

The Function of Dreams and Dreaming

Moving towards an integrated understanding

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Abstract

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This theoretical essay investigates theories concerning the function of dreams and dreaming starting with the contributions made by Freud (1900) to the present day. Several theories within psychodynamic, evolutionary and neurocognitive perspectives are presented and discussed in light of relevant empirical research. These include theories which postulate that the function of dreaming is to guard sleep (Freud, 1900) and theories which propose that dreaming poses an adaptive advantage either by allowing for the simulation and rehearsal of threat avoidance behaviours (Revonsuo, 2000), practicing social skills (Franklyn & Zephyr, 2005), solving emotional or intellectual problems (e.g. Barrett, 2007; Hartmann, 1996) or aids us in the consolidation of memories (Paller & Voss, 2004). Theories that view dreaming as being functionally epiphenomenal are also discussed, such as proposals that dreaming is a by-product of the development of specific cognitive abilities (Domhoff, 2010) or merely a reflection of sleep-related changes which occur in the brain (Hobson, Pace-Schott & Stickgold, 2000). It appears that the theories presented in this essay are limited in accounting for much of the empirical evidence derived from the content analysis of dreams and the study of related neural correlates, and few attempts have been made at integrating some of the perspectives to provide a more comprehensive understanding of the nature and function of dreams and dreaming. Possible reasons for this are discussed, as well as proposals for how several theories may be integrated, followed by suggested avenues for future research and concluding remarks.

Foreword

Last summer I was struggling with my initial research project when the last participant dropped out of my study. After almost a year of work I realised that I had no choice but to start again with another thesis topic. I considered several fields of study to centre a theoretical essay around but none seemed to re-spark my enthusiasm, when one morning I awoke from a dream that I wrote my thesis on the function of dreaming.

Dreaming has fascinated me since I was young and I was surprised after studying psychology for several years that the topic had hardly been broached. After completing this thesis I realise that there is probably little focus on this area of study due to the lack of a comprehensive understanding of why we dream. It has been a pleasure spending the last semester of my studies immersing myself in theories of dreaming and contributing with my own suggestions as to how an integrated understanding of the function of dreams may be developed.

I would like to thank my supervisor, Professor Bruno Laeng, for invaluable help and feedback, and my friends and family for providing encouragement and support. Finally I would like to express gratitude to my lovely man for providing comfort and patience throughout the process.

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1 Introduction

1.1 Objectives

Dreams and the process of dreaming have fascinated mankind since ancient civilizations to modern times, although its systematic and scientific study is only a recent development (Hobson, 2009). As early as in 350 B.C. Aristotle stated that “We must inquire what the dream is, and from what cause sleepers sometimes to dream, and sometimes do not; or whether the truth is that sleepers always dream but do not remember, and if this occurs what is its explanation” (para. 2). Since then 23 centuries have passed and a plethora of theories have been proposed as to the nature of dreaming. Within the realm of psychology and psychiatry, interest in the topic was first sparked by Sigmund Freud (1900), who proposed that dreams act as ‘the guardians of sleep’ by providing a protective role which allows the expression of repressed unconscious wishes without disturbing sleep itself. Consequent theories pertaining to the function of dreaming reflect a wide range of diverging perspectives including psychodynamic theories (e.g. Solms, 1997) evolutionary models (e.g. Revonsuo, 2000) and neurocognitive models (e.g. Hobson, Pace-Schott and Stickgold, 2000) The lack of consensus between theories in the field of dream research may be partly attributed to dreams being innately difficult to study due to their subjective nature. As of yet, dream content cannot be directly observed and it is difficult to manipulate dreams experimentally making it nearly impossible to predict the contents of specific dreams (Arkin & Antrobus, 1991). As a result contemporary dream research has made a shift from investigating dream content of specific dreams to investigating neural activity of the collective properties of all dreams, thus moving from content to form (Nir & Tononi, 2009). Despite this shift, promising work has been done attempting to link dream phenomenology to neurophysiology although there is still little consensus between dream researchers and few attempts have been made to integrate diverging perspectives (Barrett, 2007).

The aim of this theoretical essay is to examine the major psychological theories related to dream research in an attempt to provide an integrated framework under which the function of dreams and dreaming can be understood. Firstly, a definition of dreams, dreaming and function will be presented along with a brief explanation of the physiology of sleep and dreaming. This will be followed by the theoretical background, which provides an outline of major theories concerning dream function, ranging from the psychodynamic to the

neurocognitive. These theories will consequently be discussed in light of relevant empirical research, followed by a suggested framework under which several of these theories can be integrated. Finally possible avenues of future research will be discussed along with concluding remarks.

1.2 Definitions

1.2.1 Dreams and dreaming

The lack of consensus in the field of dream research is also reflected in the lack of a widely accepted definition of dreams and dreaming. According to the American Heritage Dictionary of the English Language (2000) dreams are “a succession of images, ideas, emotions and sensations occurring involuntarily in the mind during certain stages of sleep”. In psychology and neuroscience Hobson (2002) offers a simpler definition of dreams and dreaming as “mental activity occurring during sleep” (p. 7). Some definitions of dreaming also include a component relating to consciousness. For example Revonsuo and Tarkko (2002) define dreaming as “a subjective phenomenon of consciousness produced by the brain with absent or only minimal contributions from external sensory stimulation” (p. 4). Other definitions within research on dreaming often focus on the proposed function of dreams and thus vary in accordance with what perspective is emphasized. For example, Hobson (2002) provides a definition of dreams and dreaming based on their proposed biological substrates: “The experience during sleep caused by selective activation of brain circuits underlying emotion and selective inactivation of brain circuits and chemicals underlying memory, directed self-reflective awareness and logical reasoning” (p. 6). However, researchers who attribute dream experiences to other processes or neural networks would most likely not accept this definition (e.g. Solms, 2002).

For the purpose of this essay the definition of dreams and dreaming as “mental activity occurring during sleep” (Hobson, 2002, p.7) will be employed due to its simplicity.

1.2.2 Function

According to Tooby and Cosmides (1995) the only relevant standard of functionality when attempting to determine why brain and cognition are organised in a certain way is the

biological evolutionary standard. If a cognitive system acts to promote an organism's inclusive fitness it can be said to be a biologically functional system. In this sense, the term 'function' refers to how a system has caused its own propagation in ancestral environments (Tooby & Cosmides, 1995). Thus, in relation to dreaming it can be said that dreaming has an adaptive function if it solves problems whose solutions promote reproduction and enhance survival. If dreaming is a by-product of other adaptive processes, i.e. a result of being dragged along in evolutionary history due to active selection of the feature it was coupled to, it cannot be said to have a function in itself (Revonsuo, 2000). Flanagan (1995) argues that it is also important to distinguish between "natural" and "invented" functions where the former refers to adaptive function and the latter refers to invented cultural or psychological functions. For example, although certain cultures may find the interpretations of dreams as meaningful or enlightening this does not entail that dreams and dreaming have a "natural" function per se.

In line with the majority of dream theories to be presented in this current theoretical essay, the term "function" is used to refer to adaptive qualities in the strict Darwinistic sense.

1.3 The physiology of sleep and dreaming

1.3.1 Stages of sleep

Research on the physiology of human sleep is generally conducted in a sleep laboratory with the use of electroencephalography (EEG), electro-oculography (EOG) and electromyography (EMG). This enables sleep researchers to distinguish between arousal states during sleep by measuring brain activity, eye movements and muscle activity (Carlson, 2004). During sleep our brain passes through four stages characterized by differing waves of brain activity as well as rapid eye-movement (REM) sleep, in a cyclical manner (Rechtschaffen & Kales, 1968). Stages 1-4 sleep may also be referred to as non rapid eye-movement (NREM) sleep.

Stage 1 sleep, which lasts for approximately ten minutes, is characterized by theta activity and marks the transition between sleep and wakefulness. This is followed by stage 2 sleep, which is generally irregular but contains periods of theta activity, K complexes (sudden, sharp waveforms) and sleep spindles (short bursts of waves). After approximately 15 minutes stage 3 sleep is followed by stage 4, the deepest stage of sleep. Stage 3 and 4 may be referred to as slow-wave sleep due to the presence of delta activity. The distinction between these stages is not clear cut as they both consist of high-amplitude delta waves although stage

4 sleep has a higher proportion of such waves (more than 50 %) than stage 3 sleep (20-50%). In 2007, these stages were combined by the American Academy of Sleep Medicine to form a single stage due to their lack of distinction (cited in Schulz, 2008).

Following 90 minutes of sleep onset a sudden change occurs where the eyelids start to dart back and forth between the closed eyelids, the EEG becomes mostly desynchronized and the EMG indicates a profound loss of muscle tonus. This is referred to as rapid eye-movement (REM) sleep and includes a small amount of theta waves along with beta activity, which is usually seen during wakefulness or stage 1 sleep. REM-sleep lasts for 20 – 30 minutes whereby the sleep cycle starts again alternating between REM and NREM-sleep. Each cycle lasts for approximately 90 minutes, thus an 8-hour long sleep will contain four or five periods of REM-sleep, which become more prolonged for each cycle. Most of the slow wave sleep occurs in the first half of the night and subsequent bouts of NREM-sleep consist increasingly of stage 2 sleep (Carlson, 2004).

1.3.2 The discovery of REM-sleep

In the early 1950s Aserinsky and Kleitman attempted to systematically investigate the possibility that REM-sleep was somehow associated with dreaming. In their observations of sleeping infants, and later adults, they hypothesised that the physiological changes which occur when entering REM-sleep suggest an emotional ‘disturbance’ which may indicate dreaming. Aserinsky and Kleitman (1953) and later Dement and Kleitman (1957) awakened subjects from the midst of their REM-sleep and discovered that on average 70% of these awakenings yielded dream reports. This discovery linking the phenomenon of dreaming with the physiological occurrence of REM-sleep has now been confirmed in numerous studies and marks one of the first and most groundbreaking findings in dream research (Franklin & Zyphur, 2005).

Although subsequent studies have demonstrated that dreaming may also occur in NREM-sleep (e.g. Foulkes, 1962), the theories that form the basis of this theoretical essay invariable differ as to the importance they give dreaming in NREM. Some dream researchers such as Solms (2000), actually use the lack of focus on dreaming in NREM as the basis for their critique of competing theories. The occurrence of dreams in NREM-sleep and its implications for theories of dream function will be further elaborated in the following section, as well as in the Discussion.

2 Theoretical background

There is a wide spectrum of theories pertaining to the function of dreams and dreaming (Dallett, 1973) and for the purpose of this essay is it not possible to review them all. However, there is a great deal of overlap among the various theories and it is possible to provide an outline of some of the most representative perspectives on dream function in the psychology literature. In the current essay, these have been divided into three main subsections:

Psychodynamic, Evolutionary and Neurocognitive theories. Although some specific accounts may intersect into more than one category they have been placed in the subsection considered to most accurately reflect their central tenets. Each perspective to be outlined here will be expanded upon and evaluated in the Discussion in light of relevant empirical research.

Some theories which have previously garnered much attention and stimulated the debate on dream function (e.g. Crick & Mitchison's, 1983, "reverse learning" hypothesis) will not be included in this theoretical essay if they have subsequently been rejected by the majority of current dream researchers due to a lack of empirical support.

2.1 Psychodynamic theories

2.1.1 Freud

We begin in chronological order, with theories that emerged from the psycho-analytic movement. At the end of the 19th century it was generally thought that dreams are reactions to external or internal stimuli that they most often occurred during the process of waking and were brief in duration (Domhoff, 2002). Some writers, such as Alfred Maury (1853), emphasized the role played by waking experiences and insufficiently-inhibited emotions in the process of instigating dreams. Sigmund Freud (1900) tried to bring some of these perspectives together in his influential book "The Interpretation of Dreams", combining them with his ideas about the role of the unconscious and his novel theories of neurosis. This was the first attempt in the field of psychology and psychiatry at providing a systematic theory pertaining to the function and processes involved in dreams and dreaming (Fisher & Greenberg, 1996).

Freud (1900) viewed a neurotic symptom as a product of trying to satisfy both a conscious wish and a conflicting, unconscious, repressed wish. He posited that, during

wakefulness, unconscious repressed wishes (often of an infantile sexual nature) are held in check by a 'censor' which prevents them from entering our conscious minds. However, this censor is less alert during sleep, allowing repressed wishes to enter our dreams if they are sufficiently disguised in dream content. Freud viewed this disguise of unconscious wishes as the product of 'dream work' and could account for creating bizarreness in manifest dream content. He believed 'dream work' to involve several processes including condensation, displacement, representation and symbolization.

The process of condensation implies compressing the meaning of the dream such that a particular element of the obvious content represents several underlying themes.

Displacement occurs such that overt elements of the dream actually represent other, more hidden elements, resulting in a discrepancy between the manifest dream content and the underlying dream content. Representation involves translating thoughts into visual images that are more acceptable for the censor and symbolization results in replacing a particular character or action with symbols. Freud (1900) believed that these processes work together, actively contributing to obscure and disguise the true meaning of the dream. According to Freud (1900) this disguise is necessary due to the salacious and mainly sexual nature of the hidden content.

Freud (1900) argues that dreams are made possible due to daytime experience ('day residue') of problems, worries, unsatisfied wishes or indifferent material which are somehow linked to repressed infantile wishes contained in the subconscious, thus triggering the emergence of related memories. The images from waking experience that are contained in the clear content of dreams allows the related infantile repressed wish to be disguised such that it can slip past the half-asleep sensor and gain a degree of expression for itself. The obvious content of the dream may be further disguised in the waking mind through secondary revision in order to give the dream story a more logical and intelligible façade. Freud (1900) believed that only through 'free association' of each element of the dream could its true meaning and the underlying repressed wishes be uncovered.

Freud (1900) proposed dreams to be very similar to neurotic symptoms, acting as the guardians of sleep, by providing a protective role which allows the expression of unconscious wishes without disturbing sleep itself. He argued that awakening from dreams is a result of failure of the dream to sufficiently disguise the unconscious repressed wish thus arousing the censor to full waking alertness. This implies that the true function of dreams and dreaming, in Freud's (1900) view, is to preserve sleep in the face of unconscious needs for excitement.

A further elaboration on the aspects and processes Freud proposed to be involved in dreaming will be provided in the discussion when presenting relevant empirical research.

