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Strengths and Weaknesses of McNamara's Evolutionary Psychological Model of Dreaming

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Abstract: This article includes a brief overview of McNamara's (2004) evolutionary model of dreaming. The strengths and weaknesses of this model are then evaluated in terms of its consonance with measurable neurological and biological properties of dreaming, its fit within the tenets of evolutionary theories of dreams, and its alignment with evolutionary concepts of cooperation and spirituality. McNamara's model focuses primarily on dreaming that occurs during rapid eye movement (REM) sleep; therefore this article also focuses on REM dreaming.

Keywords: McNamara, costly signaling, dreaming, REM, cooperation, spirituality

Overview of McNamara's Evolutionary Psychology of Dreaming

Taking into account neurological, hormonal, and genetic aspects of sleep and dreams, McNamara's (2004) model centers on genetic conflict and costly signaling theory. For one to know whether or not a particular communication is true, it must be costly to produce and hard to fake. McNamara argued that REM sleep, which is closely associated with emotionally powerful and vivid dreaming, is costly and hard to fake. In evolutionary theory, the production of costly traits indicates that the person has the genetic-based stamina to withstand this energetic cost and still function successfully in life. This signals to a prospective mate, in a hard-to-fake way, that the person has good genes, thus theoretically increasing that person's chances of passing on those genes.

As described by McNamara (2004), many properties of REM are risky to one's health: "PGO waves, activations of the amygdala, ANS [autonomic nervous system] storms, cardiovascular instabilities, respiratory impairment, thermoregulatory lapses, dynamic changes in GH release, and so on, suggest that REM is risky for one's health" (pp. 8-9). Given these risky and costly characteristics, McNamara posited that REM serves an important function: "I argue that serious consideration of the costs associated with REM might help us identify its benefits and therefore its adaptive functions" (p. 10).

McNamara (2004) acknowledged benefits associated with REM such as memory consolidation and learning, but he did not view these as the primary functions of REM. He described relevant research on the function of both REM and NREM in the formation and consolidation of memories, but pointed out that reduction in or loss of REM does not result in the inability to learn. Although McNamara agreed that REM and NREM are involved in memory function, he argued that this involvement does not explain the function of sleep from an evolutionary perspective:

Thus, even if memory consolidation occurs in sleep, this does not tell us what the specific function of sleep may be. We do not say that the function of the waking state is learning simply because learning takes place during the waking state. On the other hand, information flow to and from the hippocampus during sleep apparently takes on unique properties during REM and NREM, and thus sleep's role in memory consolidation may indeed be special and selective. (p. 100)

McNamara (2004) argued that dreams produced during REM sleep are likely to influence the person's mood and emotions upon awakening, because dreams generally get more vivid and emotionally charged during the later stages of REM sleep. According to McNamara, many of these emotional states are negative, creating a handicap for the dreamer. Contrary to what seems to make sense, the handicap actually functions to enhance the social interactions of the dreamer, thus enhancing the dreamer's fitness as a member of the group.

Costly signaling theory was also used by McNamara (2004) to explain cultural and religious uses of dreams. For example, in tribal societies dreams often provide symbols and rituals that must be incorporated by tribal members as expressions of spirituality. As these expressions may be counterintuitive and costly to produce, they can serve as hard-to-fake signals of the members' commitment to the tribe, increasing unity and cooperation and exposing those who are not willing to make sacrifices for the common good. McNamara concluded that REM sleep and dreams are forms of costly signaling that promote reliable communication, which enhances human wellbeing.

It is important to note that McNamara argued that it is not REM sleep per se that constitutes a signal in the waking state; rather, the emotions experienced during REM dreams result in residual affect or moods that serve as hard-to-fake signals, enhancing social interaction, and REM dreams in relation to spiritual practices provide symbols that are hard to fake, increasing cooperation and unity among the members of the group who adhere to the spiritual practice.

Consonance with Neurological and Biological Properties of REM

McNamara (2004) thoroughly described neurological, physiological, hormonal, and genetic characteristics of REM sleep and REM-related dreaming.

