

lated to a dream-like state, then these observations implicating dopamine, 5-HT, and acetylcholine are generally consistent with the transmitter model of dreaming suggested in this commentary.

In conclusion, original contributions to understanding neurobiological mechanisms of dreaming, such as those of **HOBSON ET AL.** and **SOLMS**, will no doubt continue to generate not only new models but also new directions for research in neuropsychiatric disease.

Metaphoric threat is more real than real threat

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Abstract: Dreams represent threat, but appear to do so metaphorically more often than realistically. The metaphoric representation of threat allows it to be conceptualized in a manner that is constant across situations (as what is common to all threats begins to be understood and portrayed). This also means that response to threat can come to be represented in some way that works across situations. Conscious access to dream imagery, and subsequent social communication of that imagery, can facilitate this generalized adaptive process, by allowing the communicative dreamer access to the problem solving resources of the community.

[REVONSUO; SOLMS]

REVONSUO believes that dreaming enhanced adaptive fitness in the ancestral environment and that dreams provide "perceptually and behaviorally realistic rehearsals of threatening events." His notion of "realistic," however, appears shaped by the implicit presumption that environmental selection mechanisms can best be considered as the array of things and situations that "leap out at us" and "cry out to be named" (Brown 1965, p. 478), and not as something more generally conceptualized. In **REVONSUO's** scheme, these are the particular and namable elements of the Pleistocene savannah – the specific dangers that lurked there (predators, enemies, disasters). It is not clear, however, that the ancestral and current human environments are fundamentally different, or that threat can best be mastered as a consequence of its "basic-level" representation.

On the surface, this appears contentious. How can the environment of the prototypical African human progenitor be considered reasonably equivalent to that of the modern individual? The problems we face while sitting at our computers seem very much unlike those of the more "natural" world. What constitutes threat, however, or even "environment," depends on level of abstraction, and there are levels that allow for representations of danger that are isomorphic across all conceivable frames of reference (Peterson 1999).

Let us first determine just what "threat" means, in the broadest possible sense. Humans are goal-directed (Adler, in Ansbacher & Ansbacher 1956; Gray 1982; Oatley 1999). Emotions, including anxiety, signal the interruption of specific goal-directed schemes of conceptualization and patterns of action. Anxiety signals threat, to be sure (Gray 1982) – but more generally indicates the emergence of the unknown or the anomalous (which is initially nothing but undifferentiated evidence for the insufficiency of current plans) (Peterson 1999). This means that the concrete dangers of the natural world may be most usefully considered specific exemplars of a more general category. This more general category – the anomalous – lurks everywhere; it is a universal constituent element of experience. This is because we dramatically simplify the world (Miller 1956), while engaging in our goal-directed processes, and because these simplifications may constantly be revealed as insufficient, in the real environment. It is such revelation that constitutes the most basic and universal threat (Binswanger 1963).

This implies that the dream may represent threat most usefully at the highest level of abstraction – that level allowing for most

cross-situational generalization. Once this is understood, the relationship between the dream, consciousness, and the adaptive activity of cultural construction can be explicitly comprehended. Consider an actual dream, as exemplar – the production of a highly verbal five year old boy, about to leave his family and join the novel world of kindergarten. He was happy during the day, although deeply immersed in a pretend world: He spent much of his time dressed as a knight, with a plastic helmet and sword. He was not sleeping well, however, and frequently screamed for his mother late in the evening. One morning he described a nightmare. Armless, greasy, dwarf-like beaked creatures had been jumping on and biting him. Each creature had a cross shaved on the top of its hairy head. In the background loomed a fire-breathing dragon. The dragon exhaled smoke and fire, which promptly transformed itself into more biting beaked dwarves. Everyone who heard his dream report was fascinated and shocked.

It was clear that this boy had never really encountered biting dwarves or dragons. What possible purpose could such representation therefore serve? Well, after the boy had recited his tale, he was asked a question: "What could you do about this dragon?" This seems something simple, but it is not. It is instead the sort of utterance that allows a lawyer to "lead" a witness. It is a question full of "triggers" (Bruner 1986) or implicit information. The question says as much as it asks. It says, "something can be done about dragons," for example, and "small boys like you can do that something." This leading question therefore puts forth in exceedingly compressed form the plot and character elements necessary to successfully complete the narrative of the dream – that is, to solve the problem it poses.

