

the (equally unknown) function of REM sleep . . . should be uncoupled from one another" (sect. 9, para. 4).

In both the Introduction and in section 4 SOLMS states that "not all dreaming is correlated with REM sleep." This may be the starting point to confront his model with NIELSEN's. Nielsen recognizes the difficulty of establishing a rigid correlation between REM/NREM sleep on one hand and different types of mentation on the other hand (the two generator isomorphic model). His proposed solution is straightforward: Whenever we encounter mentation during sleep, REM sleep processes, manifest or covert, must be at work. It is therefore a one-generator model, which identifies in REM sleep processes the unique source of mental activity during sleep.

In my view, the model implicitly assumes that covert REM sleep processes are responsible for some form of brain activation, a feature that is hence shared by the two models. In fact, by disturbing the homeostatic condition of SWS, all physiological variables that connote the covert REM sleep processes may contribute to shifting the level of brain activation; NIELSEN specifically mentions cortical EEG desynchronization in the "atypical NREM sleep episodes" (sect. 3.3) that may depend on covert REM sleep processes. Moreover, in the list of factors that might induce "convert REM sleep to be activated during NREM sleep" (sect. 3.2) quite a few (arousal processes, sensory stimulation, drug effects, sleep deprivation) are known to enhance the energy metabolism of the brain.

The two facets of brain activation (electroencephalographic and metabolic) are therefore prerequisites for the model. NIELSEN's hypothesis is based on well known physiological evidence, and has the merit of being experimentally testable. Polygraphic recordings show that the transition from NREM to REM sleep is not a clear-cut, abrupt event. Rather, different physiological variables change with different, contradictory time courses, and the macroscopic result may be the REM episode or an awakening or a return into NREM sleep. A single physiological variable can change alone, and may anticipate by many seconds, even minutes, the state change. It can be assumed that the complex process ultimately generating the full-blown REM sleep episode may have false starts and aborted outcomes; in this troubled transition (dynamic stage of train stem release in Parmeggiani's model, 1968); many physiological variables (increments in brain temperature and cerebral blood flow, heart rate, and blood pressure, Franzini 2000; motoneuron excitability changes, Nakamura et al. 1978) show a loose temporal link with the REM episode.

All this can be translated, in the terminology of NIELSEN's model, as "covert REM sleep processes" (sect. 3.2). As NIELSEN acknowledges, "evidence of mentation in stage 3 and 4 sleep (Cavallero et al. 1992) is particularly difficult for this model to explain" (sect. 3.14, para. 4). The difficult task of validating the model requires: (1) that some of the physiological markers of "covert REM sleep processes" be identified in the uniform and stable conditions of stage 3 and 4 sleep; and (b) that the apparently "deactivated brain" of SWS may show focal signs of metabolic brain activation linked to the same physiological markers.

The prevalence of typical dream themes challenges the specificity of the threat simulation theory

Anne Germain,^a Tore A. Nielsen,^b Antonio Zadra,^a and Jacques Montplaisir^p

Sleep Research Center, Hôpital du Sacré-Coeur de Montréal, ^aDepartment of Psychology, ^bDepartment of Psychiatry, Université de Montréal, Montréal, Québec H4J 1C5, Canada. a-germain@crhsc.umontreal.ca

Abstract: The evolutionary theory of threat simulation during dreaming indicates that themes appropriate to ancestral survival concerns (threats) should be disproportionately represented in dreams. Our studies of typi-

cal dream themes in students and sleep-disordered patients indicate that threatening dreams involving chase and pursuit are indeed among the three most prevalent themes, thus supporting Revonsuo's theory. However, many of the most prevalent themes are of positive, not negative, events (e.g., sex, flying) and of current, not ancestral, threat scenarios (e.g., schoolwork). Moreover, many clearly ancestral themes (e.g., snakes, earthquakes) are not prevalent at all in dreams. Thus, these findings challenge the specificity of the threat simulation theory.

[REVONSUO]