Strengths

McNamara's (2004) description of the neurochemical, electrophysiological, physiological, hormonal, and genetic characteristics of REM sleep and dreaming was based on properties that can be measured and observed empirically. His evolutionary theory of dreaming is based largely on the physiological costs of REM, as well as on the handicapping properties of REM dreams, which he related to the destabilizing effect of REM on the ANS and other physiologic systems, and the emotions produced by the parts of the brain that are activated during REM, respectively. Costly signaling, central to McNamara's evolutionary theory, arises in connection with genetic conflict, which he described in relation to sleep processes. Although costly signaling may "emerge from conflict," according to McNamara, "it may operate to allow for cooperative alliances and honest communication between individuals who may otherwise have conflicting genetic interests" (p. 14).

McNamara (2004) described genes that regulate sleep, including separate genes that regulate REM and NREM, and presented information that indicates that some genes regulating REM are imprinted by paternal alleles, and some genes regulating NREM are imprinted by maternal alleles, lending support to his theory that genomic conflict influences the interactions of REM and NREM sleep. The idea that brain development and function are influenced by imprinted genes is supported by Wilkinson, Davies, and Isles (2007) who found that maternally expressed genes influence higher cognitive functions, whereas paternally expressed genes influence emotional and autonomic functions: One interpretation of the data might be that the maternal interests are, in broad terms, mediated by neurodevelopmental effects on 'higher' cognitive systems, whereas the paternal interests are mediated by effects on brain systems that sub-serve 'emotional' or 'autonomic' functions" (p. 833).

This finding aligns with McNamara's (2004) statement that NREM dreams, regulated by maternally expressed genes, are more thoughtlike, whereas REM dreams, regulated by paternally expressed genes, are more emotional.

In a study that included 100 REM dream reports and 100 NREM dream reports, McNamara, McLaren, Smith, Brown, and Stickgold (2005) found that friendly and aggressive social interactions occurred in both REM and NREM dreams, but there were significantly more aggressive interactions in REM dreams. Showing an even greater difference, dreamer-initiated aggression occurred in 52% of the REM dreams and in zero of the NREM dreams. Conversely, dreamer-initiated friendliness occurred in 90% of the NREM dreams and only 54% of the REM dreams. These results strongly support McNamara's (2004) theory that different genes, some of which are paternally or maternally imprinted, regulate REM and NREM, producing different states of brain activation and neurochemical patterns. McNamara et al (2005) concluded that REM promotes aggressive feelings whereas NREM promotes cooperation while inhibiting aggressive impulses.

Lending support to this conclusion, Isles, Davies, and Wilkinson (2006) stated that there are many imprinted genes in the adult brain, and they postulated that maternally expressed genes promote social cooperation whereas paternally expressed genes do not:

It is possible to make a tentative suggestion that in adults autosomal genes predominantly expressed from the maternally derived allele will generally

promote social, cooperative behaviour among all group members, whereas those genes predominantly expressed from the paternally derived allele may suppress or inhibit such behaviour. (p. 2234)

McNamara (2004) stated that this link between genomic conflict and REM versus NREM sleep would not be definitive until a molecular basis for sleep regulation was articulated. Supporting a genetic basis for sleep, Maret et al (2007) found that in mice, *Homer1a*, which is involved in intracellular calcium regulation and synaptic glutamatergic signaling, is the brain molecule that responds most clearly to sleep deprivation: "Our findings suggest that *Homer1a* might represent the molecular link between sleep, cognition, and neuropsychiatric disorders" (p. 20095).

McNamara (2004) described how REM and NREM processes interact in various conflicting patterns, for example, to influence the release of and affect the circulating level of different hormones. Cellular and neuronal signals are also exchanged during REM and NREM sleep.

The destabilizing effect of REM on the ANS and REM's debilitating effects on the cardiovascular system, respiratory system, thermoregulatory system, and antigravity musculature can all be measured and observed. As noted by McNamara (2004), increased REM sleep is also associated with increased risk of mortality. Clearly, REM poses a risk to human health and is thus costly from a biological perspective, a feature that McNamara used to associate REM sleep and dreams with costly signaling.

McNamara's (2004) evolutionary theory of dreaming accounts for all the patterns of brain activation that have been shown through imaging, and for the neural substrate of dreaming as described in Domhoff (2003). Of special interest in regards to costly signaling is the REM phenomenon of pontine-genicul-occipital (PGO) related activation of the amygdala, which is involved in fear-related responses, creating negative physiological and emotional effects. Again, McNamara's costly signaling theory focuses on REM sleep and dreaming being risky, and thus costly. McNamara's theory also accounts for the high degree of activation during REM of the limbic system, which is involved in emotional processing.

