory features dissociated from the original episodic context), 2) element recombination (mixture of fear memory features into the dream-world in a simulation of reality), 3) emotional expression (modification of emotions due to recombined features occurring because of daytime emotional demands and affect load) (Levin & Nielsen, 2007).

Fear acquisition, on the other hand is crucial as an adaptive function to save the individuals from repeating potentially dangerous errors (Nielsen & Levin, 2007). It occurs when

the sensory information is transmitted to the lateral amygdala through sensory cortices and thalamus (Germaine et al., 2008). Furthermore, the information is spread from the lateral amygdala to the central nucleus of the amygdala where its projections are sent to hypothalamic and brainstem regions which are responsible for autonomic and visceral fear responses (Germaine et al., 2008).

It has been already explored that negative emotions are ample in dreams (e.g. Domhoff, 1996), therefore, a relationship with fear conditioning during sleep can be expected. According to Germaine et al., (2008) the effects of fear conditioning are correlated to increased neuronal activity of the brainstem reticular activating system while sleep state. Hyper-activation in amygdala, locus coeruleus (LC) and dorsal raphne during sleep after fear conditioning disrupts REM sleep (Germain et al., 2008) and this prevents fear extinction processes being accomplished. The AND model (Nielsen & Levin, 2007) relies on this same notion when hypothesizing that nightmares disrupt fear extinction function of dreams. When the dreamer is awakened by the intense emotional dream content, fear extinction cannot take place, and therefore conceived as a dysfunction of the process.

The four main brain regions involved in the possible neural mechanisms of nightmare frequency and distress in posttraumatic and non-traumatic nightmares, as mentioned previously, are AMPHAC (Nielsen & Levin, 2007). This areas work is organized as a main emotional control structure and contributes to mediating other higher order cognitive functions, behavior and affective responses especially related to the formation of dysphoric dreaming (Nielsen & Levin, 2007).

Each of the neural correlates of this process according to Nielsen and Levin (2007) is involved as follows:

1) Amygdala: in charge of affect load expression such as conditioned fear, fear memory, fear detection and the corresponding autonomic activation to produce a response. The amygdalar activity is directly involved in nightmares as it underlies the expression of fear during both dream and wake states. The predominance of fear in dream reports (Merrit et al., 1994) and increased amygdala activation during REM compared to wakefulness supports this hypothesis.

2) MPFC: down-regulates the emotional activity that takes place in amygdalar components. It also contributes in the production of extinction memories in order to constrain fear that has been already conditioned. Supporting evidence shown by Phan et al. (2002) indicates the role of this brain area in regulating and processing emotions.

3) Hip: regulates fear extinction, re-expression of conditioned fear by controlling the fear memory context (imaging). The activation of the Hip prevents the excessive expression of all kinds of affects but especially fear. This explains why its deactivation during REM sleep contributes to fear expression and the maintaining of extinction memories in response to negative emotions. When the Hip is at its highest activity is when brain produces highly visual and emotional dream content.

4) ACC: brain area that regulates the degree of affect distress that arises when emotions are activated. Therefore, implicated in nightmare production.

The AND model is one of the few models that explains neural mechanisms of nightmare formation and the affect distress experienced by PT-NM or non-traumatic nightmare sufferers. It does not discard propositions made by other theories. Therefore, in a way is an attempt to unify cognitive neuroscience, psychology and other fields involved in dream research. However, even though based on a robust body of previous evidence, if seen through a biological perspective fear

extinction may lead to a failure in reproductive success. Further studies should be called for to develop more in depth this speculative model of nightmare production.

Nightmares as functional dreams

In the mood regulation theories, as explored above, researchers agree in the dysfunctional nature of nightmares. However, it is worth addressing Hartmann's view on this subject. For him, nightmares could be seen as a paradigm for all dreams, as in them, the emotional concern caused by a trauma or any stressful situation is more evident and consequently a way to understand clearly what goes on in a dream (Hartmann, 1999). He states that in traumatic nightmares (not PTSD necessarily) an important function is accomplished. According to him the process of gradually resolving a trauma involves the following sequence of events: first, the trauma is replayed in dreams vividly and dramatically (may have alterations in content). Later on, trauma begins to combine with similar memories already stored in the network and memories expand by taking in more material. As a consequence of successful integration of traumatic memories, trauma plays a smaller and smaller role in the individual's life by producing net disturbances and weakening of connections. Subsequently to the integration of memories the normalizing of dream content is accomplished (Hartmann, 1996). Dreaming about trauma contributes to the recovery process of the individual as it serves emotional adaptation to the traumatic situation experienced (Stickgold, 2008) . In severe cases where trauma does not resolve adequately, PTSD develops and nightmares turn into repetitive post traumatic nightmares with salient trauma memories (in this case failure of process and dysfunctional). Instead of serving as a desensitization process of trauma related memories, it turns into a maladaptive sensitization process where the dreamer is constantly re-exposed to the trauma (Germain & Zadra, 2009).