REVONSUO's theory depends largely upon the observation that much dreaming is threatening in nature. But do the scenarios typically dreamed about today reflect the ancestral themes so central to the logic of this theory? Observations by our research group of the typical dream themes remembered by students and sleep-disordered patients are pertinent to evaluating the theory because they afford a global view of the scenarios most readily dreamed about over a lifetime within a given population. Our Typical Dreams Questionnaire (TDQ) includes 55 typical dream themes (cf. Griffith et al. 1958) that subjects check off if they have ever experienced them. We have administered the TDQ to over a thousand undergraduate students at different sites in Canada, the United States, and Japan and to close to a thousand sleep-disordered patients seen at the Sleep Disorders Center in Montreal. Consistencies between the lifetime prevalences of the most common TDQ items and those of Griffith et al. (1958) have been quite remarkable (Zadra & Nielsen 1997). Similarly, consistencies across our various samples have been very high (Nielsen et al. 1998; 1999c; Zadra & Nielsen 1999). In the case of three separate undergraduate student samples from McGill University (M age 20.3 ± 4.5 yrs; 113M; 228F), the most prevalent typical theme, endorsed by 78%, 86%, and 81 % of the student samples respectively (M = 82%) was the threat dream of being chased or pursued, but not physically injured (Zadra & Nielsen 1999). This theme was the second most prevalent typical dream of 233 Japanese undergraduates (M age 18.8 ± 2.3 ; 112F; 121M), 67% (Nielsen et al. 1999c), as well as the second and third most prevalent typical dream theme of two sleep-disordered patient samples much older in age (M age 44.9 ± 14.3 years; 249M; 235F), that is, 54% and 55% (M = 54%) (Nielsen et al. 1999b).

Such high lifetime prevalences of a threat theme are to some extent consistent with REVONSUO's theory of threat simulation during dreaming. However, the high prevalence of many other typical themes poses problems for the specificity of the theory. Two themes that fall consistently among the "top 4" in both our populations are of sexual experiences (undergraduates M = 76% and patients M = 55%) and falling (M = 72% and 47%). These are not obviously related to the ancestral threats described by REVONSUO. It might be argued that sexual dreams address issues of genetic transmission through sexual reproduction. However, threat is not the principal dynamic of such dreams. Falling dreams may echo long distant threats to the successful evolution of the upright stance in humans, but this is clearly not the type of evolutionary adaptation REVONSUO's model is attempting to explain.

Other highly prevalent themes pose similar problems. Dreams of flying or soaring through the air ranked 9th among both undergraduates (50%) and patients (38%) and typically reflect positive affect, not threat. Other prevalent themes deal less with ancestral sources of threat than with contemporary concerns, in the case of students, schools, teachers, studying (ranked 3rd; 73%), arriving too late, for example, missing a train (5th; 59%), trying again and again to do something (6th; 58%), and failing an examination (10th; 47%). It is not clear why dreaming should so often represent similar positive themes and/or contemporary concerns if its function is still geared toward dealing only with ancestral sources of threat.

Several of our least prevalent themes also do not support the theory because they are ancestral threat themes that occur in very few young or old subjects. Among the undergraduates, tornadoes or strong winds (ranked 45th; scored by 15% of sample) and earthquakes (48th; 12%) are rarely dreamed about. In fact, the likeli-

hood of dreaming of these natural disasters is about the same as dreaming of being a member of the opposite sex (46th; 15%). Other natural disasters, such as fire (33rd; 23%) and threatening animals such as snakes (35th; 21%), wild, violent beasts (40th; 16%), or insects or spiders (23rd; 31%), also have low lifetime prevalences in our samples.

REVONSUO does offer some explanations for why such ancestral themes might be infrequent in dreams. First, some dream contents appear to change over time. For animals and aggressions at least, dreams appear to be more ancestral among children: "The brain has not yet had the chance to adjust the biases in order to better fit the actual environment" (sect. 3.4.2.2). The findings for children's dreams may well fit the threat simulation model, but it is not clear why the same pattern (i.e., high prevalence in the young, decreasing prevalence with age) should not hold true for other categories of threat, such as natural disasters. Nor is it clear why, in the case of children raised in environments relatively free from threat, the brain does not then adjust its simulations so as to be free of threat altogether. The notion of "change over time" in dream content (from ancestral themes to current themes) is problematic because such change would serve no obvious function. As described, it is only ancestral content that serves the (evolutionary) function stipulated by the theory. In sum, consistencies in the prevalences of typical dream themes in multiple study samples offer only limited support for the idea that dreaming is threat simulation. These findings would be more consistent with a less specific version of the theory that postulates simulations of positive, as well as negative, and of current, as well as ancestral, dream themes.

NOTE

Address correspondence to the first author.

Each distinct type of mental state is supported by specific brain functions

Claude Gottesmann

Laboratoire de Psychophysiologie, Faculté des Sciences, Université de Nice-Sophia Antipolis, 06108 Nice cedex 2, France. gottesma@unice.fr

www.unice.fr/psychophysiologie

Abstract: Reflective waking mentation is supported by cortical activating and inhibitory processes. The thought-like mental content of slow wave sleep appears with lower levels of both kinds of influence. During REM sleep, the equation: activation + disinhibition + dopamine may explain the often psychotic-like mode of psychological functioning.