Weaknesses

McNamara (2004) viewed hormonal, neuronal, and cellular interaction between REM and NREM sleep as a type of signaling system. He theorized that this signaling would follow the rules of animal communication and that if REM and NREM interact through signaling in physiological systems, then REM and NREM could interact in sleeping to exchange signals that affect the structure, imagery, and content of dreams during REM and NREM sleep. Although this seems plausible, he did not present any evidence of an exchange of dream elements as signals.

Fit Within Evolutionary Theories of Dreaming

McNamara (2004) and McNamara and Szent-Imrey (2007) posited that REM sleep dreaming evolved to produce costly signals that function to handicap the dreamer during

waking life. These signals facilitate communication, thereby enhancing the dreamer's fitness. According to McNamara and Szent-Imrey: "Dreams can also function to facilitate production of signals when they produce some daytime effect such as a memory or mood (or both) or a behavior that communicates a message to an observer" (p. 29).

Strengths

Evolutionary theory holds that an organism's traits change over long periods of time to adapt in ways that enhance the organism's fitness for survival. Valli and Revonsuo (2007) argued that REM sleep and dreaming are products of evolution:

Dreaming and its closest physiological correlate, the REM state of sleep, are energetically costly, and natural selection does not retain costly characteristics unless they provide advantages. Thus, natural selection would not have favored REM sleep and dreaming unless the benefits overran the costs that went into producing them. (p. 96)

Franklin and Zyphur (2005) also argued for dreaming as a product of evolution: "The natural selection of dreaming as a state of consciousness...has persisted across the development of the human species. This tends to suggest that the dream state was selected for as an adaptation which increases overall fitness" (p. 60). In agreement with this, McNamara (2004) posited that REM sleep and dreaming, although costly, are traits that have evolved to increase fitness.

In situating his theory of REM sleep dreaming within evolutionary theory, McNamara (2004) provided a detailed description of the appearance of REM and NREM sleep states in mammals and argued that these distinct sleep states emerged from a combination of sleep states that first appeared in monotremes. Furthermore, in discussing genetic determinants of sleep, McNamara described sleep behavior that has been observed in fruit flies. In accordance with evolutionary theory, based on the appearance of sleep traits in insects, fish, amphibians, reptiles, birds, monotremes, and mammals, McNamara suggested that sleep has evolved as an adaptation to enhance fitness: "Sleep is a very ancient adaptation indeed and its benefits outweigh the risks associated with quiescence and reduced responsiveness to the environment" (p. 65).

In continuing to build an evolutionary framework for sleep and REM, McNamara (2004) examined how REM is expressed during a person's lifetime, beginning with fetal development, because natural selection is most pronounced in its effects by eliminating organisms in their early developmental stages. According to McNamara:

The ways in which and the effectiveness with which species respond to typical selective pressures encountered early in development predict later reproductive success and so are all-important. It is therefore likely we will find important clues concerning the evolutionary history and functions of sleep by examining early development of sleep processes. (p. 16)

In light of this importance on how REM is expressed in various life stages, McNamara (2004) described several evolutionary theories about the effects of sleep and REM, including pregnancy and genetic conflict, parent-offspring conflict, life history theory, attachment theory and related behavioral strategies, REM's affect on brain development, costly signaling between mothers and infants, REM and cosleeping, nursing and sleep states, and childhood sleep and dreams.

McNamara (2004) presented evidence supporting a genetic conflict model of pregnancy, arguing that because the developing fetus has 50% of its genes different from the mother, the mother and the fetus will have different genetic goals. Thus, there will be conflict in that the fetus will attempt to extract the maximum amount of resources for itself, while the mother may have other interests. Hore, Rapkins, and Graves (2007), who reviewed the evolution of imprinted genes, concurred with this model of genetic conflict for most imprinted genes. To illustrate this model, McNamara described the changes in maternal sleep that occur during pregnancy. These are mediated by hormonal and other physiological processes that can be measured.

Continuing in his development of an evolutionary theory for REM sleep, McNamara (2004) presented evidence that REM processes function as costly signals from infants to their mothers. For example, when rats and monkeys are separated from their mothers under experimental conditions, there is an initial increase in their REM times, followed by a dramatic reduction. McNamara (2004) argued that this is evidence that REM functions as a costly signal: "There is no sense in signaling need in the absence of the mother. It is more adaptive to conserve resources and wait" (p.36).