Evolutionary theories

What is a Function?

Evolutionary perspectives suggest that for a process to be categorized as evolutionary, it must provide naturally selected benefits contributing to the individual's survival (Tooby & Cosmides, 1995). This means that adaptive functions must be designed to solve evolutionary matters. By taking a biological perspective on the definition of "causes" and "functions", we can divide causal explanations of dreaming and nightmares into "proximate" and "ultimate" types of explanations. "Proximate" explanations refer to preceding stimuli and experiences in the individual's life (e.g. traumatic experiences, stress) that may trigger bad dreams and nightmares. They are the immediate cause of the explanation of these phenomena. "Ultimate" explanations concern the original evolutionary functions of dreaming and nightmares: Why were they selected for during evolution? What advantages did they bring to ancestral humans (if any)? In this sense, a "function" of dreaming must be described in terms of its evolutionary history and selection. Namely, after watching a horror movie, it is possible that the memory patterns in the brain will activate during sleep in the following nights causing bad dreams or nightmares. In this case, the stress or fear experienced during the horror movie is the "proximate" cause of nightmares.

Now that function and adaptation have been clarified in the evolutionary approach, in the upcoming section the Threat Simulation Theory (TST) (Revonsuo, 2000a) will be reviewed as a current proposal of dream and nightmare function for humans.

Threat Simulation Theory (TST)

After years of dream research, evolutionary approaches have taken a firm position in psychology and cognitive neuroscience, and thus, their attempt to explain dream function from this perspective keeps developing. These explanations go further back in time and try to

understand how and when the brain evolved the capacity to produce dreams (Valli, 2008).

Revonsuo (2000a) claims dream function is well-defined and its biological role is certainly

adaptive. He posits a theory where it is considered that human ancestors derived more benefits

from dreaming because it represents a safe off-line model of the world where ancestral threats

could be rehearsed. Bearing in mind that the ancestral environment was full of menaces this

mechanism may have contributed to the inclusive fitness of humans living in the EEA

(Environment of Evolutionary Adaptedness) or prehistoric Pleistocene environment more than

10,000 years ago. For this matter, dreaming state is not just a by-product of sleep or its

underlying mechanisms, but instead it served a biological function to these people (Revonsuo,

2000a).

As a cognitive neuroscientist, psychologist and philosopher, Revonsuo (2000a)

developed The Threat Simulation Theory (TST) based on six empirically testable propositions.

The Theory puts forward the notion that while dreaming, our ancestors who lived as hunter-

gatherers could rehearse threatening events that probably had to be overcome in real life. This

way, the simulation of hazards would enhance their skills to successfully respond to those threats

by avoiding them and activating behavioral programs. The dream production system has been

inherited from one generation to the other; nonetheless, nowadays they may not serve the same

purpose as they did in the past (Revonsuo, 2000a). What centuries ago represented something

essential for survival, probably now serves as a reminder of primitive necessities (Tooby &

Cosmides, 1990, 1995).

Propositions. The first hypothesis proposed by TST claims dream experience is an organized and selective simulation of the perceptual world. It disagrees with conceiving dream phenomenon as random activation reflecting neurobiological processes (Hobson, 2002; Hobson et al., 2000a, 2000b). Current evidence does indeed support dreams as well-organized and complex models of the world (Domhoff & Schneider, 1999; Revonsuo & Salmivalli, 1995; Strauch & Meier, 1996) where there is an active self-body interacting with various characters, objects and visuo-spatial world in a multi-modal way similar to waking life (Revonsuo, 2000a). Revonsuo (2000a) argues dreams are a too well-organized dream narrative to be created just by chance. If they were random "noise" they should appear as more disorganized sensations and isolated percepts than they actually do.