The boy said, excitedly: "I would take my dad, and go after the dragon. I would jump on its head and poke its eyes out with my sword. I would go down its throat to the fire. I would cut out the box the fire came from, and make a shield from it." This is a complete and spontaneous recreation of a traditional hero myth – and hero myths detail successful encounters with the unknown (Peterson 1999). It is not necessary, however, to posit the derivation of this tale from the "collective unconscious" (Jung 1959). This boy had seen many movies, heard many stories, and had observed patterns of successful (and unsuccessful) real-world behavior. So the pattern for the "hero" was something thoroughly embedded in his social world. But he had never conceptualized himself as heroic. One leading question, however, provided sufficient motivation for that. His dream represented him as threatened by "archetypal" dangers – not so much by particular threats (in the form of the dwarves), but by threat itself (in the form of the dragon). When he reconceptualized himself, therefore – as a consequence of social prompting – he came to understand that he was more than someone who could face particular threats: He was someone who could overcome the class of threatening things itself. This is a far more useful conceptualization because of its cross-situational generalizability (and one that did in fact eliminate his nightmares).

The fact that it was social prompting that led to such reconceptualization also sheds light on an additional mystery. Why communicate dream content? There is a simple answer to this question: Two heads – or two thousand – are better than one. Traumatized individuals experience intrusive thoughts about the threatening occurrence (Tait & Silver 1989) and need to talk about their experience (Erslund et al. 1989; Rime 1995). Those denied opportunities to engage in social-mediation of such experiences tend to suffer more, in the aftermath (reviewed in Petrie et al. 1998). Why? What good does talking do? Well, ability to report on internal states in a communicable manner also means capacity to draw on the problem-solving resources of the community to deal with threat. This capacity to communicate dreams could have been selected for after the rise of language. So – threatening dreams become memorable and compel communication (become nightmares) precisely when they represent a threat so profound that it exceeds the current adaptive capacities of the dreamer. Such dreams are then reported, in a dramatic and intrinsically fascinating fashion. Then the community helps solve the problems they pose.

The global significance of this process should not be underestimated. Dreams are part of the lengthy, historically-elaborated process by which threats, as a class, come to be metaphorically represented – as something reptilian, for example, unpredictable, chaotic, devouring (Eliade 1978) – and then, as a class, come to be mastered (Peterson 1999). The construction of protective culture itself can reasonably be regarded as a consequence of this motivated process – not so much to escape from the specific dangers of the Pleistocene environment, but to alleviate the total consequences of human vulnerability, across all conceivable contexts.

SOLMS's observations on the potential dopaminergic mediation of dreams are interesting in this regard and help tie the threat representation capacity of the dream to its evident facility for bizarre conceptual portrayal. We know, for example, that dopaminergic activation is associated with exploration (Gray 1982) and with increased categorical flexibility (Ashby et al. 1999; Lubow 1989). These two phenomena are logically related: Categorical flexibility should increase during exploration, so that current schemes of apprehension may be modified as a consequence of learning. Adaptation to threat means either reconceptualization of self and the acquisition of new and relevant skills, or reconceptualization and recategorization of the feared object (Foa & Kozak 1986; Williams et al. 1989; 1997). Finally, we have the fact that general mood states in dreams tend to be positive (REVONSUO) – something in keeping with the first two phenomena, as dopaminergic activation is associated with positive emotion (Gray 1982; Ashby et al., 1999). This all implies that dreams may be positive, exploratory, creative play, when they are not dealing specifically with an anomaly intense enough to be traumatizing. So it seems reasonable to posit that dreams may be considered more broadly part of the process of adjustment to novelty, and that their facility for dealing with threat might be considered as something subsidiary to that broader function.

One machinery, multiple cognitive states: The value of the AIM model

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Abstract: The AIM model represents an original and comprehensive example of how changes in conscious states can be reconciled with specific neurophysiological factors. However, further elucidation of the biological parameters necessary to define a specific space-state relationship should be considered.