McNamara (2004) reviewed the evidence that REM promotes brain development. He stated that it has been found that REM sleep is important to the development of lateral geniculate neurons, which are implicated in the development of the visual system. He also described a positive correlation between REM sleep and breastfeeding, and between breastfeeding and increased activity in the occipital-temporal-parietal area of the infant's brain. In describing the dreams of children, McNamara noted that children with higher visual-spatial abilities typically have better dream recall.

McNamara (2004) also claimed that REM's role in activating amygdaloid and limbic areas supports the theory that mothers respond to REM related signals in deciding how much to invest in their infants. The amygdala and limbic forebrain structures have been shown to be involved in "emotional expression, vocalization, and mother-infant attachment processes" (p. 37). REM also plays a role in the release of hormones that control interactions and affection processes between the mother and infant.

More recently, several researchers (Isles and Holland, 2005; Kozlov et al., 2007; Liljelund, Handforth, Homanics, and Olsen, 2005) have elaborated the role of genomic imprinting and (Champagne, 2008; Champagne and Meaney, 2007) other epigenetic mechanisms in the interaction between mother and offspring in the postnatal period. As described in these studies, genomic conflict plays a role in growth, development, sleep regulation, maternal behavior, and maternal-infant interactions, supporting McNamara's claim for the role of genomic conflict in REM and NREM sleep and dreams.

Isles and Holland (2005) reviewed the role of *Peg1/Mest* and *Peg3/Pw1* in mice. Both of these maternally imprinted/paternally expressed genes enhance the growth of the

infant and influence maternal care through expression of oxytocin neurons in the hypothalamus. The human homologues of these genes, *PEG3/PWI* and *PEG1/MEST1* are imprinted; *PEG3/PWI* is paternally expressed in the brain, but according to Isles and Holland, the imprinting status of *PEG1/MEST1* in the brain is unknown. Although the exact role of *PEG1/MEST1* in relation to maternal behavior in humans is not known, Isles and Holland pointed out that it may regulate brain processes, functions, or maternal behaviors that are related to autism: “genomic association studies have frequently linked the region containing *PEG1/MEST* on chromosome 7q with autism” (p. 75). McNamara (2004) pointed out that in rats the mother must be in NREM sleep for oxytocin release to occur. Conversely, infant rats prefer to nurse while they are in REM sleep. McNamara described the interaction of sleep state and maternal behavior: “Imprinted genes (*Peg1* and *Peg3*) play a key role in this nocturnal interchange by influencing hypothalamic circuits that promote both wake-related and nursing-related maternal behaviors in the mother” (p. 85).

Another paternally expressed gene that affects hypothalamic function is *Magel2*, as described by Kozlov et al. (2007). *Magel2* is in the same imprinted domain, 15q11-13, as the genes responsible for Prader-Willi Syndrome (PWS). McNamara (2004) pointed out that REM sleep disorders have been observed in children and young adults with PWS. Kozlov et al. found that loss of *Magel2* expression resulted in a reduction of orexin in the hypothalamus. In addition to regulating sleep and wakefulness, orexin is involved in regulation of food intake and male fertility.

Liljelund et al. (2005) found that in mice, *grbrb3*, which codes for GABA receptor, is imprinted, affecting EEG and behavior. McNamara (2004) noted that the genes that code for GABA receptors in humans play a role in sleep, specifically in the neuroendocrine regulation of REM and NREM.

Not only are aspects of maternal behavior caused by imprinted genes, but also maternal behavior causes epigenetic effects in the offspring, which are then transmitted to future generations (Champagne, 2008; Champagne and Meaney, 2007; Weaver et al., 2004). Through DNA methylation, effects of maternal behavior change the oxytocin-estrogen interactions, estrogen receptor levels in the hypothalamus, and oxytocin receptor binding in the hypothalamus (Champagne, 2008; Champagne and Meaney, 2007). Maternal behavior also causes changes in DNA methylation that result in epigenetic alterations to the glucocorticoid receptor gene promoter in the hippocampus (Weaver et al., 2004). The hippocampus is highly activated during REM dreaming (McNamara, 2004).