Secondly, TST proposes dream machinery is specialized in the simulation of threats. Negative emotion is depicted in dreams in a higher percentage than positive emotions (Domhoff, 1996). If threatening simulations are carried out during dreaming, these events include negative elements leading to negative emotions rather than positive (Revonsuo, 2000a). Hall and Van de Castle (1966) conducted empirical research where over 700 emotions reflected in dream reports 80% of them were negative (Domhoff, 1996). It is possible that the negative emotions in dreams are signs of threatening events. It is known that the most common interaction in dreams is aggression and in the vast majority of situations, the dream-self is involved as the victim of aggression rather than the aggressor (Domhoff, 1996). This dream content is consistent with the original evolutionary environment where ancestral humans lived and their physical well-being was constantly under hostile situations. According to the Hall and Van de Castle coding system, enemies in dreams are animal creatures (96% of animal interactions in dreams are aggressive) and male strangers (Domhoff, 1996). Revonsuo (2000a) suggests that probably in modern life

this would not appear as threatening; nonetheless, for ancestors confronting carnivores and poisonous animals it would represent a mortal threat. Males usually appear as the enemy in dreams and this also reflects the ancestral environment. During the EEA the interactions between different groups were aggressive and violent because of the high competitive situations caused by fighting for resources such as territory. In this sense, the traces of the orginal dream production mechanism for threat simulation is still reflected in current dream life by representing animals and unknown men as potential threats. Children's dreams reflect ancestral threats more clearly than adults because they are born with the threat simulator mechanism still programmed for ancestral lives.With time, when the mechanisms adjust to the current environment, dreaming about animal creatures decreases (Revonsuo, 2000a).

Recurrent dreams and nightmares appear as very powerful threat simulations of ancestral threats (Revonsuo, 2000a). They both contain similar content such as being chased or attacked which are the most common ones according to the various studies in Domhoff (1996). When stress increases, the activation of recurrent dreams and nightmares takes place indicating the threat simulation function of dreams is being accomplished. Evidence yielded by neuroimaging technique studies (Maquet, et al., 1996), shows that brain activation during REM sleep reflects the neural correlates of threat simulation (Revonsuo, 2000a).

The third proposition consists of the relationship between encountering real threat events during waking life and subsequent dream content (Revonsuo, 2000a). For instance, in PTSD nightmares there is a clear consequence of being exposed to a traumatic event and the content of the nightmares. Since the threat simulation mechanism is working at its full capacity, similar replications of the event will be reproduced during dreaming to acquire the necessary behavioral skills and overcome it in future encounters. According to the TST real life threats are the

necessary cues to activate the threat simulation system (Revonsuo, 2000a). Valli et al. (2005) conducted a study where this hypothesis was tested by comparing the dreams of traumatized and less traumatized Kurdish children with long-life history of persecution and a control group (non-traumatized Finnish children). Their results reflect almost 80% of dreams of traumatized children contain threats compared to 56% and 31% of less traumatized and Finnish children respectively. The TST states that dream content correlates with the state of recovery where the trauma is rather than causal as conceived by Mood Regulatory Theories (dreaming of trauma gradually reduces it) (Valli, Revonsuo, Pälkäs, & Punamäki, 2006).

Now, according to TST why does the brain select traumatic content to be depicted in dreams? (Revonsuo, 2000a). Traumatic experiences are situations that may put at risk the physical well-being of a human being, and this would mean the reproductive success is jeopardised. Since the biological function of dreaming is to create a safe place to simulate threats in order to acquire the behavioral skills needed to guarantee reproductive success, negative emotion that comes with threathening situations are perceived as salient to the dream production system. The dream production system is highly sensitive to any event reflected as critical for physical surival (Revonsuo, 2000a).

The fourth proposition of the TST (Revonsuo, 2000a) claims that the efficiency of the threat simulation mechanisms lies in perceptions and behaviors simulated as realistic. The lack of awareness of being in a dream is what constitutes a useful rehearsal. If it was not perceived and acted as real, it would not be taken seriously and the dreamer would not be motivated to defend himself by rehearsing threat-avoidance skills (Revonsuo, 2000a). When an action is carried out in a dream, the brain activates the same areas that are involved in that action as if a subject was performing it in waking life. However, inhibitory cell groups in the pons avoid the acting out of

the dreamed behavior in real life since muscles don't receive action commands (Revonsuo, 2000a). This aforementioned explanation leads to the next proposition by TST.

