DECONSTRUCTING DREAMS: THE SPANDRELS OF SLEEP

There are two famous philosophical problems about dreams.¹

1. How can I be sure I am not always dreaming? (Descartes's problem; also Plato's and Cicero's)
2. Can I be immoral in dreams? (Augustine's problem)

After his transformation from philandering pagan to ascetic Christian, Augustine proposed a theory for how dreams might contain sinful content without being sins. The proposal in modern terms was that dreams are happenings not actions. Augustine wrote:

You commanded me not to commit fornication...But when I dream [thoughts of fornication] not only give me pleasure but are very much like acquiescence to the act...Yet the difference between waking and sleeping is so great [that] I return to a clear conscience when I wake and realize that, because of this difference, I am not responsible for the act, although I am sorry that by some means or other it happened in me (ibid., pp. 233-34).

* This paper was written as the Presidential Address for the Society for Philosophy and Psychology in Memphis, June, 1994. Versions of the paper were given at the University of Arizona, Cornell University, Stanford University, East Carolina University, and the International Institute for Advanced Study in Kyoto, Japan. Deborah Stahlkopf has been a great help listening to my ideas and helping me sort through the literature on the function question. Thanks also to J. Allan Hobson, Greg Cooper, Robert Brandon, Patricia Churchland, Daniel Dennett, Gail Marsh, Larry Rosenwald, and especially to David Sanford who has patiently listened to each day's new discoveries about sleep and dreams.


© 1995 The Journal of Philosophy, Inc.
A third problem emerged in the twentieth century in the hands of Norman Malcolm and Daniel Dennett, a natural sequel to the prominence of verificationist ideas generally. The question was this:

(3) Are dreams experiences?

Or are so-called "dreams" just reports of experiences which we think we had while sleeping but which in fact are, insofar as they are experiences at all, constituted by certain thoughts we have while waking or experiences we have while giving reports upon waking?

The answers to the first three dream problems are these: (1) rest assured, you are not always dreaming; (2) Augustine is right that committing adultery, murder, and so on in dreams is not sinful; (3) dreams are experiences that take place during sleep.

Given that dreams are experiences that take place while sleeping, a fourth dream problem suggests itself:

(4) Is dreaming functional?

Now, there are many senses of functional, and in my reflections on this, the fourth dream problem, I shall try to sort out the way dreams look using different senses of 'function'. But I want to state my general answer to the fourth dream problem upfront so that the reader can understand better the use I am making of various sorts of empirical evidence along the way. The answer is this: although there are credible adaptionist accounts for sleep and the phases of the sleep cycle itself, there is reason to think that the mentation—the phenomenal mentation—that occurs during sleep is a bona fide example of a byproduct of what the system was designed to do during sleep and sleep cycling. If this is right then there is a sense in which


2But Malcolm and Dennett are right to express the worry that dream reports are putrid evidence that this is so. We need a neuroscientific account to shore up the phenomenological confidence that dreams are experiences that take place while asleep. We now have such a theory, I claim, although I shall not set out the argument here (I have in "Towards a Unified Theory of Consciousness, or What Dreams Are Made of," in J. Cohen and J. Scholte, eds., Scientific Approaches to the Question of Consciousness: 25th Carnegie Symposium on Cognition (Erlbaum, forthcoming); also see Hobson, The Dreaming Brain (New York: Basic, 1988) and Sleep (New York: Scientific American, 1989); and unpublished papers by Hobson et al., "Dreaming: A Neurocognitive Approach" (1995) for the theory—AIM—I depend on). Some of this research has just been published in Consciousness and Cognition, iii, 1 (1994): 1-128. Dreams turn out to be experiences on that theory and thus to belong to the heterogeneous set of experiences we call 'conscious'.

---

---
dreaming, phenomenally speaking, is an "automatic sequela," a spandrel, and exaptation. 5

1. CONSTRUCTIVE NATURALISM AND THE NATURAL METHOD
I raise the epiphenomenalist suspicion about dreams not as another skeptical philosophical exercise. It is intended as a serious proposal I have been lead to in my work on consciousness within the framework of two general assumptions: (1) consciousness has depth, hidden structure, hidden and possibly multiple functions, and hidden natural and cultural history; (2) consciousness is heterogeneous in kind.

Regarding (1), consciousness has a first personal phenomenal surface structure. But from a naturalistic point of view, the subjective aspects of consciousness (call these p-aspects—the 'p' for phenomenal)—do not exhaust the properties of consciousness. Part of the hidden structure of conscious mental states involves their neural realization. Conscious mental states supervene on brain states—call the neural realization the b-aspect(s)—'b' for brain. These brain states are essential aspects or constituents of the conscious states, as are the phenomenal aspects (the p-aspects) of these states. But, of course, nothing about neural realization is revealed at the phenomenal surface, not even that there is such realization. The phenomenal surface often hints at or self-intimates the causal role of conscious states. But the phenomenology leaves us clueless as to how conscious thoughts and intentions actually get the system doing what it does; and, of course, experience intimates nothing about the causal origins and evolutionary function, if there is any, for the different kinds of consciousness.

From the first personal point of view, consciousness only has p-aspects. So with respect to dreaming, all we know about first personally is p-dreaming. The story of the brain side—of b-dreaming—as it were, will need to be provided by the neuroscientists, and the functional-causal role(s) of dreaming (now taking both the phenomenal and brain sides together) will need to be nested in a general psychological cum evolutionary (both natural and cultural) account.