2.1.2 Jung

The Swiss psychiatrist Carl G. Jung was considered one of Freud's closest friends and most promising students until they had a falling out in 1914, partly as a result of their differing views as to the nature and function of dreaming (Homans, 1979).

Jung opposed Freud's theory that dreams intentionally disguise their meanings, arguing instead that dreams are a natural and direct expression of the dreamer's current concerns (Jung, 1967). Jung claimed the nature of dreams is to present "a spontaneous self-portrayal, in symbolic form, of the actual situation in the unconscious" (Jung, 1967, Vol. 8, para. 505). He believed we have difficulties understanding dreams when conscious because they adhere to the language of our unconscious. This language involves the use of images, metaphors, and symbols (Jung, 1967).

Jung (1967) distinguished between objective and subjective levels of a dream's meaning. The objective level of a dream's meaning is related to activities of the dreamer's daily life in the external world such as people, events and activities. The subjective level of a dream's meaning relates to the inner world of the dreamer such as thoughts and feelings, where characters in dreams may be personifications of these. Jung (1967) criticized Freud for only focusing on the objective level of a dream's meaning, neglecting the subjective level. Jung believed that the true nature of dreams is to portray both these levels of the dreamer's life.

Jung (1967) believed that in addition to expressing personal content, dreams might also reflect collective or universal content in the form of archetypes. Archetypes, according to Jung, refer to primitive mental images which are inherited from the earliest human ancestors and present in the collective unconscious (Fordham, 1966). Jung claimed that archetypes reflect a natural wisdom buried deep in the unconscious which can serve to guide the dreamer towards achieving wholeness by providing insights.

According to Jung (1967) dreams serve two functions. The first is to compensate for imbalances in the dreamer's psyche by expressing content from the unconscious that the dreamer has actively repressed, ignored or depreciated. For example a person who is overly intellectual may have dreams which express the psyche's emotion-oriented content in an effort to achieve greater psychological balance. For this to occur it is important that the

dreamer accepts and recognizes the unconscious content. Jung (1967) believed that the second function of dreams is to provide prospective images of the future. This does not imply that dreams predict the future but rather generate possibilities and anticipations of what the future might hold for the dreamer. Ultimately, Jung believed the true function of dreams is to unite the conscious and unconscious in a healthy and harmonious state of wholeness. Jung (1967) termed this process ‘individuation’ and regarded it as the most important developmental process in human life.

2.1.3 Solms

The psychoanalyst Mark Solms (1997) based most of his theory of dreaming on clinico-anatomical studies of patients suffering from a wide variety of brain injuries. Solms (2000) developed several hypotheses concerning which anatomical areas of the brain are necessary for dreaming, in an attempt to integrate findings from neuropsychology and psychoanalytic theory to create a new field called neuropsychanalysis (Solms & Turnbull, 2002). In his research, Solms (1997) compared brain scans and psychological tests with changes in dreaming reported by patients following their brain injuries. Solms’ (1997) findings that dreaming is closer associated with neural networks in the forebrain rather than previous claims that dreaming is associated with neural networks in the brain stem (Hobson & McCarley, 1977) led him to a series of conclusions. Firstly, he suggested that the notion of dreaming as merely “an epiphenomenon of REM-sleep” (Hobson, Stickgold & Pace – Schott, 1998, p.12) was flawed, as dreaming was also found to occur during NREM-sleep and activity in the brain stem observed during REM-sleep (assumed to result in dreaming) was not present when dreaming in NREM-sleep (Solms, 2000). Secondly, the Freudian theory had wrongly been rejected on the basis of these previous, faulty, claims that REM-sleep and thus dreaming was a ‘mindless’ activity, due to their presumed connection with random signals arising from the tegmental region of the pons (this claim will be further elaborated on in the section concerning Hobson and McCarley’s, 1977, activation synthesis hypothesis).

According to Solms and Turnbull (2002) the functions Freud attributed to the ‘libidinal drive’ (the primary instigator of dreams) equates to the main function of the forebrain; that is “to motivate a subject to seek out and engage with external objects which can satisfy its inner biological needs” (Solms, 1999, p.5). Thus, he argues that the findings that dreaming is associated with neural dopaminergic networks in the forebrain can be taken as evidence for the Freudian theory of dreams. Solms (1999) summarises this as follows:

Dreaming is initiated by an arousal stimulus which in turn may activate the motivational mechanisms for the brain, if the stimulus is intense or persistent enough. This sets off the dream process but because the motor system is blocked during sleep, the purposive action is rendered impossible resulting in the activation process becoming regressive. This occurs in a two-stage process where higher parts of the perceptual system (which serve memory and abstract thinking) and the lower parts of the perceptual system (which serve concrete imagery) are activated. Thus, what Solms termed a regressive process results in imagining oneself engaging in motivated activity during dreaming and accepting this imagined scene as a real perception, mainly as a result of inactivation of reflective systems in the frontal regions of the brain.

Although Solms (1999) supported Freud's view of dreaming as the guardian of sleep, he did not attribute any functions to the specific content of dreams, simply regarding them as bizarre hallucinations mistaken for real perceptions due to weakened reflective processes in the forebrain. However, Solms (2000) did not argue against a function of dreaming but rather that the biological function still remains unknown. Solms's (2000) conclusions, connecting his neuro-anatomical findings with Freudian theory, have subsequently generated a host of criticism and will be further elaborated in the discussion.

2.2 Evolutionary theories

Evolutionary theories generally posit that the contents of dreams have an adaptive biological function that can further the survival of our species. The evolutionary perspectives to be outlined here are those of "threat simulation theory" (Revonsuo, 2000), social learning perspectives (Franklin & Zyphur, 2005), as well as theories that stipulate dream content to have an adaptive function in simulating environments that allow for the solving of intellectual or emotional problems (e.g. Barrett, 1993).

2.2.1 Threat Simulation Theory

The Finnish psychologist Anton Revonsuo (2000) has put forward a detailed "threat simulation theory" which posits that the biological function of dreaming is to provide a virtual reality that simulates threatening events, such as being chased or falling, in order to allow for the rehearsal of threat avoidance behaviours. Revonsuo (2000) argues that because human evolution took place in very threatening environments there was an adaptive advantage to

simulating real-life threatening confrontations. Such simulations could improve the ability to perceive and avoid threats during wakefulness. The dream state is ideal for this type of practice, as it provides a safe environment that the dreamer experiences as real, where various scenarios reflecting threatening events can be repeated and combined.

Revonsuo (2000) has combined findings from psychology, biology and cognitive neuroscience to suggest six underlying propositions of his theory. These propositions stipulate that dream consciousness is a selective, organized and specialized simulation of threatening events in the perceptual world. The threat simulation system can only be fully activated by exposure to threatening events, which are perceived as real, and that dreams can provide such a perceptually and behaviourally realistic environment. This rehearsal can improve the ability to perceive and avoid threats during wakefulness, regardless of whether the dreams are explicitly remembered or not. The final proposition by Revonsuo (2000) in support of his theory is that the human brain evolved in a dangerous environment that involved threats to the success of human reproduction. As a result, threat simulation mechanisms were naturally selected for by improving the chances of survival and consequently procreation.

The types of threatening events Revonsuo (2000) describes and their rate of occurrence in dreams will be further evaluated in the discussion in light of empirical evidence from the content analysis of dreams collected from dream journals and sleep laboratories.

2.2.2 Social learning functions of dreaming

Psychologists Michael Franklin and Michael Zyphur (2005) have expanded upon Revonsuo's (2000) threat-simulation theory by adding the notion that dreams also allow of the rehearsal of interacting in social situations.

Drawing on evidence from cognitive neuroscience and philosophy of the mind, Franklin & Zyphur (2005) believe that dreams reflect general virtual rehearsal mechanisms which exert fitness-enhancing benefits in the development of higher-order cognitive capacities related to social skills. They argue that this view is supported by empirical findings which indicate that during REM-sleep some areas of the brain related to the processing of social information (especially conflict resolution and social judgment) are activated and that content analysis of dreams often contain people interacting in social situations. Franklin and Zyphur (2005) believe the rehearsing of social situations in dreams improves the ability to resolve interpersonal conflicts and confrontations in waking life and that for our ancestors this

process increased access to resources in a social group such as mates and food. Thus individuals adept at successfully navigating through the social environment had an increased chance of survival and dreams which exerted a fitness enhancing aspects by allowing the rehearsal of such skills was selected over time. Thus the true the function of dreams, according to Franklin and Zyphur (2005) is to create a “virtual reality” where individuals can strengthen their capacity to deal with threats, as well as their capacity to successfully interact in social environments.

2.2.3 Dreaming as problem-solving

In psychology, a number of dream theorists argue that dreams can have problem-solving functions which promote psychological well-being by allowing the individual to adjust to and cope with current intellectual or emotional concerns in waking life (e.g. Barrett, 2007). Many of these theories are very similar in their general assumptions and central tenets and thus only a few will be described in this section. As a group, these theories will be further evaluated in the Discussion drawing on a host of empirical research from sleep laboratories and dream journals, as well as anecdotal accounts which are often taken for support for the view of dreams as serving problem-solving functions.

Psychologist Deirdre Barrett (2007) believes that dreams provide a creative canvas for solving personal and objective problems which was passed down from our ancestors as a result of having an adaptive advantage that increased their chances of survival. She describes dreaming as thinking in different biochemical states where we continue to work on current concerns that originate from our wakeful state. She believes that problems are especially likely to be solved during dreaming when vivid visualization can contribute to the solution or if the solution may be reached by “thinking outside the box”.

Psychologist and sleep-researcher Rosalind Cartwright (1991) proposes that dreams act as a natural healer by relating new emotional problems with older patterns of problem-solving that have worked for the dreamer in the past. She believes that dreams may diffuse the emotional charge of real life events enabling the sleeper to see things in a more positive light upon waking. She proposes that dreams generally function to regulate mood and that this process can sometimes short-circuit in people suffering from mental illness resulting in disturbed sleep and worsening of symptoms.

Similarly to Cartwright (1996), the psychiatrist Milton Kramer (1993) has proposed that dreams function as “selective mood regulation”. Specifically, he argues that the function

of dreams is to protect sleep by containing the “surge of emotion” which he believes to occur during REM-sleep. If the containment of this emotional surge is unsuccessful the dreamer wakes. If it is successful the dream first states the problem and then attempts to resolve it. This process consequently leads to no recall of the dream and has a positive affective result on the dreamer.

Breger (1967) argues that dreams have a problem-solving aspect, emphasizing that they initially have a developmental function for children in facilitating their efforts at mastery. He points out that children work through their problems using the natural thought mode of fantasy where dreams allow finding creative new solutions through “fantasy programs”. He expands on this idea by combining his account with an information-processing model arguing that the function of dreams in both children and adults is to find solutions to affective and personal problems. Breger (1967) believes that dreams reflect current affective-arousing problems that are tested to fit previous “programs” which aided the dreamer in resolving conflicts at an earlier time. He proposes that any real-life event that the dreamer considers an emotional concern can lead to problems of emotional or behavioural adjustment. During dreaming these emotional problems can be solved, thus contributing to the psychological well-being of the individual. Breger (1967) argues that the dream state is ideal for dealing with emotional material for a number of reasons whereas the overall effect is the “creative opening up of the memory systems” (Breger, 1967, p.25)

In his “contemporary theory of the functions of dreaming” psychiatrist Ernest Hartmann (1996) argues that dreams facilitate psychological healing by contextualizing our emotions and emotional concerns in pictorial metaphors. Hartmann (1996) draws heavily on connectionist models of neural activation, proposing that these “neural nets” make connections more widely interactive during dreaming than when we are awake. Hartmann (1996) argues that dreaming has a quasi-therapeutic function which allows for cross-connection of emotional material in neural networks in the context of a “safe place”. This occurs particularly in the case of traumatic experiences through association and integration of material with other related emotional material of the dreamer’s life and results in “calming the storm”. Over time, as the trauma is resolved or integrated, the cross-connecting and thus the dreams becomes less intense and therefore the dreams change their character. Hartmann (1996) believes that establishing these connections further helps us when encountering new but similar problems, since appropriate contexts and cross-connections are already present. Thus dreaming also has a restorative function in producing changes in memory networks which are adaptive for the future. Hartmann (1996) argues that this perspective is compatible

with many theories which view dreaming as having an emotional adaptive function, including those of Cartwright (1991), Kramer (1993) and Breger (1967) outlined above. Hartmann (1996) believes his theory of cross-connections in neural nets may serve to further integrate these viewpoints by providing a common understanding of the process that lies behind the emotional problem-solving function of dreaming.

2.3 Neurocognitive theories

Cognitive theorists such as Foulkes (1985) and Domhoff (2010) are the most adamant supporters of the view that dreaming is biologically epiphenomenal. This does not entail that dreams have no coherence or meaning (which they argue is often mistaken for function) but rather that dreaming is a by-product of the evolution of other processes, such as sleep and consciousness (Flanagan, 1995). The neurocognitive theory called “activation-synthesis hypothesis” (Hobson & McCarley, 1977) also views dreams as the by-product of other biological phenomena, although this was later expanded on by Hobson (2009) to include the view of REM-sleep as possibly having evolved to provide a virtual reality mode that may function to develop and maintain waking consciousness. Although these theories contain an evolutionary aspect, they differ from the evolutionary perspectives outlined above which stipulate that the main function of dreams can be understood in light of the presumed adaptive nature of their specific content (e.g. Revonsuo, 2000; Franklin and Zyphur, 2005). Before moving on to the discussion, the following section will outline accounts that regard dreaming as a product of memory consolidation during REM and NREM-sleep.

2.3.1 A new cognitive approach to dreaming

Psychologist and dream-researcher William Domhoff (2010) suggests a ‘new cognitive approach’ to dreaming and dream content, which he argues can also be extended to encompass a neurocognitive understanding. Domhoff (2010) attempts to refute the Freudian, Jungian, and activation-synthesis models (to be outlined below) of dreaming by presenting empirical evidence that stresses the parallels between waking cognition and dreaming than suggested by these theorists. Domhoff (2010) views dreaming as the ‘default’ position of the brain when it is not constrained by focusing on physical and social reality by external stimuli and the “self-system” that “reminds us of who we are, where we are, and what the tasks are that face us” (p.1). He proposes that we have a “conceptual system” of schemas and scripts

which underlie all human knowledge and beliefs. During waking this system plays a part in developing human thought and imagination. Domhoff (2010) argues that if this same conceptual system is activated under the following conditions dreaming occurs: An adequate level of cortical activation, blocking of external stimuli, an intact and fully mature neural network for dreaming and loss of conscious self-control. He believes that dreaming may also occur under relaxed waking states as long as these conditions are present.