Proposition five of the TST puts forward the suggestion that the simulation of perceptual and motor skills leads to enhanced performance in real life-threatening encounters even though the dream and the rehearsal of threat is not remembered upon awakening (Revonsuo, 2000a). According to Revonsuo (2000a) when we learn a new ability by threat rehearsal in dreams, not being aware of what is being learned is of no importance as there is implicit learning after the process is accomplished. Neuroimaging studies support this hypothesis. Conducted experiments have shown the simulation hypothesis of motor imagery, similar to dream imagery, is empirically supported. For example, the imagery of voluntary movement of body parts activates corresponding motor representations in the brain involved with those movements (Ehrsson, Geyer, & Naito, 2003). Dickstein and Deutsch (2007) suggest positive effects of imaginary practice on motor performance in athletes, healthy subjects and patients with neurological conditions. Following this same logic, the rehearsal of threat simulation could enhance threat-avoidance and threat-behaviors (Revonsuo, 2000a).

Lastly, the sixth hypothesis proposed by TST as the aforementioned ones is also empirically testable. The last proposition suggests that the original environment in which human being's ancestors lived included life-endangering events that exposed life reproductive success and were severe selective pressures for the population in ancestral life (Revonsuo, 2000a). A higher probability of successful reproduction depended on the activation of the threat simulation mechanisms by ecologically valid threat cues. Owning this dream production mechanism was an advantage selected for during evolution (Revonsuo, 2000a). Revonsuo (2000a) claims that since the EEA was dangerous and full of constant threats or menaces, the activation of the threat

simulation system was most likely constant. The dream production system must have been

suffering of chronical PTSD (according to modern criteria). However, this might have been the

normal state of the dream production system.

Dream-Threat rating scale. Revonsuo and Valli (2000) developed a content analysis of

threatening events contained in dream reports. This instrument was elaborated to test the TST

(Revonsuo, 2000a) in future studies and obtain reliable data supporting the predictions of this

theory. The Dream-Threat rating scale (Revonsuo & Valli, 2000) contains eight scales and each

one is divided in subcategories that refine the obtained data. The eight rating scales are the

following: I) Nature of the threatening event (searches the threatening event) , II) Target of the

threat (attempts to answer who or what is being threatened by the event) , III) Severity of the

threatening event for the self (surveys what the risk would be for self if threatening event was

encountered in real life), IV) Participation of the self to the threatening event (does self

participates in the course of events?), V) Reaction of the self to the threatening event (how is the

reaction of self?), VI) Consequences of the threatening event to self (losses suffered by the self

as consequence of threatening event), VII) Resolution of the threatening event (situation at the

end of the dream) and VIII) Source of the threatening event (source of information in real life for

learning about represented threats in dreams).

Other dream researchers have tested the TST by using the Dream-Threat scale to validate

if the evidence yielded by testing each proposition may account as robust evidence to support the

theory (e.g. Valli et al., 2005; Zadra, Desjardins, & Marcotte, 2006). However, in order to be

tested properly the following criteria must be fulfilled: 1) the samples of dream reports should be

large and preferably from experienced dream reporters, 2) the method used as content analysis

should be designed to extract "threatening events" from dream reports specifically (frequency

and severity can be observed individually and by populations), 3) populations or conditions that can function as approximate models of ancestral exposure to threat, equal exposure or control conditions or populations and lower exposure to threats (Revonsuo & Valli, 2008). Otherwise, results may be altered by misinterpretation of the TST of dreaming and the use of inadequate or different methods to test it (Malcom-Smith, Solms, Turnbull, & Tredoux, 2008).

Now that the six propositions and the instrument of content analysis of TST have been explained, it can be summarized that the TST is a theory of dreams that postulates this phenomenon has an evolutionary origin. As the TST concerns, dreams are an organized model of the world whose function was to simulate threats for threat-perception and threat-avoidance in ancestral human environment. By rehearsing these threats, their life reproductive success was increased and their survival skills enhanced. Current humans inherited these dream production mechanism along with the dream content that for ancestral humans represented real life threats. However, given the actual environment and its differences with the EEA, dreams most probable cannot fulfill the original function they were selected for.

Discussion

The first aim of this present thesis was to describe in the light of psychology and modern cognitive neuroscience what dreams and nightmares are and why they are so commonly experienced. Even though there is still no general agreement among dream theorists and researchers, it is widely accepted that dreams are a simulation of the perceptual world (Domhoff, 2007; Feinberg & Keenan, 2005; Foulkes, 1999; Hobson, 2009; Metzinger, 2003; Nielsen, 2010; Revonsuo, 1995; Windt, 2010). Regardless of whether or not they support the TST (Revonsuo, 2000a) of dreams, many of the main dream theorists have now incorporated this concept into the characterization of dreams. This has led to a more unified and widely shared conceptualization of

the nature of dreaming that has marked a step-forward in the theoretical explanation of dream phenomenon (Revonsuo et al., 2015).