In studying REM within the framework of evolutionary theory, McNamara (2004) chose to focus on conflict theory because it accounts for traits that may be harmful to the organism, and yet still yield fitness benefits overall. Conflict theory includes costly signaling theory, which encompasses models of communication behavior. McNamara (2004) posited that REM dreams create costly and hard-to-fake signals that nonetheless enhance communication, increasing the dreamer's overall fitness. McNamara and Szent-Imrey (2007) described the type of information that is conveyed by these signals: “Like any other mood state, these dream-related dispositional and mood states, we claim, can be ‘read’ by observers as informational about the internal states and quality of the dreamer” (p. 30).

Supporting the theory that dreams affect subsequent waking experiences, Kramer (1993) found that performance, mental activity, and verbal behavior are all influenced by the dreams of the previous night. Kramer concluded that dreams affect daytime mood: "Wakefulness is clearly responsive to the experiences during the sleep that preceded [sic] it" (p. 151).

McNamara (2004) reported that REM dreams have been found to be more emotional than NREM dreams: "NREM dreams were characterized as being less vivid and more thoughtlike than REM dreams" (p. 73). Agreeing, Fosshage (2007) argued that dreams function to regulate affect, and that visual images evoke more affect. While acknowledging that both REM and NREM dreams are imagistic, Fosshage stated that REM dreams are more "imaginistically dominated than NREM dreams" (p. 214) and thus REM dreams are more emotionally powerful than NREM dreams: "Research has demonstrated that affect-loaded, imaginistically dominated REM dreams are more important than NREM dreams...in dealing with emotional issues" (p. 218).

Adding support to McNamara's (2004) claim that REM dreams have more influence on waking affect than NREM dreams, Ritchie and Skowronski (2008) found that affect from dreams faded most rapidly from dreams that occurred as the person was falling asleep – typically NREM dreams, moderately rapidly from dreams in the middle of the night, and least rapidly from dreams that occurred as the person was waking – probably REM dreams. Thus, not only are REM dreams likely to be more emotionally powerful than NREM dreams, but they are also more likely to produce affect in waking life that lingers for a longer period of time.

From an ethnographic perspective, Lohman (2007) provided a detailed description of the role of dreams in shaping cultural and social interactions in a variety of traditional cultures in the modern world. He posited that dreams influence cultures and societies, which in turn influence dreams. Furthermore, according to Lohman, dreams play an important role in shaping human interactions: "Dream beliefs and experiences sometimes provide necessary links of relatedness, and may over time influence the development and change of models of human relatedness, roles, and identities" (p. 56). This is central to McNamara's (2004) theory that REM dreams create costly signals that facilitate meaningful social interaction.

Persons with autism spectrum disorder (ASD) experience problems with human relatedness and meaningful social interactions. ASD has been associated with several of the imprinted genes in the 15q11-13 region (Wilkinson et al., 2007), which is also implicated in the regulation of REM sleep. As has been described above, imprinted genes, which arise in the context of genomic conflict, regulate among other things, brain development, mother-infant interaction, and REM/NREM sleep states. Furthermore, as described above DNA methylation can occur as a result of mother-infant interaction, and the epigenetic changes are then passed on to the next generation. As stated by Wilkinson et al. (2007) this raises interesting questions about the interrelationship of these phenomena:

One provocative hypothesis...is the suggestion that brain-expressed imprinted genes have the potential to contribute to the long-term risk of psychopathology by modifying the postnatal experience of infants, and the

idea that they could do this by controlling key components of the early-life environment, notably mother-infant interactions. (p. 840)

Morewedge and Norton (2009) found that in addition to creating emotions that carry over into waking life, dreams impact many people's waking feelings, thoughts, and actions more than actual waking experiences do:

We suggest, however, that people do not merely lend the same amount of credence to thoughts that occur in dreams as thoughts that occur while awake but actually treat the content of their dreams as *more* meaningful than the content of similar waking thoughts. (p. 249)

Morewedge and Norton also reported that the majority of participants in their study stated that dreams influenced their social interactions and their decision making.

According to McNamara and Szent-Imrey (2007), REM dreams can affect daytime mood and behavior, sending honest signals, even when the dream is not remembered. They pointed out that remembering and sharing a dream is another way to influence daytime mood and behavior. Because dreams are involuntary, telling one's dream to another is providing an honest view of one's internal processes. McNamara and Szent-Imrey contended that dreams often include negative emotional experiences, which handicap the dreamer in his or her subsequent interactions with other people. This "facilitates some vital communicative goal of the dreamer" (p. 30).