Domhoff (2010) proposes that the contents of dreams are the expression of people's conceptual systems. He particularly emphasizes the expression of conceptions concerning the self ("self-conceptions"), which he defines as cognitive generalizations that may guide the processing of events and self-relevant information. Domhoff (2010) believes that dream content expresses schemas, scripts and general knowledge in a dramatic and perceptible way, reflecting conceptions that form the basis for action when awake. He generally views dreams as "plays the mind stages for itself when it doesn't have anything specific to do" (Domhoff, 2010. p.2).

Thus, Domhoff (2010) views dreaming as having no adaptive function per se, but as a by-product of the evolution of cognitive abilities involved in generating mental imagery, creating an autobiographical self and organizing experiences in narrative form. He does not reject the idea that dreams may have psychological meaning, as their contents reflect and portray conceptions and emotional preoccupations in creative and dramatic ways. However, he argues that it is important to distinguish between meaning and purpose since "not everything with form or structure has an adaptive function" (Domhoff, 2010, p. 9).

2.3.2 Activation-Synthesis Hypothesis

The activation-synthesis hypothesis of dreaming, first proposed by Hobson and McCarley in 1977, emphasizes that dream content is random. They propose that REM-sleep occurs when "REM-off" neurological activity in the brain stem (relating to aminergic activity) reaches a level low enough to allow the inhibited "REM-on" neurological system (relating to cholinergic activity) to be activated. Hobson and McCarley specifically propose that during REM-sleep there is activation of ponto-geniculo-occipital (PGO) waves which are generated in the pontine brainstem (P), then spreading to the lateral geniculate body of the thalamus (G) and the occipital cortex (O). These PGO waves barrage the forebrain with random stimuli which subsequently attempts to make sense of the internally generated stimulation by synthesizing dream images that correspond to their activation patterns. Dream images would

be loaded from memory and selected by the forebrain to isomorphically correspond to those patterns of motor commands and eye movements that are elicited during REM-sleep. Hobson and McCarley (1977) believe that these processes can account for the bizarreness experienced in dreams, as the brain is merely attempting to make sense of randomly generated internal stimulation. The images selected by the forebrain to form dream content are loaded from memory where those easily accessible in short-term memory (day residues) are particularly salient; for example, if the randomly produced stimuli resemble those produced when running, then the forebrain may activate memories that trigger a dream of running. The forebrain may then latch on to other easily accessible memories; for example if the dreamer has been startled by a cat earlier in the day, thus producing a dream of being chased by a lion.

Hence, Hobson and McCarley (1977) view dreaming as the preprogrammed running of an internal system. They argue that dreams have no function or meaning but are merely the brain's reaction to other biological processes that occur during sleep.

In light of more recent neuroimaging data and lesion studies the activation-synthesis hypothesis of dreaming has subsequently been revised and expanded to what is now known as the "activation input modulation model" (Hobson, Pace-Schott and Stickgold, 2000).

2.3.3 Activation Input Modulation model

The activation input modulation (AIM) model is a three-dimensional model for brain states first put forth by Hobson, Pace-Schott and Stickgold (2000). AIM uses the three values of activation (A), input-output gating (I) and modulation (M) to describe different states of consciousness and how these vary during waking and sleeping. Specifically, AIM focuses on physiological features of dreaming at the neuronal and molecular level providing an explanation of how the three factors are coordinated and engineered to regulate the "system of consciousness states" (Hobson, 2009):

Activation (A)

Drawing on neurophysiological evidence Hobson et al. (2000) describe how the brain is not a collection of passive reflex circuits but rather has the ability to regulate its own activation. In relation to consciousness, they argue that neuronal populations in large parts of the brain (including subcortical and neocortical areas) are activated during waking and REM-sleep and deactivated during NREM-sleep.

Input-output gating (I)

Hobson et al (2000) propose that, despite brain activation in REM-sleep, external sensory input and motor output is actively suppressed such that the brain is kept 'off-line' and the result is not waking up. This input-output gate control is mediated by the brainstem, where PGO waves are partly responsible for keeping the brain asleep. PGO waves occur mainly in the visual system but also in sensorimotor systems in the forebrain. The PGO system is proposed to constitute the informational building-blocks for perception and motor control via their phasic coordination and promotion of sensorimotor integration in general (Hobson et al. 2000). PGO waves may also account for the construction of hallucinatory visual imagery during dreaming and why dreams are experienced as real due to the brain treating endogenous stimulation as events arising from the external environment. According to Hobson (2009): "The spontaneous activation of this system in sleep supports the hypothesis that the brain simulates its interaction with the external world" (p. 809).

Modulation (M)

Hobson et al (2000) outline various research findings concerning the neuromodulator release of aminergic neurons to explain the shift that occurs between external input during waking to internal input during dreaming. They propose that REM-sleep is initiated when 'REM-off' cells (which are active during waking) become aminergically suppressed and 'REM-on' cells (which are active during REM-sleep) become cholinergically potentiated. Hobson et al (2000) argue that during REM-sleep the release of dopamine and the absence of 'wake-state' modulators noradrenalin, serotonin and histamine may account for several of the cognitive characteristics of dream content including lack of self-reflective awareness, visual hallucinations, amnesia and bizarreness.

Similarly to the activation-synthesis hypothesis, the AIM model views dreams and dreaming as merely reflecting the sleep-related changes in the brain outlined above, thus rendering them functionally epiphenomenal (Hobson et al. 2000). Stickgold, Hobson, Fosse and Fosse (2001) have subsequently built on this view maintaining that dream content poses no adaptive advantages but that the mechanism involved in dream construction may be a function of sleep-dependent learning and memory reprocessing (to be outlined in the next section).

Hobson (2009) has recently taken the AIM model even further, proposing that REM-sleep may constitute a protoconscious state (i.e. a virtual reality model of the world). He

hypothesizes that primary consciousness (emotion and perception) constitutes an important building block for secondary consciousness (e.g. self-reflective awareness, abstract thinking, volition and meta-cognition) and that REM-sleep as a precursor for the latter can account for why dreaming during REM-sleep includes features of primary consciousness but lack features of secondary consciousness. Hobson (2009) suggests that the function of early REM-sleep, which precedes the onset of dreaming in early childhood, is to prepare the brain for consciousness as well as other integrative functions, such as learning and senso-motoric integration (as mentioned in 'I' of the AIM model). He proposes that REM-sleep enables neurons to act as a unified system, as during REM-sleep neurons are connected both temporally and chemically through activation and neuromodulatory functions (as outlined in the AIM model). He further proposes that "the developing REM-sleeping brain has built-in predictions of external space and time" (Hobson 2009, p. 808) where these intrinsic predictions are adjusted as a product of real-world experience. To summarize, Hobson (2009) still holds the position that dreaming is epiphenomenal but that the state in which dreaming most often occurs, namely REM-sleep, has evolved in humans to promote the development and maintenance of consciousness and other higher-order brain functions, such as problem-solving, during waking.

2.3.4 Dreaming as memory consolidation

Memory consolidation refers to the neural processing which occurs after information is initially registered resulting in more permanent storage in memory (Nadel & Moscovitch, 1997). Interest in the view that memories may be processed or consolidated during sleep dates back to at least 1924 when Jenkins & Dallenbach reported findings that an intervening period of sleep had a subsequent positive effect on recall (cited in Vertes & Eastman, 2000). Since then a host of theories have been proposed regarding the function of REM-sleep and dreaming on memory consolidation where some of the most recent will be outlined here. Drawing on experimental research in neuroscience these will be further examined in the Discussion.

Stickgold, Hobson, Fosse & Fosse (2001) integrate converging neuroscience and psychological data in an attempt to construct 'a new cognitive neuroscience of dreaming'. They propose that one of the functions of the 'mechanism of dream construction' is sleep-dependent learning and memory reprocessing. Drawing on empirical research in neuroscience, they specifically argue that REM-sleep allows for selective strengthening of associations and consolidation of semantic memories. Stickgold et.al. (2001) hypothesize that

these strengthening processes occur as a result of reduced information flow from the hippocampus to the neocortex during REM-sleep, as well as increased flow of weakly associated semantic content from the neocortex to the hippocampus. With regards to function, they view the manifest content of dreams to contain no biological advantages per se, but to be a by-product of other processes, including semantic memory consolidation during REM-sleep. Thus, Stickgold et al. (2001) argue that dreaming is epiphenomenal, which explains the apparent bizarreness experienced in dreams, where barely-related objects, characters and locations lacking in spatio-temporal coherence can play out in illogical sequences.

Payne and Nadel (2004) believe that in different stages of sleep the content of dreams reflect aspects of the process of long-term memory consolidation. They argue that the purpose of this process is to strengthen neural traces of recent events, integrate these with previously stored knowledge and older memories, and provide stability for existing memories in the face of new experience. Payne and Nadel (2004) particularly focus on the role that the stress hormone cortisol plays in this process. They hypothesise that variations in cortisol, in addition to other neurotransmitters, has an effect on memory consolidation during sleep by determining the functional status of neocortical and hippocampal circuits. According to their theory, levels of cortisol exert control over the hippocampus thereby influencing which states the brain oscillates between during the night. This varies between states that are either more conducive to consolidating episodic memories or states that are more conducive to consolidating semantic memories. They focus on memory consolidation and dreaming in both REM and NREM-sleep, proposing that the often fragmented and bizarre nature of dreams in REM-sleep is due to the content reflecting only neocortical activation as opposed to hippocampal activation. In general, they view dreams (when remembered) as providing windows to the inner workings of our memory systems. The empirical data Payne and Nadel (2004) draw on to back up their hypothesis will be further outlined and evaluated in the discussion.

In line with Stickgold et al (2001) and Payne and Nadel (2004), Paller and Voss (2004) believe that connections among dispersed cortical networks and hippocampal-neocortical connections are strengthened by sleep. They particularly stress the gradual process of cross-cortical consolidation of declarative memories during sleep through formation and elaboration of associations with other memories. They argue that this ‘memory reprocessing’ results in more cohesive and more thoroughly integrated declarative memories which can lead to the development of interrelated memories in complex networks and alignment of memories with long-term goals and strategies. Paller and Voss (2004) hypothesise that the principle

function of dreaming is to form new connections between pairs of memory fragments resulting in enrichment of 'our storehouse of declarative memories'. Ultimately, Paller and Voss (2004) believe this process can lead to new insights and behaviour strategies as a result of novel combinations of memory fragments formed during dreaming in REM and NREM-sleep.

3 Discussion

The following section will discuss each major ‘dream theory’ outlined in the theoretical background in light of empirical research ranging from content analysis of dream reports, experimental studies in sleep laboratories, anecdotal evidence, developmental studies, neuropsychological studies of changes in dreaming following brain lesions and correlational research relating dream recall to variables of cognition and personality. The following section progresses in the same sequence as the theoretical background, where each theory is discussed separately. The majority of theories to be assessed here have already generated a host of criticism from competing dream theorists, some of which will be summarized in each section. This will be followed by a General Discussion, where a suggested framework under which several of these theories can be integrated, will be presented. Finally, lines of future research will be discussed followed by concluding remarks.

3.1 Psychodynamic theories

3.1.1 Freud

Freud (1900) believed that the biological function of dreams is to preserve sleep, allowing for unconscious repressed wishes to be discharged without waking the dreamer. These unconscious wishes are disguised through ‘dream work’, which involves processes of condensation, displacement, representation and symbolization. According to Hobson (2002), Freud described many of the now generally accepted and scientifically evaluated qualities of dreams including the presence of strong emotions, bizarreness, dream amnesia and the visual form. However, Freud’s (1900) proposal of the function of dreams and the processes involved in ‘dream work’ has subsequently been rejected by many theorists on the basis of refuting empirical evidence, some of which will be outlined here.

According to Domhoff (2002) there is a lack of convincing evidence of the operation of ‘dream work’. A review of experimental and correlational studies by Fisher and Greenberg (1996) suggests that the manifest content of dreams contains much more information about the dreamer than one would expect if the content was actively disguised. This is also supported by a recent study by Domhoff and Bulkeley (2010) who, using a ‘word search’ approach, found that they could accurately predict an individual’s personality attributes,

relationships, activities and cultural preferences solely on the basis of analysing their manifest dream content. Domhoff (2002) also notes that many of Freud's (1900) examples of 'dream work' frequently include sexual slang, jokes and proverbs and that this demonstrates figurative thought rather than the processes proposed by Freud.

Freud (1900) believed that emotions are often inappropriate to the content in dreams, as a product of displacement and substitutions. However, several studies derived from sleep laboratories suggest that emotions are rarely mismatched in dreams and most often "overwhelmingly appropriate" (Foulkes, 1999, p. 68). Other studies of dream reports from sleep laboratories have also rejected Freud's (1900) claim that dream content is usually unrealistic or bizarre. For example Snyder (1970), who studied several hundred such reports, concluded that dreams are a "clear, coherent, and detailed account of a realistic situation involving the dreamer and other people caught up in very ordinary activities and preoccupations, and usually talking about them" (p. 148). This finding also counters Freud's (1900) claim that dreams most often depict repressed unconscious wishes of a sexual nature as there is little evidence of predominant sexual content in dreams (e.g. Hall & Van de Castle, 1966).

Hobson (2009) still holds that dream content is often bizarre, although he argues that this is a result of differing processes and mechanisms than those proposed by Freud, as outlined in the "activation-synthesis hypothesis" and the AIM model above. Bizarre elements in dreams will be further discussed in the section concerning these two hypotheses.