Why would the human brain evolve the capacity to dream? But most importantly, why would the dream production mechanism produce an alternative reality during sleep when wakefulness can provide similar phenomenal features? There is no clear answer to these questions, and cognitive neuroscientists seem to have given up this search and assumed there is no specific reason after all. Psychologically inspired models of dream research claim dreams serve the function of adapting individuals emotionally and promoting well-being in their current lives. However, Revonsuo (2000a) by proposing the TST of dreams seems to have exposed both contemporary dream approaches (RAT and Mood Regulation Theories) and introduced a third perspective. The TST (Revonsuo, 2000a) takes into consideration why and when humans evolved the dreaming capacity and for what reason it has chosen to simulate the waking world. For years, dream theories have conceived nightmares as dysfunctions in the function of dreaming, even though it is stated and supported by their own evidence that they serve to gradually mitigate salient memories after trauma exposure (e.g. mood regulation theories of dreaming) (Hartmann, 1996; Kramer, 1991a, 1991b, 2014; Levin, 1998; Stickgold, 1998). But, this new evolutionary approach instead of considering them as a failure of a function, claims nightmares and bad dreams are powerful threat-simulations reflecting the dream machinery working at its best (Revonsuo, 2000a).

The proposal that nightmares, which are disturbing emotionally intense dreams that cause spontaneous awakening to the dreamer (American Psychiatric Association, 2013) can be in any way functional seems to cause controversy. Nightmares involve threatening scenarios, anxiety, fear and many other negative emotions (Hartmann, 1998; Nielsen & Levin, 2007). This

seems to be a sufficient reason for clinically inspired researchers to infer that something that can be as disturbing as nightmares, even though not always the case cannot be functional. They suggest nightmare distress indexes the low well-being of nightmare sufferers (Blagrove et al., 2004). In this same line of thought, Hartmann's proposition of boundaries dimension (Hartmann, 1989) appears to somehow imply that being able to frequently and vividly dream is by some means related to psychopathological traits. To illustrate, subjects with "thin boundaries" which are likely to recall their dreams more than "thick boundaries" subjects are described as: not always distinguished from reality, no clear sense of self, less well defended and tendency to be over involved in relationships, among others (Hartmann, 1996). These features resemble some of the criteria comprised for many mental disorders found in the international diagnostic manual such as DSM V (e.g. schizophrenia, borderline personality disorder, among others) (American Psychiatric Association, 2013). Conversely, Hartmann (1996) suggests people with "thick boundaries" (lower capacity to recall dreams) are organized in time and space and have a solid sense of self. Recurrent dreams and nightmares are claimed to be related to one's psychological well-being (Blagrove et al., 2004; Zadra & Donderi, 2000b). In other words, having dreams with positive or negative valence is in a way correlated either to pathological traits or reduced well-being. One may argue that in order to take steps forward into explanatory theorems of a function of dreaming (including nightmares) it is necessary to withdraw the pathology notion of them. Although, according to the TST every individual owns a threat-simulation system that is at some level of activation determined by various factors such as: inherited personality traits (e.g. Hartmann's boundary dimension), threat exposure during the individual's development, recent threatening events and current stress level (Revonsuo & Valli, 2008).

PTSD nightmares are commonly seen as pathological perhaps because of their severity. Since PTSD nightmares may cause unbearable distress to the dreamer it may seem that if they are actually accomplishing any function at all, it is to a highly cost. However, if seen through TST (Revonsuo, 2000a) of dreaming this nightmares are simulating a real-life encountered threat and activating the simulation process to acquire the necessary skills to overcome the threat if ever present in the future (in exact or similar way). To clarify, ancestral humans did not suffer from stress related symptoms (Revonsuo, 2000b).

The second aim of the thesis was to explore the empirical findings yielded by each theory to have an insight of the neural correlates, occurrence and theoretical explanations of dream phenomenology. First of all, after reviewing the main literature of dream research, it must be highlighted that dream theorists merit recognition for formulating complex hypotheses and elaborating empirical studies to shed light into the dream field. In the last decades, dream studies have developed a robust body of evidence supporting the importance of dreams in understanding the brain and consciousness phenomenon. As Revonsuo (1995) elucidates, dreams are a pure form of conscious experience that due to its features can be appropriately used as a model to study consciousness. The dreaming brain allows this study because it may show which processes are completely necessary to achieve conscious experiences. An important advance was made in the late 1990s with the neuroimaging studies which also gave insights of the dreaming brain (e.g. Esposito et al., 2004; Maquet, et al., 2005; Miyauchi et al., 2009; Solms, 2000). However, it seems that each of the three main approaches of dream research that explain dreaming function develops into their own ideas rather than being open to contribution among them, even though they overlap in some theoretical ideas.