In considering which dreams are most likely to be shared, Curci and Rime (2008) found that the emotional intensity of the dream most determined which dreams would be shared. They found that negatively valenced dreams were generally more emotional, but that positively valenced dreams were more likely to influence the dreamer to change his or her worldview. Both positive and negative dreams created intense emotional impacts that carried over into waking life, and were likely to be socially shared: "The proportion of dreams that were socially shared at least once amounted to 60% for positive dreams, and 72% for negative ones, and this difference did not reach significance" (Curci and Rime, 2008, p. 164).

In providing support for this costly signaling theory of REM sleep and dreams, McNamara and Szent-Imrey (2007) pointed out that REM sleep dreams specialize in emotions and usually contain several characters with whom the dreamer interacts. Because they were arguing that REM dreams facilitate emotionally important communication in daytime social interactions, it makes sense that REM dreams are emotional and involve interactions with other people. This is further supported by Franklin and Zyphur (2005), who argued that increased activity of the anterior cingulate during REM involves cognitive functions that are implicated in social interactions: "These data suggest that aspects of cognition centering on the processing of social information are strongly activated during REM sleep" (p. 69). Supporting the theory that dreams and social interaction are linked, Kramer (1993) found that the number of characters in a night's dreams had a significant effect on mood.

In order for REM dreams to function as a costly signal in an evolutionary sense, the

ability to send this signal must indicate that the sender is more genetically fit, and thus able to bear this cost. McNamara and Szent-Imrey (2007) supported this argument by showing that healthier individuals are more able to bear REM deprivation and the subsequent increased REM without ill effects: "Healthier individuals showed fewer signs of ill effect of the [REM] deprivation procedures. The fact that high REM intensity is associated with costs for some individuals demonstrates that it is an ideal trait for signaling purposes" (p. 33).

Weaknesses

Although McNamara (2004) situated his argument for the evolutionary selection of REM sleep and dreaming in the genetic conflict that occurs between mother and fetus during pregnancy, he nonetheless concluded that the interaction between maternal and fetal sleep is not understood.

McNamara (2004) gave a brief description of how life history theory relates to sleep. Basically, because developmental sleep processes may affect brain development, sleep behaviors may have an impact on how much energy an individual directs toward somatic versus reproductive strategies. Although this seems plausible, McNamara does not offer any evidence to support this theory.

As described by Franklin and Zyphur (2005), mental imagery abilities enhance performance in numerous activities, and improve the success of creative undertakings. They stated: "Thus, it appears advantageous to be able to create vivid representations in the mind's eye of various scenarios, which in fact, is what dreaming entails" (p. 65). This could also be a reason for the evolutionary selection of REM sleep and dreams. As stated by Barrett (2007), there can be more than one reason for phenomena as complex as REM sleep and dreaming: "Evolution gradually uses genes and the proteins they produce to play roles in many complex interactions. Knowing the physiological reason for a few characteristics of an elaborate physiologic/behavioral complex would rarely rule out other contributing adaptive functions" (p. 136).

McNamara's (2004) evolutionary theory of dreaming centers on the claim that REM produces hard-to-fake costly signals, which create emotional handicaps that are necessary to ensure the integrity of social communication. However, as he pointed out, there is no evidence for this: "REM deprivation, therefore, should impair social communication abilities, but I know of no such evidence yet available" (p. 123).

McNamara (2004) based his argument that REM dreams produce costly handicapping signals on his claim that most dreams include negative emotions. However, McNamara (2004) cited several sources who contradicted this by finding that joy is frequently cited in dreams and that dreams did not contain more negative than positive emotions. McNamara stated that emotional content of dreams is uncertain: "Further studies are needed to clarify emotional content of typical dreams" (p. 133). Even so, he maintained his claim about the negative emotional content of dreams:

Dreams more often involve negative than positive emotion. At the very least, negatively toned dreams are more often remembered than are positively toned dreams, and this fact must contribute to the ways in which

dreams function to affect waking mood and behavior. (p. 133)

McNamara (2004) based his claim about negative emotions in dreams in part on dreams scored using the Hall/Van de Castle scoring rules. According to McNamara, when using these scoring rules, about 80% of dreams of men and women contain negative emotions. However, as Bulkeley (2007) pointed out, that may be at least in part because the Hall/Van de Castle coding categories include four negative emotions (anger, fear, sadness, and confusion) and only one positive emotion (happiness). Domhoff (2003) argued that these categories are valid because there are only a few basic human emotions: "anger, fear, love, joy and sadness" (p. 70). Domhoff argued that these basic emotions are adequately represented by the Hall/Van de Castle coding categories. However, it seems that a system with an equal number of positive and negative emotions could be devised, for example: anger, fear, sadness, happiness, love, and joy. Surprise or confusion could also be used – it may be negative, positive, or neutral depending on the context. Such a system would include the Hall/Van de Castle emotion categories and the basic emotion categories identified by Domhoff, and it would not be biased toward negative or positive emotions.