Freud (1900) proposed that dreams are rarely remembered during waking as they are actively repressed from the conscious mind. Hobson, Pace-Schott and Stickgold (2000) outline the phenomenon of dream amnesia in the AIM model but reject the claim that this is a product of repression. As previously mentioned, they attribute poor recall of dreams to a state dependent amnesia resulting from the demodulation of aminergic neurons during REM-sleep. Domhoff (2002) rejects Freud's (1900) ideas of active repression, citing instead laboratory studies which demonstrate that the recency, length and intensity of a dream (as reported after awakenings during REM-sleep) best predicts which dreams will be recalled the subsequent morning (e.g. Trinder & Kramer, 1971). Other researchers suggest that dream recall is associated with individual differences, such as the personality trait 'openness' as measured with the five-factor model. For example, in his studies on dream recall in a group of 169 students, Watson (2003) found that individuals prone to imagination, fantasy and absorption were particularly likely to recall their dreams and that these individual differences were strongly stable over an interval of two months.

Freud (1900) viewed dreams as discharging wishes that would be deemed unacceptable to the conscious mind claiming that “wish-fulfilment is the meaning of each and every dream” (p. 106). He argued that dreams with anxious content were simply a result of a failure of the ‘censor’ to disguise the unconscious wishes enough to make them acceptable. Although this claim is difficult to falsify it is highly unlikely that such a process can account for the occurrence of traumatic or recurrent dreams, such as the repetitive nightmares often evident in post-traumatic stress disorder (Barrett, 1996) or findings relating to the content analysis of more than 500 dreams that suggest as much as 80% of dream content may contain negative emotions (Hall & Van De Castle, 1966).

Dement (1960) attempted to further test the hypothesis that dreaming discharges unacceptable wishes that might otherwise disturb waking consciousness by depriving individuals of REM-sleep (thought to be the stage of sleep most conducive to dreaming). He found that after 3-5 days cognitive deterioration was evident and individuals needed far more arousals to prevent them from entering REM-sleep as the days progressed. Dement (1960) argued that this was an indication that the body needed to ‘catch up’ on lost REM-sleep concluding that it was not sleep but dreaming that was crucial to mental health. According to Hobson (2009), Kales and colleagues (1964) countered this claim in their research on sleep deprivation which demonstrated that cognitive deterioration was equally detrimental if participants were deprived of NREM-sleep instead of REM-sleep. It is also important to mention here that there is an ongoing debate of dreaming in REM vs. NREM-sleep indicating this divide is not as clear cut as previously assumed and that there may be a continuum between the two. This will be further discussed in the section concerning the “activation-synthesis hypothesis” (Hobson and McCarley, 1977) and the AIM model (Hobson, Pace-Schott & Stickgold, 2000).

Freud’s (1900) claim that the biological function of dreaming is to act as the “guardian of sleep” also appears to be contradicted by a number of findings in the empirical literature. For example, Foulkes (1999) found that preschool children rarely dream (they only report dreaming 20% of the time when awakened from REM-sleep) but still have regular sleep. Laboratory studies of leucotomized patients with schizophrenia show that they have regular sleep although they seldom report dreams upon awakening or when aroused from REM-sleep (Jus et al., 1973). In his clinico-anatomical studies, Solms (1997) also found evidence that patients with injuries to the parietal lobes did not report dreaming although their sleep was preserved. However, Solms (1997) concludes that some of his findings of aminergic activation and anatomical areas involved in dreaming lend support to Freud’s (1900) claims

of dreams as wish-fulfilment and ‘guardians of sleep’. These findings will be further evaluated in the section concerning Solm’s (2000) theory of dream function.

3.1.2 Jung

Jung (1967) rejected Freud’s idea that dreams intentionally disguise their meaning. He believed instead that dreams reflect an individuals’ current concerns both relating to the external world as well as thoughts and feelings of the dreamers inner world. This is supported by much empirical research that has found continuity between waking cognition and dream content. For example, in the content analysis studies by Hall and Nordby (1972) they found that dreams most often reflect the thoughts, emotions, people and interests one is preoccupied by in waking life. Domhoff (2002) argues that these findings contradict Jung’s claim that dreams may also work to compensate for imbalances in the psyche by expressing content from the unconscious. According to Domhoff (2002) this theory would predict that if a person were overly outgoing and active in waking life their dreams would compensate for this imbalance by including contents of being reflective and introspective. Hall and Nordby’s (1972) content analysis of dreams show that this is not the case. However, it is difficult to refute or support the idea of a compensatory function in dreams as this may take many subtle forms, especially if dreams adhere to the language of our unconscious by using images, metaphors and symbols, as Jung (1967) proposed.

Jung (1967) believed that the unconscious content contained in dreams must be recognized, reflected over and accepted by the individual in order to achieve greater psychological balance. However, many studies show that there is great variability in dream recall where some individuals rarely remember their dreams whereas others remember several dreams per night (e.g. Watson, 2003). If the function of dreaming is to compensate for imbalances and this is achieved by actively processing dream content during waking, one would expect incidence of dream recall to be higher in the general population as is the case.

Jung (1967) proposed a second function of dreams, namely to provide prospective images of what the future might hold for the dreamer. This may simply be accounted for by the previously mentioned findings that dream content reflects current preoccupations (Hall & Nordby, 1972). One can imagine that, during waking life, most individuals generate hopes, possibilities and anticipations for what the future might hold and that this preoccupation is thus reflected in their dreaming life.

The ultimate function of dreams, according to Jung (1967), is to unite the conscious and unconscious in a healthy and harmonious state of wholeness, which he termed ‘individuation.’ He believed the need for ‘individuation’ and ‘integration’ of the personality increases as life progresses and is reflected in changes in dream content in the middle years of adult life (Jung, 1967). However, little evidence for this has been found as several longitudinal and cross-sectional studies of dream journals suggest that what adults dream about remains consistent over decades and does not change in the way Jung predicts (e.g. Lortie-Lussier, Cote & Vachon, 2000).

The final tenet to be discussed here, and perhaps one of the most distinctive features of Jung’s (1967) theory of dreams, is the idea that dreams not only express personal content but also content derived from the ‘collective unconscious’ in the form of archetypes. This claim is extremely difficult to refute or support with empirical evidence and for the scope of this essay it is not possible to extensively evaluate Jung’s ideas relating to archetypes. It can be mentioned that a comprehensive analysis of these concepts by Neher (1996) concludes them to be circular, unfalsifiable and generally unscientific. This aspect of Jung’s dream theory has also been criticized for being too closely related to aspects of mysticism and the occult (Samuels, 1985). Jung (1967) countered this claim, arguing that he was merely attempting to describe and classify dream phenomena on the basis of his strictly empirical ‘observations’ of more than 80,000 dreams over a period of 60 years as a psychiatrist.

The subsequent barrage of criticism concerning Jung’s concepts relating to the collective unconscious and archetypes may partly account for why Jung’s approach to dream function has “remained outside the mainstream and is virtually unknown to American psychology” (Dallett, 1973, p. 408). However, as Dallett (1973) points out, Jung made invaluable contributions to contemporary dream theory by including previously ignored aspects of creative and ‘nonrational’ processes and giving emphasis to the world of inner subjective experiences as well as proposing that the function of dreams is to balance and complete waking consciousness. According to Revonsuo (2000) modern theories concerning emotional problem-solving aspects of dream function can be traced to Jung’s (1967) notions of dreaming as an aid to maintaining an individual’s psychic balance. Some of these problem-solving theories share many similarities with aspects of Jung’s (1967) dream theory in positing that dreams may function to promote psychological well-being, although they invariably differ as to the proposed mechanisms by which such a process occurs. This will be further discussed in the section concerning evolutionary perspectives on dream function.

3.1.3 Solms

On the basis of his clinico-anatomical studies, Solms (1997) concluded that certain aspects of Freudian theory are supported by findings that dreaming is triggered by the dopaminergic system of the forebrain. Solms (1997) regards this as support for ‘wish-fulfillment’ in dreams as the dopaminergic system is associated with appetitive and motivational interests. However, subsequent research has shown that dreams persist despite dopaminergic blockers (Hobson, Pace-Schott & Stickgold, 2000), suggesting that the neurochemical structure which may be involved in dream production is more complex than that which is proposed by Solms (1997).

Another criticism to Solms’s (1997) research is the limited set of conclusions that can be reached through the use of lesion studies in determining brain areas involved in dreaming. “As neuroimaging studies make clear, dreaming is a complex process occurring in a system of multiple interacting units across the brain. In such a distributed system, lesion studies cannot provide any means for deciding on a single location as the controller, because in fact there need be no such clearly defined module.” (Bednar, 2000, p. 908).

Although Solms (1997) originally defended Freud’s view of dreams as ‘the guardians of sleep’, he later stated that ‘the biological function of dreaming remains unknown’ (p. 849, Solms, 2000). Despite Solms’ lack of a theory concerning the function of dreaming, his clinico-anatomical study and conclusions he are included in this theoretical essay, because they still represent invaluable contributions to the field of dream research. Specifically, they provide building blocks which may aid in the development of a comprehensive dream theory, as well as in furthering the understanding of mechanisms involved in dream production. This is specifically exemplified by his finding (to be outlined below), which suggests that Hobson and McCarley’s (1977) “activation-synthesis hypothesis” was faulty in proposing dreaming to originate in the brain stem during REM-sleep. Solms (1999) found that dreaming did not cease in patients with lesions in this area, and dreaming could occur during NREM-sleep without activation of the brain stem. This has subsequently led to a revision of the “activation-synthesis hypothesis” as well as an ongoing debate between many dream researchers (including Domhoff, Hobson, and Solms) concerning dreaming in REM vs. dreaming in NREM-sleep and to what extent mechanisms involved in REM and NREM-sleep can account for generating dreams (see the issue no 23, year 2000, in Behavioral and Brain Sciences for extensive articles on this topic). For the scope of this essay the ongoing “REM/NREM controversy” and the findings it has generated is too comprehensive to be outlined in full although, as previously mentioned, certain aspect will be further touched upon in discussing

dream function according to the “activation-synthesis hypothesis” (Hobson and McCarley, 1977) and the AIM model (Hobson, Pace-Schott & Stickgold, 2000).

3.2 Evolutionary theories

3.2.1 Threat Simulation Theory

According to Revonsuo (2000), the function of dreaming is to provide a virtual reality that simulates threatening events such that threat perception and avoidance behaviours can be practiced. As outlined in the theoretical background, he suggests six underlying propositions of his theory. Some of the predictions that are generated by his propositions, specifically those concerning dream content, will now be discussed in light of relevant empirical research.

Revonsuo (2000) proposes that dream content is specialized in the simulation of threatening events. This would predict that dream content should contain a disproportionate amount of negative elements and emotions that are related to concerns of ancestral survival (i.e. reflect threatening events). In their content analysis of 500 home-reported dreams, Hall and Van de Castle (1966) found that more than 700 emotions were expressed in the dreams, where about 80% were negative and 20% were positive. Approximately half of these negative emotions were classified by the dreamer as “sadness”, “anger” and “confusion”, whereas the other half were classified as “apprehension”. Hall and Van de Castle (1966) also found that 411 of these dream reports included cases of “misfortune”, where almost 90% of these “misfortunes” consisted of accidents, losses of possession, injuries or illnesses, obstacles and threats from the environment. Themes of misfortune connected to death or falling were found to be rare. Revonsuo (2000) argues that these findings support his proposition that dream content is specialized to simulate threats. However, it can be suggested that the dream reports collected by Hall and Van de Castle (1966) reflect predominantly negative emotions not as a result of threatening elements being overrepresented in dream content, but rather that there is a bias towards recalling dreams with negative content rather than dreams with positive content. This may be particularly relevant when evaluating content from dream journals, as these dreams are spontaneously recalled, as opposed to dream reports collected in sleep laboratories as a result of awakenings from REM-sleep. This may partly account for why more recent studies have found mixed results in support of Revonsuo’s (2000) proposition. For example, Strauch and Meier (1996) studied a sample of 500 dreams and found that less

than 30% of these contained negative emotions. In their study of typical dream themes, Germain, Nilsen, Zadra and Montplaisir (2000) administered the Typical Dreams Questionnaire (TDQ) to over a thousand sleep-disorder patients and a thousand students in different countries over several years. They summarize their findings as partly supporting Revonsuo (2000) in that threatening dreams involving chase and pursuit were among the three most prevalent dream themes. However, many of the prevalent themes were found to relate to positive events (e.g. sex or flying) rather than negative events, and the themes were more closely related to current threat scenarios (e.g. exams and schoolwork) rather than ancestral threat scenarios. Germain et al. (2000) argue that the prevalence of such themes poses problems for the specificity of dream content as predicted by the threat-simulation theory.

Revonsuo (2000) predicts that children's dreams should particularly reflect the natural bias of dreams to simulate ancestral threats, as "the brain has not yet had the chance to adjust the biases in order to better fit the actual environment" (p. 885). Domhoff (1996) outlines the study of more than 600 dream reports from children where he found that 20-30% of characters in children's dreams consist of animals, compared to only 5% in adult dreams. Domhoff (1996) also found that this tendency towards dreaming of animal characters steadily declines with age. Van de Castle (1970) reports similar incidences of animal characters in children's dreams, where he also found that in 40% of these dreams the animals were wild (e.g. lions, tigers, snakes and bears) as opposed to domestic animals such as cats and dogs. Revonsuo (2000) takes these findings as support for his threat-simulation theory in that children's dreams appear to show strong biases towards simulating an ancestral environment with wild animals. However, as mention above, a limited set of conclusions can be reached when dealing with content analysis of home-reported dreams due to a possible bias in which dreams are spontaneously recalled. In addition, Foulkes (1999) conducted a laboratory study of REM awakenings and found evidence that preschool children rarely dream. He argues that the home-based reports of small children reflect active confabulations and "uncontrolled parental suggestions" rather than actual dream content (Foulkes, 1999). Another point which can be made in regards to this, are findings which suggest that dreams reflect everyday life. As mentioned earlier, Bulkeley and Domhoff (2010) found that a blind analysis of dream content could accurately predict an individual's waking life. As such, one might expect children's dreams to contain animals as a significant part of their waking life is centred around children's stories, playing with animal toys and watching cartoons which often feature animal characters. In line with this, Peterson and De Young (2000) argue that dreams constitute positive, exploratory, creative play. They agree with Revonsuo (2000) in that

threatening elements can be simulated and rehearsed in dreams but that this is a reflection of the broader function of dreaming, namely adjustment to novelty (Peterson & De Young, 2000).