Mood regulation theories advocate that dreams depict the emotional concerns of the dreamer and its main function is the emotional problem solving of these preoccupations (Hartmann, 1996; Kramer, 1991a, 1991b, 2014; Levin, 1998; Stickgold, 1998). Although there is a large body of evidence showing that the emotional concerns of the subjects are revealed in dream content (Hartmann, 1996; Kramer, 1993), the literature seems inconclusive in demonstrating that indeed dreaming solves that concern or helps to integrate trauma by "making connections in a safe place" (Hartmann, 1996). But what happens to recurrent dreams related to a traumatic event? There is no convincing explanation that elucidates why after being exposed to a severe trauma people dream about it recurrently causing no psychological recovery. If dream function is to psychologically heal emotions, then PTSD nightmares are not accomplishing their function at the moment they are needed the most. It seems misguided that this dream function would serve to heal mild cases, but when severe trauma is present, they fail. If dreaming about emotional concerns is functional, but dreaming about traumatic experiences (containing emotional concerns) is dysfunctional, then there is no easy way to draw the line and distinguish when they are pathological (dysfunctional) and when they are psychologically adaptive. A study with a sample of severely traumatized and less traumatized Kurdish children revealed that dreaming about realistic horror scenes and negatively toned content did not seem to be helping in the recovery of the severely traumatized children (Punamäki, Ali, Ismahil, & Nuutinen, 2005). In this same study (Punamäki et al., 2005) less traumatized children, however, had less nightmares and dreamed of positive content rather than unpleasant dream imagery suggesting more psychological well-being. In other words, dreaming about real traumatic experiences does not show indices of emotional recovery processes as suggested by psychological theories of dreaming.

Mood regulation theories assert in their claim that emotional concerns guide the dream content. But, more evidence is needed to prove that the content of dream has the capacity to heal those emotional concerns. If one compares these theories with TST (Revonsuo, 2000a) of dreaming, it may be suggested that the dream content containing either emotional concerns or threat-simulations correlate in a similar way. When one is encountering a threat, an emotional concern immediately arises. The preoccupation of being able to achieve the right response and successfully overcome the threat may represent the emotional concern referred to by mood regulation theories. Could it be possible that indeed our emotional concerns are biologically guided as an attempt to strive for survival (in the present environment)? Those emotional concerns may now represent real concerns in this current environment. But, probably for ancestral life emotional concerns were less important than life-threatening events. Agreeing with Desjardins and Zadra (2006) psychological adaptation to one's environment may also be crucial for reproductive success. Mentally impaired individuals may decrease the chances of survival and reproduction. In other words, biological and psychological adaptation together may have also contributed to ancestral reproductive success (Desjardins & Zadra, 2006). Probably emotional concerns contributed to a lower extent. However, it may be considered that in ancestral life biological adaptation was more important than psychological and in current environment the psychological adaptation plays a central role.

Revonsuo (2000a) proposes the function of dreams is biological and lies only in simulating threats for threat-avoidance and acquiring threat-related skills. If threats represent a problem or a future problem in waking life and needs to be resolved for reproductive success, somehow mood regulation and evolutionary theories also correlate. Perhaps tens of hundreds years ago when the brain needed to adapt and evolve the capacity to dream, the dream

production machinery was specifically designed for threat-simulations as they were necessary for reproductive success. However, as we keep evolving and the current environment changed, even though ancestral threats are still present in our dream content, could it be possible that emotional regulation has become also part of dream function? Perhaps the function of dreams may not be correlated to produce emotional recovery while dreaming (as scarce evidence has been found), but to offer the simulation of emotional preoccupations and acquire emotional skills to resolve them in waking life (e.g. social simulation). Because it seems emotions are a significant part of current human concerns rather than for our ancestors who were striving for survival and life-threats were the main concerns. But if dreams did have a biological function that kept alive our ancestors, then this virtual reality will either have somehow adjusted to current threats or likely disappear one day. This may be just like when the number of teeth reduced as humans evolved smaller jaws (Vastardis, 2000). As probable or improbable the aforementioned may seem one can at least argue that dreams and nightmares serve the function of threat-simulation. What for ancestral humans represented a life threat (e.g. being devoured by a carnivore, natural disasters, and male strangers) probably nowadays is represented in different ways (kidnapping, robbery, rape, harassment). Nonetheless, even though current environment is safer than the ancestral context, this does not decrease the current emotional concern humans experience after encountering threats in their present life. That is, if the threat-simulation program in any way depicts current simulations, then it is as biologically functional as it was for hunter-gatherers. Tooby and Cosmides (1990) claim that organisms may act a certain way guided by an emotion and perceive things as truth regardless if they are or not. This occurs because those things were true in the past and emotions are simply reflecting the structure of human past life; therefore,

emotions contain information about the nature of ancestral environment (Tooby & Cosmides, 1990).