Central to McNamara's (2004) costly signaling theory of REM dreams is the impact the dream continues to exert in the waking life of the individual. McNamara argued that this continuing impact sets a negative emotional tone, creating a handicap that positively influences the individual's meaningful communication interactions with others. In contrast, Kramer (1993) found a frequent decrease in the Unhappy mood scale between night and the following morning, indicating that a happy mood would carry over into the following day. In addition, contrary to McNamara's focus on negative moods, Kramer found that "the more characters of any type that appeared in dreams the greater the decrease in the Unhappy subscale from night to morning" (p. 176).

Moreover, in studying the impact of dreams on waking life, Kuiken and Sikora (1993) found several types of dream impacts that were not negative. These included dreams that increased transcendent awareness and mundane dreams with an absence of any intense emotion or aggression. Of the 47 dreams recalled by their participants, 26 were in the transcendent or mundane category (positive or no emotions) and 21 were in the existential or nightmare category (negative emotions).

McNamara (2004) reviewed Kuiken and Sikora's (1993) study in relation to the emotional processing functions of dreams, but McNamara didn't refer to the emotional content of their study, even though McNamara's theory revolves around the central idea that negative emotions in dreams have a continuing impact on waking life. Instead McNamara commented that he didn't see how ordinary dreams or unrecalled dreams could impact waking life: "Except for these types of 'big' impactful dreams, it is hard to see how other dream types, particularly ordinary dreams, can have an effect on waking experience if, as we know to be the case, most dreams are never recalled" (p. 145). McNamara then contradicted this statement while discussing the emotional impact of REM dreams: "REM-related production of emotional states and costly signals would influence dream content and the display of emotional signals the person emits the next day, whether or not the person remembered any dream that morning" (p. 163).

In any event, as Barrett (2007) pointed out, dreams with negative emotional tones

that carry over to the following day to create costly signals in social interactions, only account for some of the dreams that people have. Moreover, Barrett cited evidence that negative dreams and their associated handicapping in the waking state do not enhance fitness: "Cheerful, confident-appearing people seem to have the advantage in mate selection and most other types of interactions" (p. 137).

Alignment with Evolutionary Concepts of Cooperation and Spirituality

McNamara (2004) theorized that REM dreams produce two types of costly signals. One type of costly signal was discussed above: the emotional handicapping that occurs because of the predominance of negative emotions in dreams, which McNamara posited increases cooperation in social interactions. The other type of costly signal is the production of images that are used to construct religious ceremonies and rituals in cultures that view dreams as sacred. Participation in these ceremonies and rituals, according to McNamara, could be used to gauge the commitment of tribal or community members.

Strengths

Support for McNamara's (2004) theory that costly signaling created by the lingering negative affect from dreams evolved to enhance cooperation, and thus is adaptive is provided by Fessler and Haley (2003), who agreed that emotions are adaptations to enhance fitness and cooperation within an evolutionary framework. Fessler and Haley stated "Emotions are viewed as discrete mechanisms crafted by evolutionary processes in order to shape behavior in ways that enhanced biological fitness (i.e., survival and reproduction) under ancestral conditions" (p. 9). In relation to cooperation they stated: "Natural selection will have favored psychological attributes that enhance the individual's ability to engage in, and profit from, cooperative enterprises" (p. 8).

Furthermore, support that a negative emotional tone can improve social interaction and increase cooperation is provided by Hagen (2003), who argued that depression is a costly signal that functions to elicit social benefits and improved cooperation from group members: "Behavioral studies thus confirm that depression causes an increase in provisioning of social benefits and a decrease in aggressive responses" (p. 110). Hagen also posited that the nonwestern view of depression as a strategy to restore reciprocity is likely to be correct.