Revonsuo (2000) views recurrent dreams as evidence that dreams simulate threatening events and allow for the rehearsal of threat avoidance behaviours. Zadra, Desjardins and Marcotte (2006) attempted to test this assumption by conducting a quantitative analysis of the content of 212 recurrent dreams using the DreamThreat rating scale. In line with Revonsuo's (2000) predictions, they found that 66% of recurrent dreams contained at least one threatening event (escapes and pursuits found to be the most frequent), that threats were usually dangerous and aimed at the dreamer, and that the dreamer tended to take reasonable, defensive or evasive action. However, they also found that less than 10% of the dreams were accurate depictions of realistically threatening situations and that despite efforts to evade the threatening events, the dreamer rarely succeeded. This provides mixed support for Revonsuo's (2000) theory as if the biological function of dreaming is to allow for the rehearsal of threat avoidance behaviours then one would expect individuals to succeed at this in their dreams and that the threatening events would reflect more realistic situations. Zadra et al. (2006) propose that recurrent dream content is more likely to be related to the dreamer's current level of well-being or to unresolved difficulties in their life, rather than to simulations of threatening events.

Revonsuo (2000) also views recurrent nightmares, often suffered by individuals diagnosed with Post Traumatic Stress Disorder (PTSD), as highly realistic threat simulations, which are triggered as a result of experiencing real traumatic events. However, in describing how such nightmares can facilitate adaptation, Revonsuo (2000) ignores the large body of evidence which describes the dysfunctional aspects of recurrent nightmares in PTSD. Nielsen and Germain (2000) cite several studies which exemplify this, before moving on to a more general critique of Revonsuo's (2000) threat simulation theory. They argue that Revonsuo's (2000) characterization of dreams is limited in that he only considers one adaptive function relevant to the evolution of humans. However, successful threat avoidance behaviour was probably only one of many factors which gave a reproductive advantage in prehistoric time. Nielsen and Germain (2000) suggest that highly advanced cognitive, social and emotional skills may also have been selected for in such environments. They propose that dreams can have several adaptive advantages. For example, the presence of interactive characters in dreams may reflect the simulation of "attachment relationships", which they consider as fundamental to survival as threat avoidance (Nielsen & Germain, 2000). This proposition will

be further discussed in the next section concerning Franklin and Zyphur's (2005) hypothesis that dreaming, in addition to simulating threats, may function to provide an environment in which social skills can be practiced.

In summary, studies of typical dream content offer limited support to the idea that dreams mainly function to provide simulations of ancestral threatening events. Although there are some findings consistent with Revonsuo's (2000) predictions, it is more likely that threat-simulation is only a small piece of a larger puzzle. However, it is important to mention here that Revonsuo's (2000) threat-simulation hypothesis can be considered "good science" in that it generates testable empirical predictions that have already furthered our knowledge and understanding of some of the phenomena related to dreaming and dream content.

3.2.2 Social learning functions of dreaming

In line with Nielsen and Germain (2000), Franklin and Zyphur (2005) expand upon Revonsuo's (2000) threat-simulation theory to add the notion that dreams may have additional fitness-enhancing aspects related to the evolution of higher-order cognitive faculties. This proposition will now briefly be discussed drawing on empirical data in dream research.

The first thing that should be determined in discussing Franklyn and Zephyrs (2005) hypothesis is whether being "socially sophisticated" has any fitness-enhancing benefits at all. This debate is too comprehensive to be outlined in the current theoretical essay. However, it can be mentioned that many theorists, such as Foley (1989), argue that individuals who interact with others in the absence of interpersonal conflicts or confrontations, will most likely have better access to a group's resources, such as mates and food. However, there is great variability in cultures as to what is deemed socially appropriate behaviour. Franklin and Zephyr (2005) believe that social information processing during dreaming can "tip the scale" in allowing individuals to behave optimally in social interactions where the social nuances vary across time and culture.

A study by Braun and colleagues (1997), in which they attempted to determine the cerebral blood flow throughout the sleep-wake cycle by using metabolic markers and positron emission topography (PET-scan), found evidence that during REM-sleep there is a consistent increase in activity in the anterior cingulate cortex which is situated in the medial frontal region of the brain. Neuroanatomical studies by Devinsky, Morell and Vogt (1995) implicate this area in functions including decision-making, conflict resolution, social cognition and social judgment tasks which require theory of mind (TOM). These findings suggest that

during REM-sleep certain aspects of cognition which are related to the processing of social information are activated. Owen Flanagan (2000) argues that this does not support the hypothesis that there is an adaptive advantage to rehearsing social interactions in dreams because dreams do not give an accurate representation of ourselves and others. However, several studies, such as the previously mentioned blind analysis of dream content by Bulkeley and Domhoff (2010) indicates that dreams are an accurate reflection of the dreamers waking life including personality attributes, relationships, activities and cultural preferences.

According to Whiten and Byrne (1988) the development of mental capacities in primates is influenced by complex social interactions and information processing in the social domain. Although dreams are often found to contain interacting people and social situations (Kahn, Pace-Schott & Hobson, 2002), the question is whether this social information processing during dreaming can exert an influence on waking life to the extent that it poses an adaptive advantage, as proposed by Franklin and Zyphur (2005). This is related to a more general question that concerns all the evolutionary theories mentioned in this essay: Namely, can the activities we experience in our dreaming world, be it rehearsing threats, practicing social skills or solving emotional and intellectual problems, have a positive effect on our performance during waking? This will now be discussed in the final section concerning evolutionary theories that propose dreaming has a more general function of problem-solving. Some of these theories may be viewed as encompassing the function of dreaming as proposed by Zephr and Tarkko (2009) as solving emotional problems would probably have a positive effect on our capacity to successfully interact in social environments.

3.2.3 Dreaming as problem-solving

Theories which propose that dreams function as problem-solving have proven difficult to test empirically. While some researchers have employed the use of dream-incubation studies, where participants are instructed to think of a problem they wish to solve prior to going to sleep, others rest on analogies with discoveries in related fields or on anecdotal evidence. Some of the theories of “dreaming as problem-solving” mentioned in the theoretical background will now be discussed in light of the findings from use of these methods.

In support of her theory that dreams provide a creative canvas for solving personal and objective problems, Barrett (2001) presents a wealth of anecdotal accounts from both artistic and scientific fields. Van de Castle (1994) also presents a comprehensive overview of such case material in his book “Our Dreaming Mind”. To mention a few of the creative problem-

solving examples, two key scenes in “The Strange Case of Dr Jekyll and Mr. Hyde” were conceived in a dream by author Robert Louis Stevenson, Mary Shelley got her idea for “Frankenstein” in a nightmare, composer Handel heard the last movement of his oratorio “The Messiah” in a dream, the melody of “Yesterday” was first heard in a dream by Paul McCartney and Italian director Federico Fellini drew heavily on his dreams to create the grotesque and surreal characters featured in “8 ½”. When it comes to solving intellectual problems, chemist Kekulé reported that his Nobel-prize winning discovery of the benzene molecule as hexagonal came to him after dreaming of a snake grasping its tail, Mendeleev conceived his idea of the periodic table for classifying chemical elements in a dream and Elias Howe had a dream of a needle with a hole at the pointed end which led him to invent the sewing machine. In relation to discoveries important to the field of psychology, Nobel-prize winner Loewi reported that he awoke with the idea for how to experimentally confirm his theory of neurotransmission following a dream and Nobel-prize winner Eccles first conceived his electrical theory of synaptic inhibition in a dream. There are also anecdotal accounts related to the improvement of athletic or procedural activity such as in the case of golfer Jack Nicklaus. His career had progressively declined when he dreamed of holding his golf club differently and mastering the perfect swing. As a result of adopting this technique, his scores subsequently improved rapidly.

Although these anecdotal accounts suggest that dreams have aided individuals in finding solutions to problems they have been facing, Domhoff (2004) argues that just because dreams can be inspirational and contain content which inspires creative endeavours in waking life, this does not entail that dreams primarily function to solve problems. He also argues that this proposed function is unlikely in that only a small percentage of dreams are ever recalled and an even smaller percentage appear to contain a solution to a problem. Thus, Domhoff (2004) assumes that explicit recall is necessary for the content of dreams to have an adaptive advantage. However, there is some experimental evidence that decisions are sometimes based on information that cannot be consciously accessed. For example, Bornstein and D’Agostino (1992) conducted an experiment where they found that preference decisions are biased by exposure to a stimulus, particularly in cases where prior exposure to the stimulus was not consciously perceived. It is possible that a type of “implicit learning” occurs as result of dreaming of solutions to problems, which consequently has a positive effect on finding a solution during waking through biasing decisions. This idea will be further explored in the General Discussion where a suggested framework, in which several perspectives on dream function can be integrated, will be presented. Experimental evidence that sleep may inspire

“insight” through changing the representational structure of recent memories during consolidation will also be further explored in the General Discussion, as well as in the section concerning dreaming as memory consolidation (Wagner, Gais, Haider, Verleger & Born, 2004), in addition to evidence that suggests binding of different elements in memory around emotionally relevant themes during dreaming may serve to strengthen and consolidate them (Paller & Voss, 2004). Experimental evidence will now be discussed in an attempt to determine whether dreams, when explicitly remembered, can offer solutions to problems at all.

In further support of her theory, Barrett (2001) describes the ‘dream incubation’ study of Dement (1974) in which 500 undergraduate students were instructed to work on a set of intellectual “brainteasers” before going to sleep. The results indicated that the total number of problem-solving attempts in the dreams (as judged by independent raters) was 87, whereas the problem was solved in seven of these dreams (cited in Barrett, 2001). Barrett (1993) also conducted her own research using Dement’s (1974) incubation procedure, where 76 college students were instructed to think of a problem of personal relevance (with a recognizable solution) before going to sleep and keep a dream journal over a one-week period. The dreams were then rated by the participants and independent judges as to whether they contained any aspect of the problem or resulted in a satisfactory solution. Barrett (1993) found that 49% of participants reported having a dream which reflected the problem (rated 51% by the judges) and 34% felt their dreams also contained a solution (rated 25% by judges). However, it is difficult to determine whether these dreams actually improved the problem, as there was no assessment of the dream solution compared to measures of eventual problem outcome. In addition, there are several methodological constraints with using dream incubation which limits what conclusions can be drawn from the results. For example, it is not possible to draw inferences about to what extent dreams function as problem-solving in situations where the problem has not been extensively rehearsed right before going to sleep. In addition, as the dreams are collected from home-based reports and are spontaneously recalled it is not possible to conclude how many percent of dreams during the course of the night are actually engaged in finding solutions to problems. Domhoff (2004) criticizes dream incubation studies arguing that problems may be reflected in dreams, but their solution is a result of thinking about the dream during waking. Blagrove (1996) also criticizes these studies arguing that reflexive or intentional components necessary for problem-solving are absent in dream cognition. However, there is an ongoing debate concerning this topic, particularly when it comes to lucid dreaming where the individual is fully aware that they are in a dream and can

even signal this awareness using eye-blinks (LaBerge, 2000). In addition, a recent review of experimental evidence by Nir and Tononi (2009) concludes that some dreams have conserved reflective thought processes such as “theory of mind”, reflecting during dreams with social interactions, puzzling over impossible events and contemplating alternatives related to decision-making.

Psychologist and dream researcher Montangero (1991) suggests that “dream mechanisms are not particularly likely to elaborate solutions to a problem, although they constitute a very good exercise in creativity.” (p. 364). He goes on to argue that dream processes are creative in that they produce novel characters, objects, settings and plots due to the lack of rules which confines directed thought during waking. Montangero (1991) believes that this may have a positive effect on renewed ways of thinking about old problems after waking. Breger (1967) also mentions the role of creativity in dreaming, where stored information becomes more readily available, associational processes are more fluid and a greater variety of means for manipulating symbols is available. In contrast to Montangero (1991), Breger (1967) believes the dream state is ideal for solving problems, particularly those of an emotional nature, due to this “creative opening up of memory systems” (p. 25).

The problem-solving theories of dream function proposed by Breger (1967), Cartwright (1991) and Hartmann (1996) share many similarities in the notion that during dreaming current emotional problems are related to older, successful, patterns of problem solving where the overall “quasi-therapeutic” effect contributes of the individual’s well-being. Hartmann (1996) argues that his theory of cross-connections in “neural nets” may serve to integrate these viewpoints in providing a common understanding of processes involved in the emotional problem-solving function of dreams. Some of the points of this theory will now be discussed in light of empirical evidence, before moving on to neurocognitive theories of dream function.

Hartmann (1996) proposes that dreams contextualize our emotions and emotional concerns in pictorial metaphors. Although, as previously mentioned, there is much evidence that our dreams can be highly emotional and reflect current concerns, the evidence that these emotions may be presented in pictorial metaphors appears to remain anecdotal. For example, Hartmann (1996) outlines the recurrent nightmares of one of his psychotherapy clients who had been victim of assault, as reflecting feelings of mounting panic through scenes of a growing storm that culminated in a tsunami and a shipwreck. However, it is difficult to conclude that such scenes reflect certain emotions and it appears that more systematic research on metaphorical representations in dreams, than merely anecdotal accounts, is

necessary in order to provide support to Hartmann's idea.

Hartmann (1996) hypothesises that during dreaming connections are made more broadly and widely in memory systems, especially favouring those connections which are more "distant". A study conducted by Sitckgold, Scott, Rittenhouse and Hobson (1999) lends some support to this theory in that they found that participants woken from REM-sleep show preferential activation of more distantly related associations between pairs of words, rather than closely related associations. There is also some evidence, derived from behavioural studies relating to memory consolidation during sleep, which may provide support to Hartmann's (1996) proposals that during dreaming there is a) a cross-connection of emotional material in neural networks, b) an association and integration of material with other related emotional material and c) that sleep produces changes in memory networks which are adaptive for the future. These findings will be further elaborated in the section concerning dreaming as memory consolidation, although it is important to mention that, as of yet, these studies only found evidence that these processes can occur during sleep, whereas the role of dreaming is still unknown.

To summarize, there is some anecdotal evidence and empirical studies using incubation techniques which suggest there may be a problem-solving component to the function of dreaming. Hartmann's (1996) theory of cross-connection of material is useful in providing a framework under which several perspectives and processes which may underlie these functions can be understood, although it is clear that more research is necessary to fully understand if and how dreams may contribute to the solution of emotional or intellectual problems.