Revonsuo (2000a) argues against the emotional problem-solving function of dreams. He states that in order for that to be reliable, unpleasant memory traces from traumatic experiences need to disappear. Nonetheless, one may assume that if that negative memory is gradually assimilated and therefore diminished in saliency, recognizing it would be less distressing. In other words, it would already be beneficial for the subject to perceive the memory differently even though the memory is still present and active in dreams. To consider the Mood regulation theories as possible theoretical explanations they need to elaborate empirically testable hypothesis, as for now there is scarce evidence for their main claims. Perhaps a reevaluation of the proposals needs to be considered and formulate experiments where reliable data can be reflected. For example study longitudinal samples to evaluate the emotional state prior, during and after the traumatic event to investigate if dreams indeed solve the emotional conflict. There are clear barriers to implement an investigation prior a traumatic event as it is not likely to know if the subjects will be exposed to trauma in the near future. But, with prior data bases this could be possible (e.g. Hartmann & Brezler, 2008). Another way to yield reliable evidence is with the study of traumatized dreamers and traumatized non-dreamers (brain lesions) to test the quasi-therapeutic function of dreams by observing recovery after a time lapse of dreaming about trauma-realated events guided by the emotional concern.

The TST (Revonsuo, 2000a) and Mood regulation theories of dreaming both have many strengths and for that, they may account as better explanatory theories for this phenomena. Though, TST and its propositions provide with a clear methodology to empirically test the whole theory. On the other hand, RATs seem to be theories more correlated to sleep mechanisms rather

than to dreaming processes and for that, not plausible as an explanatory theory of dreams and nightmares. First of all, despite the large body of evidence presented showing dreams are organized along the lines of waking reality, they still place emphasis on the bizarre features of dreams. If dreams were mere random activations, why would they produce such organized narratives? As Revonsuo has indicated (Revonsuo, 2000b), epileptic seizures which are true forms of random brain activation do not produce coherent and organized subjective experiences like dreams do (Johanson, Revonsuo, Chaplin, & Wedlund, 2003). True random activations depict a mixture of static images (such as sleep mentation) or momentary affective states, but regularly no experience at all (Valli, 2008). It seems that RAT theories provide clear explanations as to the important function of REM sleep but irrespective of the subjective experience they produce to the dreamer. They do not offer an explanation to why dreams are produced and why they present their unique phenomenal characteristics (form and content) (Revonsuo, 2000a;Valli, 2008). Moreover, to account as a dream theory, RAT seems also out of date as researchers are not working on elaborating new hypothesis or novel experiments to yield current data and their former studies nowadays lack support.

It must be suggested that even though TST (Revonsuo, 2000a) is a novel proposal, in the last 15 years Revonsuo and his research team have provided a robust body of evidence reflecting that indeed dreams have the biological function of threat-simulation (Revonsuo & Valli, 2000; Valli et al., 2005; Valli et al., 2006). In a rat study, REM sleep deprivation produced difficulties in coping and reacting to threatening situations with adecuate defensive responses (Martínez-Gonzales, et al., 2004). After being presented with noxious stimuli, REM deprived rats were not able to produce a defensive reponse. Contrary to this, rats that were not deprived had better outcomes in coping with the situation (Martínez-Gonzalez et al., 2004). This supports the notion

stressed by the TST (Revonsuo, 2000a) that dreams are indeed functional for defensive

mechanisms in the waking world. If threatening responses are not elicited after being deprived of

REM sleep, it may be implied that dreaming is a necessary tool to produce succesfull responses

during waking life when facing thereatening events.

A second study conducted with university students participants also supports the function

of dreams in coping strategies to dangerous situations (Peterson, Henke, & Hayes, 2002). The

last remembered dream of 560 students was collected and analyzed by a content analysis scale to

determine the threatening content. In this same study (Peterson et al., 2002) the Limbic System

Checklist (LSCL-33) was applied to evaluate if individuals with limbic hyperfunction report

more threatening dream content. To be considered a threatening event it had to decrease the

reproductive success of the dreamer in the dream. In the results it was depicted that a high score

in the LSCL-33 correlated to objective threats in dream content, whether low scorers'dreams

contained more pleasant and subjective threats (e.g. a mother running after her kid with a

vegetable in her hand). In conclusion, this study suggests that the limbic system functioning

appears to be correlated to reported threatening or pleasant dream content (Peterson et al., 2002).