[HOBSON ET AL.; SOLMS]

HOBSON ET AL. and SOLMS review an impressive amount of phenomenological and physiological data in relation to waking, NREM, and REM sleep. The major objective of these authors is to find an integrative model of conscious experience in which distinct cognitive states may be quantified and tracked down to specific neurobiological events. The importance of the activation information processing modulation (AIM) model formulated by this group is owing not to this integrative approach only but especially to the understanding of consciousness as a multidimensional and dynamic process. Hence, normal and abnormal cognitive states find their own definition on the basis of the neurobiological parameters taken in account (only three in the AIM model but arguably many more). Thus the AIM-type unitary approach may be applied when studying cognitive states very different in appearance (e.g., hallucination, anesthesia, coma, etc.). In this regard the value of the AIM model goes far beyond the confines of sleep physiology.

Despite my overall appreciation of the AIM model, there are in my view several points of oversimplification that should be further discussed.

Activation. In the activation domain, it appears that the sleep-

wake related brain activity shown by functional imaging studies has been overstressed and only one of the many possible interpretations of the data is offered to the reader. This commentary does not provide the space to address detailed criticisms of the functional imaging studies, however, some elements of misinterpretation should be considered. I will limit my comments to a couple of examples.

1. It has been suggested that the higher activation of the brainstem during REM sleep is dependent on intense neuronal activity of the REM sleep generator system. This is a likely possibility and one that I happen to favor, as do the authors, our shared opinion being that the brainstem generates REM sleep's phasic and tonic phenomena. However, I am interested in why brainstem activity should be higher in REM sleep than in wakefulness. It is known that the neuronal populations responsible for arousal are located in the brainstem. For instance, the locus coeruleus noradrenergic neurons, the raphe dorsalis serotonergic neurons, the reticular activating system neurons, and so on, all lie in the proximity of the REM sleep generator system (McCormick & Bal 1997). Also it is known that in the lateral dorsal tegmentum (LDT) and ponto pedunculum tegmentum (PPT), the number of neurons selectively active during REM sleep are outweighed by the number of neurons active during both REM sleep and waking or waking alone (Kayama et al. 1992). From this observation I would expect to see similar patterns of brainstem activation in both wakefulness and REM sleep. This point remains unresolved.

2. Another example is given by the higher activation of the anterior cingulate cortex during REM sleep compared to NREM sleep or waking. This effect has been discussed by the authors in the following way: "As in waking, anterior cingulate activation contributes additional emotional features to dreaming such as valence biases, the assessment of motivational salience, and the integration of dream emotion with fictive actions" (from *Subcortical and Cortical limbic and per limbic structures in the Activation Synthesis*, sect. 3.4.4, HOBSON ET AL.). This interpretation is one possibility amongst several others. However, I question how we can reconcile this view with the large amount of data showing that the anterior cingulate cortex is a crucial part of the executive attentional and executive system and activates in tasks requiring performance monitoring and error detection (e.g., Awh & Gehring 1999; Carter et al. 1998). Such complex cognitive features do not easily fit with the authors' proposition that the dreaming brain lacks of self-awareness, judgment capability, volitional control, and so on. Finally, the higher activation of the anterior cingulate cortex contrasts with the lesion studies reviewed by SOLMS which show a correlation between anterior cingulate lesions and increased frequency and vivacity of dreaming (Solms 1997a). In conclusion, I suggest that neither the functional imaging nor the lesion studies results should be overemphasized at this stage. These results are not conclusive. In addition, several discrepancies (more than are usually considered) are present among different functional imaging studies (see Table 2 of HOBSON ET AL. article).

Information processing. The information processing domain of the AIM model implies a blockade of information flow during NREM and REM sleep in particular. Despite the fact that threshold for awakening is higher in NREM and REM sleep, there is evidence that sensory inputs are processed at the thalamo-cortical level during sleep (Mariotti & Formenti 1990; Pare & Llinas 1995) and a recent study has shown differential processing of relevant and irrelevant auditory stimuli during sleep (Portas et al. 1999). In addition, paradoxical phenomena like sleepwalking imply a certain degree of sensory processing (being sensory processing necessary for ambulation). Thus, the possibility of residual sensory processing and therefore cognitive functionality during sleep should be acknowledged and the concept of sensory blockade should be drastically reviewed in the AIM model.

Modulation. Another point worth discussing is the necessity of experiments that may address more directly the modulator mechanisms of the AIM model. The long, tedious (and necessary!) list of single cell recording, microdialysis, receptor binding, and so on, experiments used by the authors to support the validity of the Rec-