McNamara's (2004) theory that dreams produce images that are used in rituals and religious ceremonies is supported by the historical record about Native American tribes in the 17th and 18th centuries provided by Jesuit missionaries, who described the centrality of sacred dream images in the cultural and religious life of the tribal members. McNamara posited that dreams and religion are interconnected in a way that promotes cooperation: "Religion may call on the dream as a source of signals and images that are costly and that will work to establish cooperation in a local group of people and to punish potential free riders" (p. 166).

Bulkeley (2007) agreed that dreams are significant in all world religions, as well as in local spiritual traditions: "Abundant evidence from anthropology, ethnography, and psychology shows that dreams are a widely distributed and historically pervasive

phenomenon of human religiosity" (p. 71). Drawing on "insights of cognitive neuroscience, content analysis, and evolutionary psychology" (p. 72), Bulkeley concluded that mystical (MYS) dreams play a significant role in human spirituality: "The emotional power, strong carryover effects, and high degree of memorability make MYS dreams eminently useful as agents of intensified spiritual belief and revitalized religious practice" (p. 90).

Barrett (2007) also lent support to the theory that dreams evolved to provide useful images, pointing out that ancient cave paintings depict surreal images that archaeologists believe came from dreams. Barrett posited that in addition to providing images for rituals and religious ceremonies, dreams also provided other useful images: "Modern hunter-gatherers, and less industrialized societies in general, often teach explicitly that dreams can provide inspiration or solve problems" (p. 147). Furthermore, Franklin and Zypur (2005) also corroborated the role of REM dreams in human spirituality: "Dreams are a venue that have been used in a number of cultures to attain higher states of consciousness (e.g., Tibetan dream yoga, and the practices of the Senoi) and increase one's sense of well-being" (p. 73).

Weaknesses

McNamara's (2004) theory that residual negative affect from dreams creates a costly signal that enhances cooperation was based on the preponderance of negative emotions in dreams; it would then follow that the majority of people experience these negative moods. McNamara and Szent-Imrey (2007) stated this explicitly: "Most people experience distress frequently and have no qualms about expressing it openly. At least 30-50% of the population exhibit and report a chronic experience of negative emotionality" (p. 37). If the evolutionary function of the signals sent by a negative mood state is to elicit social benefits and cooperation from others, and if evolution is functioning to continually select for the production of these negative mood states that result from REM sleep dreaming, then it seems that eventually there would not be enough people who were not in a negative mood and thus able to provide social benefits to or increase cooperation with the distressed signaling persons. As such, it seems that this trait would be self-limiting, but McNamara (2004) and McNamara and Szent-Imrey (2007) did not address this.

In describing emotions that influence cooperation, Fessler and Haley (2007) discussed the effects of romantic love, gratitude, anger, envy, guilt, righteousness, contempt, shame and pride, moral outrage, admiration and elevation, and mirth. Clearly, not all of these are negative emotions or would result in negative mood states.

Summary and Conclusions

There is strong evidence that REM sleep dreaming has evolved to provide one or more adaptive functions. There is strong evidence that REM sleep and dreaming is biologically costly, and that the REM sleep state produces hormonal, neurological, and biochemical signals. In reviewing the effects of genomic imprinting on brain development, Wilkinson et al. (2007) found that imprinted genes may be involved in neurodevelopmental signaling events: "the products of imprinted genes seem to affect several signaling cascades that are involved in cell survival and differentiation, notably acting through the tumor

suppressor and key neurodevelopmental protein p53" (p. 838). It appears that the genes that regulate sleep state and dreams, growth, mother-infant interaction, and brain development and function are interrelated. To the extent that these genes are imprinted, these effects arise in a context of genomic conflict, lending credence to McNamara's (2004) evolutionary psychology theory of dreaming.

There is strong evidence that REM sleep dreaming produces signals in the form of emotional tones or moods that carry over into the waking state, and that these signals affect the individual's waking interactions with others. Whether or not these signals are predominantly negative is less certain. However, it does seem clear that these signals are hard to fake, and thus would facilitate honest, emotionally meaningful communication. It is clear that REM dreaming is costly, and that it produces hard-to-fake signals. It doesn't seem necessary to insist that these signals are also costly in the sense of being negative.

There is strong evidence that emotions affect cooperation, but less evidence that negative emotions are any more effective than positive emotions in this respect. There is also strong evidence that dreams provide images that are used in cultural and religious contexts to promote cooperation and group unity.

Overall, McNamara's (2004) evolutionary theory of dreaming would be stronger if it did not emphasize the role of negative emotions.

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