Limbic hyperfunction predicts only objective threats, that is, threats that compromise coping

strategies revelant to evolutionary fitness (Peterson et al., 2002).

Now that evidence from different studies has been explored to provide support to the TST, it

must be highlighted that this theory is the only current proposal conceiving nightmares as

functional rather than dysfunctional and this denotes a change of direction in dream research.

TST (Revonsuo, 2000a) hypothesizes that threatening events are frequent and overrepresented in

dreams and the exposure to threatening life events activates the threat-simulation system.

Moreover, this evolutionary theory claims that dream threats contain realistic rehearsals

of threat avoidance responses (Revonsuo & Valli, 2008). Many of the original studies testing

TST have been replicated and now tested by other dream researchers as well (Valli, et al., 2005;

Valli, Lenasdotter, MacGregor, & Revonsuo, 2007;Valli, Strandholm, Sillanmäki, & Revonsuo,

2008; Zadra et al., 2006). In a study conducted by Revonsuo and Valli (2000) to test the TST

theory, their predictions were confirmed: dreams content presents a high frequency of

threatening events and they reflect the original function of the dream machinery which is the

simulation of ancestral threats. The results of the study (Revonsuo & Valli, 2000) demonstrate

that more than one (1.2) threatening event is present per dream and most of the times (73%) the

self is the target of the threatening event. The majority of the sample (66%) reported at least one

threatening event in their dreams. A replication study with a sample of 50 students yielded

similar results (Valli et al., 2007). Valli et al. (2007) report 98% of the sample had at least one

threatening event in their dreams and also directed to the dream-self. In this second study 1.7

threatening events were contained in dreams (Valli et al., 2007).

In a study it was tested if dream content is more negative than waking life (Valli et al.,

2008). A sample of 39 university students provided 419 dream reports and 714 past real threat

events (interviewed to obtain real encountered threat experiences) to compare how common are

threatening event in dreams compared to waking life and viceversa. It was concluded that dream

threats indeed resemble past threats (ancestral) rather than current ones of the modern world and

as hypothesized, threat is experienced more in dream-life than in wakefulness (Valli et al., 2008).

Zadra et al. (2006) used the Dream-Threat rating scale (Revonsuo & Valli, 2000) to test

the TST. Their sample was a number of 266 recurrent dreams recorded by questionnaires. Their

findings supported six of the eight propositions of the TST of dreaming. In line with the above

studies, the majority of dreams contained at least one threatening event and the threats mainly

involved the dream-self or significant others. Not all of the predictions were verified, however, the ones that were, support previous findings of TST of dreams.

Now that studies testing the TST have been disussed, it must be mentioned that the most important strength of this theory lies in the fact that it is open to be empirically tested in order to be supported or falsified by different studies. The TST (Revonsuo, 2000a) consists of six well-defined propositions that can be tested by any researcher related to dream field and an assertive intrument has been elaborated to facilitate a dream content threat classification . Also, it must be highlighted that these propositions where formulated based on previous empirical findings that have been of main focus in evolutionary psychology, biology and neuroscience. However, evolutionary dream researchers must continue proving the propositions of this theory to obtain a stronger position in this field.

To account as a dream theory, research should be in light of a multidisciplinary approach such as the TST(Revonsuo, 2000a) of dreaming because dreaming, as part of consciousness studies involve many disciplines. Also, for dream research to keep progressing, as mentioned at the beginning of this thesis, unified concepts must be widely used as well as standardized intruments. This way, comparative studies will be possible and this will allow positive theoretical argumentation.

This present thesis has shed light on the current available evidence of the three main theories that give an explanation for dreams and nightmares. By exploring each of them it has been shown where dream research stands now and where it should be directed in the near future. As appealing as all three theories seem (one more than others), a theoretical explanation of these phenomena must consider a biological explanation. Dreaming in the biological context causally contributes to an adaptive process that has the function of maintaining and rehearsing threat

perception and threat avoidance skills for humans (Revonsuo & Valli, 2000).Therefore, at the

moment, TST (Revonsuo, 2000a) is the only plausible theory that may account as explanatory

for dreams and nightmares.

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