3.3 Neurocognitive theories

3.3.1 A new cognitive approach to dreaming

Domhoff (2010) rejects Freudian, Jungian and activation synthesis theories on the basis of that they wrongly assume there are major differences between waking cognition and dreaming. His cognitive theory of dreaming, which "begins with concepts derived from laboratory studies of waking thought" (Domhoff, 2010, p. 1) rests on assumptions that conclusion of functionality can be drawn from observations of mentation during relaxed waking states. Although there is now extensive research which indicates that dreaming and

waking cognition share more similarities than previously thought, it appears as if Domhoff (2010) ostensibly ignores the wealth of evidence which indicates that there are also phenomenological differences between these states, as supported by neurophysiological findings. Similarities and differences between waking consciousness and dreaming consciousness will now be discussed, followed by the implications these findings have for Domhoff's (2010) cognitive theory of dreams.

Findings from dream research indicate that perceptual modalities and other submodalities, which are present during wakefulness, are also found to be present in dreams. For example, dreams contain vivid visual imagery, movement, colour, shapes and include characters such as people, animals, objects and faces, as well as places (Hobson, 1988). Sounds, especially related to speech and conversation, as well as smells, tastes, pleasure and pain are contained in dreams, although the presence of sounds is more common than the four latter experiences (e.g. Hall & Van de Castle, 1966; Hobson, 2009). Positron emission tomography studies indicate that global brain metabolism is similar during dreaming and waking (Maquet, 2000) and that there is a strong activation of the occipito-temporal visual cortex (Braun et al., 1997). As previously mentioned, dreams also tend to reflect one's interests and personality (e.g. Domhoff & Bulkeley, 2010). Several research findings, such as the content analysis of dreams by Hall & Van de Castle, indicates that dreams, like personality, tends to stay stable over adulthood and that there is a correlation between one's waking and dreaming self in relation to mood, imaginativeness, interests and predominant concerns.

When it comes to differences between dreaming and waking, there tends to be a substantial reduction in voluntary control concerning action and thought during dreams (Rechtschaffen, 1973), although this is not evident in lucid dreaming (LaBerge, 2000). Recent neurophysiological evidence indicates that the right inferior parietal cortex (Brodmann's area 40) plays a role in waking volition (Desmurget, et al., 2009). This area appears to be deactivated during REM-sleep (Braun et al., 1997), perhaps accounting for the reduced voluntary control often experienced in dreams. During dreaming, as opposed to waking, there tends to be reduced self-awareness and reflective thought. For example, the dreamer tends to accept impossible events such as flying, or sudden transformations (Hobson et al., 1998), and there is often confusion about space, time and personal identities (Schwartz & Maquet, 2002). Neurophysiological evidence suggests that there is a deactivation of the posterior cingulate cortex, inferior parietal cortex, orbito-frontal cortex and the dorsolateral prefrontal cortex during dreaming (Braun et al., 1997), which might account for the reduced self-monitoring in

dreams. However, as previously mentioned, some dreams may have conserved reflective thought processes suggesting that there may exist individual differences in types of dreams (Nir & Tononi, 2009). There also appears to be altered memory processes during dreaming, where dreams are most often forgotten upon awakening if not written down. There is still a lack of consensus of why ‘dream amnesia’ occurs although the AIM model argues this is a result of deactivation of the dorsolateral prefrontal cortex and ‘aminergic de-modulation’ during REM-sleep (Hobson, Pace-Schott & Stickgold, 2000). There is also some evidence that indicates the network of associations in memory to become looser during dreaming as opposed to waking, which may partly account for “the bizarre and hyperassociative nature of REM-sleep dreaming” (Stickgold et al., 1999, p.188).

Although these findings indicate that there are many similarities between dreams and waking cognition, as proposed by Domhoff (2010), there are also several differences related to reflective thought, voluntary control, self-awareness and memory. Thus, developing a cognitive theory of dreaming based on laboratory studies of waking thought, as Domhoff (2010) does, is limited in the conclusions that can be drawn about dreaming. This does not entail that he is wrong in suggesting that dreams “are a dramatic and perceptible embodiment of schemas, scripts, and general knowledge” (Domhoff, 2010, p. 2) but rather that his cognitive theory only accounts for ‘part of the picture’, namely that dreams may reflect the conceptual systems of individuals. As such, he needs to make a convincing argument for the proposal that dreams are a by-product of the evolution of the cognitive abilities to organize experience in narrative form, to generate mental imagery and to create an autobiographical self (Domhoff, 2010). This theory of functionality also elucidates the ‘chicken or the egg’ debate, which is evident in several evolutionary theories of dreaming, as it is still not possible to conclude whether processes related to the development of higher-order cognitive abilities, be it problem-solving, conflict resolution or developing a ‘conceptual system’, evolved partly as a result of dreaming or that dreaming evolved as a by-product of these processes. Some researchers claim that other mammals dream during REM- sleep as rats show activation of the same place cells during REM-sleep as those which were active in the day during extensive maze running (Louie & Wilson, 2001) and in cats, if you remove the paralysis (atonia) which usually accompanies REM-sleep, they show typical prey behaviour such as searching, orienting and attacking (Morrison, 1983). This may lend some support to the idea that dreaming was present in mammals before the evolution of higher-cognitive capacities; however the evidence is still scant considering that animals are unable to verbally provide information about their mental processes during sleep.

An interesting last point to be made here is that a recent fMRI study conducted at the University of British Columbia found that our brains are far more active during daydreaming and ‘mind wandering’ than previously thought, where brain-areas associated with complex problem-solving become increasingly activated in this relaxed waking state (Christoff, Gordon, Smallwood, Smith & Schooler 2009). Interestingly, they found that the content of mind wandering was closely related to current personal concerns and unresolved matters and was most pronounced when there was a lack of meta-awareness (i.e. when participants were unaware that their mind was wandering). If Domhoff (2010) is right in proposing that dreaming and relaxed waking states are so similar that inferences about the former can be drawn from the latter, these findings lend more support to problem-solving theories of dream function than Domhoff’s (2010) idea that dreams have no function and can be likened to “plays the mind stages for itself when it doesn’t have anything specific to do” (p.2).

3.3.2 Activation-Synthesis hypothesis and the AIM model

The “activation synthesis hypothesis” (Hobson & McCarley, 1977) and its revised version, the AIM model (Hobson, Pace-Schott & Stickgold, 2000), views dreams and dreaming as an epiphenomenon of REM-sleep, merely reflecting sleep-related changes where the brain attempts to make sense of randomly generated internal stimulation. Several of the assumptions employed by Hobson and colleagues to frame their theories have received substantial criticism, particularly concerning the role of dreaming in REM-sleep vs. NREM-sleep, their interpretation of physiology, the proposed role of neurotransmitters and the extent to which dreams are ‘bizarre’. Drawing on empirical evidence derived from multiple sources, these four points will now be discussed, followed by the implications these findings have for the “activation synthesis hypothesis” and AIM model in relation to which conclusions can be drawn about dream function. Hobson’s (2009) proposal that REM-sleep may constitute a ‘protoconscious’ state will also briefly be discussed.

In trying to account for the physiological features of dreaming and how different consciousness states are coordinated and engineered, the activation synthesis hypothesis (Hobson & McCarley, 1977) relies heavily on the assumption that REM-sleep is the exclusive context in which dreaming occurs. This notion was originally conceived from the REM-sleep studies of Dement and Kleitman (1957) where they found that arousal from REM-sleep yielded dream reports in 70-95% of awakenings whereas NREM awakenings yielded such reports only 5-10% of the time. However, subsequent studies by Foulkes (1962) yielded

different result when he asked participants aroused from NREM-sleep what was passing through their mind rather than directly asking if they were dreaming. He found that reports of complex mentation were elicited in at least 50% of such awakenings. The majority of these dream reports tended to be more 'thought-like' (less vivid) although at least 5-10% were indistinguishable from reports obtained from post-REM awakenings (Foulkes, 1962). Subsequent studies have shown that reports from NREM-sleep stage 1 are frequent (80-90% of the time), although they are short, and awakenings from NREM-sleep stages 2 and 3 yield dream reports of some experienced content 50-70% of the time; nevertheless there is some variation between individuals and at different times of the night (Nielsen, 2000). A study by Antrobus, Kondo and Reinsel (1995) concluded that 10-30% of all NREM-sleep reports are not distinguishable by any criteria from those obtained in REM-sleep. This suggests that dreams in NREM-sleep account for a significant portion of all typical dreams, especially considering that 75% of all sleep is NREM-sleep (e.g. Dement & Kleitman, 1957). These findings "do not support a dichotomic distinction between REM and NREM mentation, rather they suggest the hypothesis of the existence of continuous dream processing characterised by a variability within and between sleep stages" (Cavallero, Fagioli, Mazzetti & Tuoizzi 1992, p 563).

The above criticisms to the "activation-synthesis hypothesis" as treating REM-sleep as the only state in which dreaming occurs, was partly responsible for the subsequent revisions which led to development of the AIM model (Hobson et al., 2000). In this model Hobson and colleagues still treat dreaming and REM-sleep as the same states in proposing that dreaming is initiated when "REM-off" cells become aminergically suppressed and "REM-on" cells become cholinergically potentiated. They propose that dreaming in NREM is attributed to subtle stimulation by the same brainstem regions that generate REM, calling this stimulation 'covert REM-sleep' (Hobson et al, 2000). However several dream researchers who have collected dream reports from NREM-sleep find no evidence of 'covert-REM-sleep' (e.g. Feinberg, 2000). In addition, Hobson's (2000) statement that "all sleep is REM-sleep" (p. 952) may engender an impression that he is 'changing the data to fit the theory' rather than vice versa, as much of the systematic evidence in dream research does not support this. Hobson (2009) has later met this criticism by stating that distinctive features of dream consciousness are maximally correlated with REM-sleep and only to a limited degree in other stages, still treating dreaming as result of the activity of "REM-on" and "REM-off" cells. Solms (2000) argues that dreaming and REM-sleep are dissociable states and that it is more useful to consider the role of forebrain mechanisms in controlling dreaming, as indicated by

his findings relating to patients with brain lesions (as previously outlined). He argues that it is important to distinguish between “REM-on” mechanisms and “dream-on” mechanisms in that these are separate from each other. It appears as if more research is necessary to fully understand the brain areas which are involved in initiating dreaming although, as Kahan (2000) notes “efforts to identify correspondences among multiple levels of analysis will be more productive for dream theory than attempts to reduce dreaming to any one level of analysis” (p. 956).

Several dream researchers also criticise Hobson et al.’s (2000) interpretations and explanations of the neurophysiology of dreaming in stating that dreams are stimulated by chaotic brainstem stimulation. For example, medical doctor Barbara Jones (2000), who conducts research within neurophysiology and neuroanatomy in relation to how the brain generates states of waking and sleep, states that she does not “know of any physiological evidence that the brainstem activation and stimulation of the forebrain is chaotic and would thus impose a chaotic influence on the cortex in dreams” (p. 956). She argues that neurophysiological evidence indicates that this stimulation does not occur in the absence of control from the cerebral cortex, as claimed by Hobson et al. (2000), neither is it chaotic. Jones (2000) conclusions are in line with earlier studies which indicate that phasic bursts during REM-sleep and unusual eye movement patterns does not correlate with bizarre dream content, as Hobson et al. (2000) predict (e.g. Pivik, 1991).

The interpretation of the role of neurotransmitters in REM-sleep in the “activation synthesis hypothesis” (Hobson and McCarley, 1977) has been criticized, especially for being too simplistic an explanation. For example, Gottesmann (2002) found that the modulation of neurotransmitters during REM-sleep seems more complex than Hobson and McCarley’s (1977) proposal of low levels of serotonin and norepinephrine and high levels of acetylcholine. In his research, Gottesmann (2002) found that the absence of serotonin, norepinephrine and histamine also plays a role and that levels of dopamine may be central. This has subsequently been revised in the AIM model (Hobson et al., 2000). Some research also suggests that levels of gamma-aminobutyric acid (GABA) are important, although it is still unclear to what extent (Siegel, 2000). It appears that the complexity and interactions of neurotransmitters involved in instigating REM-sleep, and perhaps dreaming, are not yet fully understood, and thus the conclusion drawn in the AIM model about neuromodulatory activity is too simplistic in accounting for more recent findings.

According to the AIM model (Hobson et al., 2000) the proposed activity of neurotransmitters and the brain’s interpretation of PGO waves which are generated in the

brain stem, can account for the highly “bizarre” nature of dreams in that the brain is trying to piece together a story out of random information. However, this has received much criticism in that dreams are not as chaotic and ‘bizarre’ as this model assumes. As previously outlined, much of the evidence from content analysis of home dream reports and sleep laboratories indicate that, although dreams may have some unusual settings, characters and activities (e.g. Hall & Van de Castle, 1966) they are also reasonable simulations of waking life (e.g. Domhoff and Bulkeley, 2010). In a study by Revonsuo and Tarkko (2002) they reconceptualize “bizarreness” as referring to “different types of unusual combinations of features in the binding of dream images coherently together” (p. 3). They found that external relations between a person and the context, such as the place, are frequently bizarre in dreams; although phenomenal features related to intrinsic representation of a person, such as visual outlook, familiarity and semantic knowledge, are less frequently so. It appears that if the AIM model was right in that dreams are merely a product of the brain’s attempt to interpret random signals generated in the pons, then dreams should be much more disorganized and incoherent. However, empirical research related to content analysis indicates there dreams contain certain patterns of types of themes, as well as cohesive storylines (e.g. Hall & Van de castle, 1966) indicating they are more than just a product of random information processing, as the AIM model suggests. In addition, as Revonsuo (2000) points out, this model does not provide an explanation as to why the brain should generate images at all during REM-sleep. Zephyr and Tarkko (2005) argue that to further our understanding of dreams and their function it would be useful to investigate patterns of themes and storylines exist at all in our dreams and what their purpose is, if any.

Hobson (2009) has recently added the notion of REM-sleep as a protoconscious state that has evolved in humans to promote the development and maintenance of consciousness and higher-order brain function. This may appear similar to some evolutionary theories of dream function, however Hobson (2009) does not believe the content of dreams to contribute to this process, as he stresses the role of REM-sleep in infants before the emergence of fully-fledged dreams. He proposes that REM-sleep is a precursor for secondary consciousness and that this is reflected in dream content in that they only include features of primary consciousness (emotion and perception). However, as previously outlined, dreams can occasionally reflect aspects of secondary consciousness, including reflective self-awareness, abstract thinking, volition and meta-cognition (Nir & Tononi, 2009). It appears that in his theory of protoconsciousness, Hobson (2009) still relies heavily on the notion that dreaming is a condition of REM-sleep. However this theory may be useful in providing a framework for

future research in attempting to further our understand of the building blocks of consciousness, how the brain has developed integrative functions, such as those related to learning, higher-order cognition and senso-motoric integration, as well as what role REM-sleep and dreaming may have played in this evolution of the human mind.