[**HOBSON ET AL.**; **NIELSEN**; **REVONSUO**; **SOLMS**; **VERTES & EASTMAN**]

1. Brain support of mentation during sleep-waking cycle [Hobson et al.] From a general point of view, it is difficult for a neurophysiologist to admit distinct modes of psychological functioning during waking and sleep unless they have different underlying brain states. Each 1/100 second of change, mentation probably involves thousands of variations in neuron activity in numerous complex circuits. This suggests that each mental state has to be sustained by some kind of specific brain state. We must be grateful to **HOBSON ET AL.** for carefully analyzing the psychological data in the literature to show that there are indeed general differences between slow-wave sleep and REM sleep mentation.

It is important to provide a model, as this generates hypotheses for future research. It is certainly bold to propose a unique functional schema to explain mentation during states as different as waking and the various stages of sleep. **HOBSON ET AL.**'s proposal is of high interest; they bring many convincing arguments forward to support different kinds of mental functioning. Nevertheless, two points are questionable. First, it is asserted that there seems to be an opposition between high noradrenergic and serotonergic levels and a low acetylcholine levels and vice versa. This is in-

deed true for REM sleep at the cortical level. However, it is not the case for waking mentation where there is simultaneously a high release of noradrenaline (Aston-Jones & Bloom 1981; Hobson et al. 1975), serotonin (McGinty & Harper 1976; Rasmussen et al. 1984) and acetylcholine (Jasper & Tessier 1971; Marrosu et al. 1995). Second, it seems difficult to rule out an involvement of dopamine at least in REM sleep mentation. This transmitter is not taken into account in the "AIM" model.

Our view is that, as is generally accepted, consciousness is mainly generated in the cerebral cortex. Traditional EEG studies, gamma activity, neuron firing, blood flow, glucose uptake, and acetylcholine release all show that the cortex is in a different state during waking, slow wave sleep, and REM sleep, this last stage being defined by criteria very similar to those of attentive waking (for details, see Gottesmann 1999). All these data also demonstrate greater cortical activation in REM sleep than in slow wave sleep. However, inhibitory processes are also involved in cortex functioning. Dopamine, noradrenaline, serotonin (Reader et al. 1979), and histamine (Sastry & Phillis 1976) principally inhibit cortical neurons. The function of dopamine alone cannot explain differences in mentation in normal subjects, because studies in rats (Miller et al. 1983) and cats (Trulsson & Preussler 1984) have shown that their neuronal firing rates do not change significantly during the sleep-waking cycle. Histamine neurons become silent as light sleep appears (Vanni-Mercier et al. 1984), and hence could potentially explain differences in cortical functioning during waking and sleep but not between slow wave sleep and REM sleep. In contrast, noradrenergic and serotonergic neurons fire maximally during waking, decrease their activity during slow wave sleep, and become silent during REM sleep. Thus, they might control cortical functioning during the sleep-waking cycle. The importance of serotonin, at least, is established because decreased release induces the mental distortions associated with depression.

Our hypothesis accordingly is that during waking the cerebral structures involved in mentation are activated and thus able to generate mental activity, but that inhibitory processes in some way control or "normalize" this activation, thereby explaining reflective mentation. During slow wave sleep there is a decrease of both kinds of influence, explaining thought-like mental contents, because some controlled activation does persist. During REM sleep, the strong cortical activation occurs in a context of massive disinhibition, when all monoamines except dopamine are absent. This strong disinhibition alone could explain the original properties of mentation, which partly resemble psychotic symptoms, as described by Hobson et al. (1998b). We suggest that in this original activated and disinhibited state, the release of dopamine, strongly involved in psychosis, would reinforce this often schizophrenic-like mode of functioning. Indeed, an increased release of dopamine induces nightmares (Thompson & Pierce 1999) and psychotic disorders (Buffenstein et al. 1999). Moreover, it is well known that the reduction in the influence of dopamine by induced neuroleptics (Kinon & Lieberman 1996) alleviates schizophrenia.

2. Experimental data to confirm the covert REM sleep hypothesis are still lacking [Nielsen]. The hypothesis of **NIELSEN** is highly important and confirms that dreaming only occurs in the physiological setting of REM sleep (Takeuchi et al. 1999b). This could explain why dreams have been described during slow wave sleep, in addition to thought-like activity. The problem is to determine the crucial physiological criterion to support REM sleep mentation. Dement wrote about thirty years ago (I do not remember where, nor does he) that REM sleep is like an orchestra playing a symphony: Several instruments (criteria of REM sleep) can be absent without suppressing playing (this sleep stage).

The arguments brought forward for sleep-onset dreaming are convincing. I have regularly such vivid life-like dreams currently and have wanted for months to record myself, being neither depressed nor narcoleptic. **NIELSEN** states that in addition to a possibly similar EEG, the same slow eye movements are seen at sleep onset as during REM sleep. To determine whether other criteria of REM sleep are found at sleep onset, particularly those linked