In summary, the activation synthesis hypothesis (Hobson & McCarley, 1977) and the AIM model (Hobson et al., 2000) are limited in accounting for certain dream phenomena and the conclusions which can be drawn about functions of dreaming, especially in that they appear to overstate the role of the brain-stem in dream production, assume dream content to be more random and bizarre than content analysis indicates, have too simplistic an explanation of neurotransmitter activity and reduce dreaming to a product of the REM-sleep state. However, these models have been useful in furthering our understanding of neuronal and molecular mechanisms involved REM-sleep, particularly in stimulating the debate and providing directions for future empirical studies within dream research.

3.3.3 Dreaming as memory consolidation

The theories of dreaming as memory consolidation outlined in the theoretical background all propose that connections among dispersed cortical networks and hippocampal-neocortical connections are strengthened by sleep (Stickgold, Hobson, Fosse & Fosse, 2001; Payne & Nadel, 2004; Paller & Voss, 2004). However, these theories differ in the types of memories they believe are consolidated, whether this occurs during dreaming in REM or NREM and whether dreaming plays an active role in this process or merely reflects the content which is being consolidated. Evidence of memory consolidation during sleep, what the sources of memory are during dreaming and what conclusions, if any, can be drawn from this empirical data in relation to theories of dreaming as memory consolidation will now be discussed.

There is a vast amount of research on processes of memory consolidation during sleep which is too comprehensive to discuss for the scope of this essay. However, findings and hypotheses which are considered relevant for the theories concerning memory consolidation and dreaming, will briefly be reviewed in the following paragraphs.

Behavioural studies on memory consolidation during sleep indicate that a period of sleep following learning (compared with staying awake an equal length of time) has a beneficial effect in improving both retention of declarative information and performance in procedural skills (e.g. Plihal & Born, 1997). Nishida, Pearsall, Buckner & Walker (2009) also found evidence that sleep enhances retention and consolidation of emotional information, and

Wagner, Hallschmid, Rasch & Born (2006) found this effect was detectable after four years, even when the initial period of sleep had not exceeded more than 3 hours. In a recent review on the memory function of sleep, Diekelmann and Born (2010) point out that these consolidating effects of sleep vary in accordance with specific conditions and do not occur under all circumstances. Some of their conclusions regarding memory consolidation in different stages of sleep include the following: Sleep appears to have a beneficial effect on consolidating memories in all major memory systems, although there is a preference towards consolidating those which have a behavioural relevance to the individual, as well as those which have been explicitly rather implicitly encoded. Consolidation of memories during sleep can lead to both qualitative, as well as quantitative changes in the memory representations and if an adequate encoding of a problem-solving task is ensured before sleep, this may have a positive effect on gaining insight into the problem upon awakening. Diekelmann and Born (2010) outline various findings in sleep research which suggests that memory systems compete and interfere with each other during waking but that these disengage during sleep, allowing for independent consolidation of memories in different systems. This may account for findings which suggest that during REM-sleep there is a preferential consolidation of memories related to implicit emotional aspects of memory (Nishida et al., 2009) as well as procedural aspects (Plihal & Born, 1997), whereas during slow-wave sleep (SWS, i.e. Stage 3 and 4 sleep) there is a preferential consolidation of declarative memories (Tucker et al., 2006). Diekelmann and Born (2010) argue that these findings provide support for the “dual-process hypothesis” which suggests that REM-sleep facilitates the consolidation of non-declarative memory (which is dependent on the hippocampus) whereas SWS facilitates consolidation of declarative memory (which is not dependent on the hippocampus).

These findings are not in line with Stickgold et al. (2001) who specifically propose semantic memories (a type of declarative memory) to be the primary type of memory consolidation which occurs during REM-sleep. However, Diekelmann and Born (2010) note that there are some research findings which have found that different types of memories may, under certain circumstances, be consolidated in other stages of sleep than what is typically suggested here, indicating that it is not necessarily sleep stages that mediate consolidation but rather the neurophysiological mechanisms associated with the different sleep stages, where these mechanisms may be shared between stages. This indicates that our understanding of memory consolidation is not yet sufficient in making claims which prefer one hypothesis over the other. However, it can be said that research to date does not support the notion suggested

by Stickgold et al. (2001) that semantic memories are preferentially consolidated over other types of memories during REM-sleep.

The theories of dreaming and memory consolidation proposed by Payne and Nadel (2004) suggest that the brain oscillates during the night between states that are either conducive to consolidating semantic memories or episodic memories. This is not supported by the preliminary findings that REM-sleep preferentially contributes to the consolidation of non-declarative emotional and procedural memories, whereas SWS preferentially contributes to the consolidation of both episodic and semantic memories (Diekelmann & Born, 2010).

Payne and Nadel (2004) also propose that the 'bizarre' nature of dreams is due to reduced hippocampal activation during REM-sleep. Although there appears to be a consensus among theorists that altered hippocampal functioning during sleep may be responsible for the lack of complete episodic memories in dreams (Nielsen & Stenstrom, 2005), evidence suggests that the hippocampus is rather more active during REM-sleep than less active, as Payne and Nadel (2004) suggest. For example, the previously mentioned study of REM-sleep in rats following maze learning, suggest that neuronal correlates of previously learned behaviour is replayed in hippocampal neurons in real-time during REM-sleep (Louie & Wilson, 2001).

Payne and Nadel (2004) suggest the hormone cortisol to play a central role in influencing which states the brain oscillates between during sleep and dreaming. As previously outlined, the neurochemistry involved in different stages of sleep appears to be highly complex and it appears unlikely that it can be reduced to the activity of a single hormone. In general, far too little is yet known about neurochemical influences on sleep stages to make any conclusions with certainty.

Findings in behavioural studies of memory consolidation lend some support to the theories proposed by Paller and Voss (2004). They particularly stress that declarative memories are consolidated during REM and NREM-sleep which is line with findings that sleep is of greater benefit to memories formed from explicitly encoded information (Drosopoulos, Schulze, Fischer & Born, 2007), although evidence suggests these declarative memories are preferentially encoded during SWS (NREM) sleep rather than REM-sleep (Diekelmann & Born, 2010). Paller and Voss (2004) suggest that binding these memories around emotionally relevant themes may serve to strengthen the consolidation process. As previously mentioned, there is evidence of consolidation of emotional memory during sleep (Nishida et al., 2009; Wagner et al., 2006) as well as evidence that memory for emotional components of a scene is preferentially enhanced during sleep (Payne, Stickgold, Swanberg &

Kensinger, 2008). In addition, a recent fMRI study by Payne and Kensinger (2011) found that during sleep, emotional memories are consolidated in useful and adaptive ways where qualitative changes in the emotional memory retrieval network occur. Although this lends some support to the proposals of Paller and Voss (2004) it is still unclear whether declarative memories are strengthened and consolidated during sleep as result of binding to emotional themes.

Paller and Voss (2004) also stress the process of cross-consolidation of declarative memories through formation and elaboration with other memories. In their review, Diekelmann and Born (2010) outline findings which suggest that during SWS, there is a reactivation and re-distribution of memories that is regulated by a dialogue between the hippocampus and the neocortex which “not only strengthens memories but also induces qualitative changes in their representations and so enables the extraction of invariant features from complex stimulus materials, the forming of new associations and, eventually, insights into hidden rules” (p. 122). These findings appear to support Paller and Voss (2004) also in their proposal that this ‘memory reprocessing’ results in more cohesive and thoroughly integrated memories. Paller and Voss (2004) believe these memories may then be aligned with long-term goals and strategies, which is supported by unpublished evidence (cited by Diekelmann & Born, 2010), that sleep enhances the consolidation of memories for intended future actions and plans. This is in line with recent findings by Fischer and Born (2009), which suggests that motivationally tagging of explicit memories might serve to mediate their preferential consolidation during sleep.

Whereas Stickgold et al. (2001) and Payne and Nadel (2004) believe dreams merely reflect the processes of memory consolidation occurring during sleep, Paller and Voss (2004) believe dreams play an active and adaptive role in forming new connections between pairs of memory fragments in order to enrich ‘our storehouse of declarative memories’, which can ultimately lead to new insights and behaviour strategies. As previously mentioned, a study by Wagner and colleagues (2004) found evidence that sleep facilitates the extraction of explicit knowledge and can lead to insightful behaviour by a process which appears to involve the restructuring of new memory representations. However, there is still little evidence of the role of dreams and dreaming in memory consolidation, although there is some evidence that dreaming about new material may at least enhance the subsequent recall of that material (Cipolli, Fagioli, Mazzetti & Tuozi, 2005). As Nielsen and Stenstrom (2005) conclude in their review concerning the memory sources of dreaming, a causal link between dreaming and memory remains to be demonstrated and there are still many methodological obstacles which

must be overcome before drawing any conclusions, such as the difficulty participants experience in identifying the memory sources of their dreams. Thus, it appears that research on memory consolidation during sleep is still in too an early stage to make inferences about the function dreaming can play, if any, in the consolidation processes.

3.4 General Discussion

To summarize, no single theory of the function of dreaming presented in this essay can fully account for the empirical findings generated by decades of systematic dream research. This may partly be attributed to deficiencies in the available empirical data itself, due to the inherent methodological constraints involved in studying a mental process which occurs while we sleep, but may also be attributed to the large explanatory gaps apparent in each theory of dreaming where they appear to only address a limited set of questions necessary for the development of a comprehensive theory. As theoretical physicist Comello (2005) points out, there seems to be a superficiality in modern dream theories in that they “have no recourse but to get the hypotheses they need on an ad hoc basis or through the development of ‘minitheories’, which typically integrate data taken from the experimentalist’s narrow area of interest, in effect discounting the relevance of data from related areas” (para. 4). This may perhaps partly account for why so little effort has been made in developing an overarching theory with a more comprehensive understanding of the function of dreams and dreaming. It also appears as if the ongoing debate among many dream researchers regarding functionality goes beyond empirical disagreements and into a more personal realm where they are defending personal values and ideologies. For example, Hobson’s critique to Solms (2000), elucidated by article titles such as “In bed with Mark Solms? What a nightmare!” (Hobson, 2005), reflects how their arguments are not necessarily concerned with the value of the empirical data but rather proving Freudian theory wrong or right. Hobson (2002) has actually stated that “it is true that I want to discredit Freud emphatically” (p. 2). This is arguably not a very scientific approach to generating theories and hypotheses as it increases the likelihood that empirical findings which support the opposing view will be ignored or discredited, instead of, for example, incorporating them to develop a more comprehensive theory of dream function. This may account for why the AIM model (Hobson, Pace-Schott & Stickgold, 2000) continues to emphasise the brainstem as the origin of generating stimuli which is responsible for synthesising dreams. It may be that accepting Solms (1997) findings that forebrain

mechanism related to motivational aspects of behaviour also plays a part in dream formation may be seen by these authors as lending some support to Freudian dream theory.

Although the Solm vs. Hobson debate has been used as a case study here it appears as if many of the dream theorists presented in this essay spend considerable time and article space trying to prove each other wrong, rather than admitting their views are limited and cannot account for much of the research findings on dream content, as well as the neural correlates of dreaming. Several theorists have likened this situation as analogous to the traditional tale of the blind men and the elephant. In this story the blind men set out to discover the nature of the elephant by means of touch alone. Each man believed he knew the nature of the whole from the part they touched, so the man who grasped the elephant's tail thought it was like a rope, the man who touched its ears believed the elephant was like a rug and the man who grasped its legs believed the elephant was like a pillar, and so on (Cartwright, 2000). In a similar manner, it appears as if each theory of dreams has grasped a part of the function, believing they know the nature of the whole. It is surprising that such few efforts have been made to integrate these theories as many of them do not necessarily appear to compete or discredit each other, but rather describe different aspects and phenomena related to the nature of dreams and dreaming. It seems that the time is ripe to move towards a more integrated understanding by developing a framework which can encompass several of the findings and hypotheses of dream function. In the current theoretical essay, an attempt at this will now be made. Although some of the proposals to be presented here still lack empirical support and can be considered speculation, the purpose is to provide a suggestion of how theories can be integrated. This may constitute a good starting point towards the development of a more comprehensive view and help to further our understanding of the function of dreams and dreaming.

3.4.1 A proposed framework for integrating dream function

According to the AIM model (Hobson, Pace-Schott & Stickgold 2001) dreams are a product of random signals that are generated in the brainstem. Although empirical evidence suggests that dreaming in humans is a more complex process, it is possible that dreaming first evolved as a result of such 'noise in the system' propagated by activation of the brainstem. The advantage of having 'noise' can be likened to Darwin's (1859) notion of the benefits of genotypic variability in the evolution of species, where the variability in traits increases the likelihood that a particular trait will randomly pose an adaptive advantage under certain

circumstances. Perhaps dreaming originated as a random barrage of signals where patterns of dreams, which conferred an adaptive advantage in promoting survival of the species, were selected for over time. This is similar to Blechner's (2001) idea of "Oneiric Darwinism" where he views dreams as the generation of random thought mutations where some are rejected by the mind as useless, whereas others pose an advantage and are thus retained.

The above hypothesis would predict the presence of such signals propagated in the brainstem in species which preceded the evolution of humans. There appears to be experimental evidence that PGO waves are present in non-human primates and other mammals such as cats (Datta, 1997). As previously mentioned there is some evidence which shows that, during REM-sleep, cats act out predator-behavior (Morrison, 1983). Although it is unknown whether other mammals dream or not this finding may suggest that mammals rehearse behavior which is important for their survival during the same state where dreaming most often occurs in humans. It is possible that a process akin to dreaming, as a result of noise in the system, first evolved in mammals and was passed on to primates due its adaptive advantages. This may have initially conferred an adaptive advantage in allowing for the rehearsal of threat-avoidance behaviors, as Revonsuo (2000) proposes and therefore may account for the overrepresentation of threatening elements in our dreams (Hall & Van de Castle, 1966). This may be due to an overrepresentation of phobias related to survival in our ancestral past, such as snakes and spiders, despite these not posing any particular danger nowadays to most of the people who express this fear (Seligman, 1971).

As previously mentioned, Solms (1997) found evidence that forebrain mechanisms related to motivational aspects of behaviour may be activated during dreaming, as well as other areas such as the anterior cingulate (Braun et al., 1997) which is a cortical area implicated in processes such as decision-making, conflict resolution, social cognition and social judgment tasks which require theory of mind (Devinsky, Morell & Vogt, 1995). These findings may indicate that dreaming evolved to reflect and perhaps simulate higher-order cognitive capacities necessary for social communication, problem-solving, integration, creation of knowledge, adjustment to novelty and identity formation. Although, as previously outlined, there is some empirical data from content analysis of dreams as well as anecdotal accounts which suggest many of these capacities are reflected in our dreams, the question is whether dreaming has an adaptive function in simulating these processes, and if so how does this occur.

Although differing in their perspective on dream function, many dream researchers agree that dreaming may constitute a good exercise in creativity (e.g. Breger, 1967, Montangero, 1991, Barrett, 2001, Domhoff, 2004, Hobson, 2009). This may be due to what Breger (1967) describes as a “creative opening up of memory system” where it is possible that a process (akin to Hartmann’s (1996) idea of connections in “neural nets”) occurs such that stored information becomes more readily available, associational processes more fluid, a greater means for manipulating symbols is possible and broader and wider connections are made across memory systems, in the absence of confined directed thought apparent in waking cognition. This state may be conducive to processing, consolidating or elaborating any type of information which is behaviourally relevant to the individual’s current concerns, whether relating to practicing social skills, solving emotional or intellectual problem or processing memories. The above conclusion may be supported by one of the previously mentioned arguments by Diekelmann and Born (2010) that during sleep there appears to be a preference towards consolidating information which has a behavioural relevance to the individual, including emotional and explicit memories. Studies show that memories of recent events are incorporated in an average of 50% of dream content and they do so in new and unrelated contexts (Harlow & Roll, 1992). This may provide support for the idea that current concerns are integrated with older memories as stored information becomes more readily available and broader and wider connections are made across memory systems. Another study found evidence that temporal plots of memory sources of a dramatic event shown in a film appearing in dreams follows a U-shaped curve (Nielsen, Kuiken, Alain, Stenstrom and Powell, 2004). This may be seen as evidence that dreams draw upon memories from different regions of the brain at different stages of consolidation.

Hartmann (1996) proposes that dreams contextualize our emotions and emotional concerns in pictorial metaphors. Although the evidence of this is mainly anecdotal, Smith and Hanke (2004) found that completion of a mirror-tracking task during waking led to dream reports that metaphorically presented the task such as ‘trying to stay on the road’. Perhaps in dreams, learning and processing also occurs by giving emotional valence in pictorial metaphors to information, which is not necessarily emotional during wakefulness. This is in line with the proposal of Paller and Voss (2004) that binding memories around emotionally relevant themes serve to strengthen the consolidation process. This may be supported by studies that demonstrate emotions can have a memory-enhancing effect (e.g. Bradley, Greenwald, Petry & Lang, 1992), that sleep leads to adaptive changes in the emotional

memory trace (Payne & Kensinger, 2011) and that dreams are often highly emotional (e.g. Hall & Van de Castle, 1966).

Some of the findings outlined above may also provide some support to the proposal by Jung (1967), Hartmann (1996), Paller and Voss (2004) and Cartwright (1994), that dreaming can sometimes constitute a process akin to psychotherapy, as evidence suggests dreaming about current emotional concerns may lead to the integration and formation of new connections between recent and older memories. These older memories may provide the dreamer with information of how a similar emotional problem has been dealt with in the past, where its subsequent activation may have a positive influence on how the current problem is handled. This idea of cross-connections in widely distributed memory systems where associational processes become more fluid, may also lend support to the proposals that dreaming is optimal for “thinking outside the box” thus aiding the solving of problems related to intellectual, creative or athletic endeavours. As previously mentioned, there is experimental evidence that sleep may inspire “insight” through changing the representational structure of recent memories during consolidation (Wagner, Gais, Haider, Verleger & Born, 2004). This may account for the many anecdotal examples of problem-solving outlined in the theoretical background. However, in all of these examples the individuals apparently remembered their dreams upon waking. As mentioned, there are large individual differences in dream recall and an important question here is whether processes which occur in dreams, be it solving problems, practicing social skills or finding a new golf swing, can exert an effect on waking behaviour without explicitly recalling the dream.

Several neuroimaging studies also suggest that information which is not tied to any external stimuli is treated similarly to information processed in relation to the physical environment. For example, visually imagining something and manipulating that image leads to increased activity in the visual cortex despite absence of an external visual stimulation (Kastner, Pinsk, De Weerd, Desimone & Ungerleider, 1999). It has been similarly demonstrated that imagining the actions involved in performing a repetitive motor task increases the physical representation of the associated pattern of activity in the motor cortex (Pasqual-Leone et al., 1995). In their meta-analysis of effects of mental practice on motor skills, learning and performance, Feltz and Landers (1983) found that mental imagery techniques can greatly influence many aspects of performance ranging from sport to music. These findings may lend support to the idea that in dreams, practicing social skills or motor skills, for example related to avoiding threat, may have a positive influence on waking behaviour despite recall of the dream, as the areas of the brain related to these skills is

activated, despite absence of external stimuli. When it comes to other aspects of learning in dreams, for example in relation to emotions or intellectual problems, it is possible that making connections in a wide network of associations across memory systems during dreaming constitutes a type of implicit learning, where these same areas are activated during waking, thus biasing decision despite recall of the dream. This may be supported by the previously mentioned study of Bornstein and D'Agostino (1992), who demonstrated the “mere exposure effect”, where preference decisions were biased by prior exposure to a stimulus, particularly if that stimulus was unconsciously perceived. Taken together, these findings may provide support for the idea that dream recall is not necessary in order for dream content to exert an influence on waking behaviour.

The suggested integration of theories of dream function outlined above may additionally provide support for a range of hypotheses and findings including dreaming as a function of threat-rehearsal (Revonsuo, 2000), practicing social skills (Franklyn and Zephyr, 2005), involvement of motivational aspects of the forebrain (Solms, 1997), the role of random stimulation from the brainstem (Hobson, Pace-Schott & Stickgold, 2000), dreaming as “psychotherapy” (Jung, 1967, Hartmann, 1996, Paller and Voss, 2004 & Cartwright, 1994), dreaming as emotional and intellectual problem-solving and dreaming as memory consolidation. Moreover, the dream process taken as a whole may provide support for Domhoff's (2000) notion of dreams reflecting the ability to generate mental imagery, organize experience in narrative form and create an autobiographical self. This framework may also lend some support to Hobson's (2009) idea that REM-sleep has evolved in humans to promote the development and maintenance of consciousness and other higher-order brain functions.

Although the present attempt of presenting a framework, in an area of study where sufficient empirical evidence is still lacking, may be overreaching and highly speculative, the present effort is only meant as a suggestion for a more comprehensive theory of dream function, than those available at the present. However, it is important to mention here that it is still unclear whether dreams drive many of these suggested processes forward or merely reflect them as they happen. As Hunt (1989) stated “there may not be a fundamental *function* of dreaming, any more than we can find a function for human existence generally. A self-referential, self-transforming system like the human mind will evolve its uses creatively and open-endedly as it evolved its structures” (p 76).

3.4.2 Avenues of future research

There are several methodological limitations to the study of dream content as dream consciousness is only accessible via introspective report, where the process of gathering data relies on either the spontaneous recall recorded in dream journals or laboratory awakenings from mainly REM-sleep. Spontaneous recall may produce a somewhat biased set of data, as it is possible that certain types of dreams, such as those with highly negative emotional content, are more often recalled upon awakening than others. Collecting reports in sleep laboratories where participants have electrodes attached to their heads and are aroused several times a night can arguably be stressful and as a result, this method may affect the actual content of their dreams as well as disrupt the processes under observation, such as memory consolidation. In addition, it has proved very difficult to manipulate dream content experimentally, which makes it near impossible to predict the content of dreams. These limitations have led modern dream researchers to focus on relating neuronal activity to the form of dreaming rather than their content. Although neurophysiology, functional imaging and brain lesion studies have advanced our current knowledge of the neural basis of dreaming, the resulting data is still lacking in providing an explanation for why we dream. In addition, our understanding of complex brain mechanisms and the neurochemicals involved in the process of dreaming is still at an early stage, rendering it difficult to reach any conclusions with certainty.

These limitations illuminate the constraints in studying the form and content of dreams and can probably partly account for why this field of study is characterised by such avid disagreement. But despite these difficulties, there are still several avenues for improvement of the collection of data on dream content and neural correlates, as well as how this information could be interpreted.

When it comes to studying the content of dreams with the method of self-observation, further progress may be made by training participants to accurately identify and report the subtleties of content that are less obvious than the salient features which dominate many home-dream reports. This may further our understanding of several processes such as how different types of recent and older memories are incorporated into storylines and what effect this could have on consolidation, elaboration and integration of information. It is important to consider here that there are large individual differences in dream recall where some people rarely remember their dreams (often erroneously believing they do not dream at all) whereas others have high incidence of recall. It may be useful to focus the efforts of training

participants to subtleties of dream content on those who have a tendency to remember several dreams a night and then do an in-depth analysis of this content. However, it is possible that the individual differences in recall also affect the dream content. For example, Watson (2003) found that individuals prone to imagination, fantasy and absorption are particularly likely to recall their dreams. It is possible that these personality traits (as measured by ‘openness’ on the ‘big-five’ factor model) also exerts an influence on the type of dreams individuals have, relating to for example degree of bizarreness or how ‘loose’ the network of associations become during dreaming. To further our understanding of dream function, it seems important that future research also considers individual differences in dream content and what may be the underlying explanation for this. This brings us to a related point, namely differences between types of dreams.

As Nir and Tononi (2009) outline in their review, individual dreams differ substantially in relation to aspects such as ‘conserved reflective thought processes’ and contemplating alternatives, where future studies should “consider different kinds of dreams and their neural correlates separately” (p. 92). For example, when it comes to lucid dreams, experimental studies have found that participants are able to signal to the experimenter by the use of predetermined actions, such as a series of eye-blinks, while they are dreaming (LaBerge, 2000). This is an exciting avenue for future research in that it enables precise correlations between subjective reports and physiology. However, the findings generated by using this method may not generalise to all types of dreams, as lucid dreams may differ substantially in neural correlates, and different brain areas may be activated in this state to allow reflection and awareness while dreaming.

Analysing dream content that is collected exclusively from home-reports poses several problems, since this type of data collection provides no information about what stage of sleep the dreaming is occurring. As previously discussed, the time is ripe for theories of functionality and studies of neural correlates to uncouple dreaming and REM-sleep from one another. Efforts to identify correspondence between multiple levels of analysis, rather than reducing dreaming to one level, may prove to be more productive in furthering our understanding of the nature and function of dreaming. For example, Panksepp (2000) outlined evidence suggesting that dreams in REM-sleep are more emotional, whereas dreams in NREM-sleep are more cognitive. It seems evident that in order to understand, for example, the role of dreaming in memory consolidation, it is important to decipher what types of neurophysiological and neurochemical mechanisms influence dreaming in different stages of sleep and how this can account for qualitative and quantitative changes in dreaming across the

sleep-cycle. Although not an optimal method for gathering data, it seems that laboratory studies with awakenings from REM- and NREM-sleep may still be the prime procedure in collecting dream content across sleep-stages and in relating these to specific neurochemical mechanisms and functional networks.

Deciphering such networks have until the now mainly relied on the use of PET scans. Future studies could increasingly rely on event-related functional MRI in understanding brain activity during sleep, as the spatial and temporal resolutions are far better than those offered by positron emission topography (Nir & Tononi, 2009). This could serve to further elucidate questions such as which functional networks underlie dreaming in NREM-sleep as opposed to REM-sleep and what can these differences tell us about dream function.

Perhaps in the future, methodological constraints related to analysing dream content and relating it to brain activity may be overcome by methods which allow us to “visualize” the dreams as they happen without having to rely on subjective dream reports. Nir and Tononi (2009) outline how progress in signal decoding may enable researchers to one day investigate the neural correlates of both the form of dreams and their content simultaneously. The development of such techniques should be a priority within dream research as adopting such a method may serve to answer many of the still unanswered questions relating to the nature and functions of dreaming. However, it is important that dream theorists start to adapt their hypotheses to incorporate findings which do not provide support for their initial proposals; especially if they wish to avoid stagnation and rather progress towards the development of comprehensive understanding of why we dream.

4 Conclusion

Since Freud first published his seminal work on the nature of dreams, subsequent theories concerning the function of dreaming have flourished in the field of psychology. Hypotheses have been generated within psychodynamic, evolutionary and neurocognitive perspectives, where a range of functions have been proposed. Some of these perspectives suggest dreams and dreaming may pose an adaptive advantage in simulating threats, practicing social skills, consolidating memories, or solving emotional and intellectual problems, whereas other accounts view dreaming as an epiphenomenon of other processes, such as the development of cognitive abilities or as a reflection of sleep-related changes which occur in the brain.

As of yet, these theories appear to be limited in accounting for much of the empirical evidence derived from the content analysis of dreams and the study of related neural correlates. This may be partly attributed to the methodological limitations involved in studying dream processes but may also be attributed to the apparent tendency of dream theorists to only focus on aspects of the empirical literature which lends support to their theories, seemingly disregarding contradictory findings which could ultimately help them further develop their views. This may provide an explanation for why a more comprehensive understanding of dream function has not yet been proposed, as few attempts have been made to integrate theories and empirical findings necessary for the development of such an understanding.

The current theoretical essay presents a framework under which several proposed theories of dream function may be integrated. Although certain aspects of this comprehensive understanding may be speculative or still lack empirical evidence, it is considered an important starting point for how the field of dream research may further progress to avoid stagnation. As technology advances in the field of cognitive neuroscience occur, some of the hypotheses generated in this comprehensive framework may be further investigated. Such advances may ultimately help to provide answers which further our understanding of how the process of dreaming has evolved, and what its functional benefits are, if any.

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