The idea here is to deploy the natural method. 6 Start by treating three different lines of analysis with equal respect. Give phenomenology


its due. Listen carefully to what individuals have to say about how things seem. Also, let the psychologists and cognitive scientists have their say. Listen carefully to their descriptions about how mental life works, and what jobs if any consciousness has in its overall economy.7 Third, listen carefully to what the neuroscientists say about how conscious mental events of different sorts are realized, and examine the fit between their stories and the phenomenological and psychological stories. Now, this procedure will, I claim, yield success in understanding consciousness, if anything will. The expectation that success is in store using this method is what makes my kind of naturalism constructive rather than anticonstructive, as is the naturalism of philosophers like Colin McGinn8 who thinks that although consciousness is a natural phenomena, we shall never be able to understand it.

I need to emphasize that the troika of phenomenology, psychology, and neuroscience are not enough, despite playing the initial and central role in the procedure I favor. Evolutionary biology and cultural and psychological anthropology will also be crucial players, as the case of dreams will make especially clear. Embedding the story of consciousness into theories of evolution (biological and cultural), thinking about different forms of consciousness in terms of their ecological role, and in terms of the mechanisms of drift, adaptive selection, and free riding, will be an important part of understanding what consciousness is, how it works, and what, if anything, it is good for. As consilience and reflective equilibrium emerge, if they do emerge, from these different informational sources, we shall understand the nature of consciousness more deeply. Even claims about how things seem can change as our views about how things are change.9

---

7When I say let the psychologists and cognitive scientists have their say, I mean also to include amateurs—let folk wisdom be put on the table along with everything else.


9The case of dreams is a case in point. If we ever came to have really good theoretical reasons for thinking that dreams were not experiences, they might well seem less like experiences. It is hard to imagine giving up the idea that there are perceptual experiences since such experiences take place in the specious present (or so it strongly seems); but even dreamers will admit that they are remembering both the alleged experience and the content of the alleged experience. At the Carnegie-Mellon Conference on Consciousness in the Spring of 1995, Clark Glymour proposed that theory should be as biologically constrained as possible, and he expressed the worry that cognitive information-processing models often fail to attend to biological realism. I quite agree with the normative point. But our present knowledge of the brain is thin and often hard to interpret. Sometimes it is hard to know what the neuroscientific data are or mean and thus hard to know how they should constrain our theories. For example, many effective antidepres-
also: evolutionary biology
cultural and psychological anthropology
social psychology

Figure 1: The Natural Method

II. DREAMS: A DOUBLE ASPECT MODEL. \(^{39}\)
I have said that \(\psi\)-dreaming is a good example of one of the heterogeneous kinds of conscious experience, and it is at the same time, given neuroscientific evidence and evolutionary considerations, a likely candidate for being given epiphenomenal status from an evolutionary

\(^{39}\)F. Crick and C. Koch have suggested that subjective awareness is linked to oscillation patterns in the 40Hz range in the relevant groups of neurons, that is, neurons involved in a certain decoding task "synchronize their spikes in 40Hz oscillations"—"Towards a Neurobiological Theory of Consciousness," *Seminars in the Neurosciences*, 2 (1990): 265-75. 40Hz oscillations have been found in single neurons and neural nets in the retina, olfactory bulb, the thalamus, and neocortex. Recently R. Llinás and D. Paré—"Of Dreaming and Wakefulness," *Neuroscience*, xiv. 3 (1991): 521-35—have produced strong evidence that such oscillation patterns characterize REM sleep. Llinás and Ribary—"Coherence 40Hz Oscillation Characterizes Dream State in Humans," *Proceedings of the National Academy of Science*, xc: (1993): 2078-81—report that "during the period corresponding to REM sleep (in which a subject if awakened reports dreaming), 40Hz oscillation patterns similar in distribution phase and amplitude to that observed during wakefulness is observed." The second finding of significance they express this way: "during dreaming 40Hz oscillations are not reset by sensory input...We may consider the dreaming condition a state of hyperattentiveness in which sensory input cannot address the machinery that generates conscious experience." Within Hobson's theory, the 40Hz oscillations pertain to (A)
point of view. p-dreaming is an interesting side effect of what the brain is doing, the function(s) it is performing during sleep.\(^{11}\)

To put it in slightly different terms: p-dreams, despite being experiences, have no interesting biological function—no evolutionary proper function. The claim is that p-dreams (and possibly even rapid

activation level, while the tuning out of external stimuli is explained by the mechanisms of input-output gating (I). The main point for present purposes is that the reason dreams seem like conscious experiences is because they are conscious experiences and they are like awake conscious experiences in certain crucial respects.

Llinás and Paré suggest this unifying hypothesis: 40Hz activity in the nonspecific system comprised of the thalamo-cortical loop provides the temporal binding of contentful states that involve 40Hz oscillations in the areas devoted to particular modalities. That is, the neural system subserving a sensory modality provides the content of an experience and the nonspecific system consisting of resonating activity in the thalamus and cortex provides "the temporal binding of such content into a single cognitive experience evoked either by external stimuli or, intrinsically during dreaming" (op. cit., p. 2081). Llinás and Paré write: "it is the dialogue between the thalamus and the cortex that generates subjectivity" (op. cit., p. 552).

These data and hypotheses, in light of other data and theory, increase the credibility of the claim linking REM sleep with vivid experiences. Whether it is really true that dreams are experiences depends, of course, on whether it is true that 40Hz oscillations turn out to be a marker, a constituent component, or a cause (which one they are is, of course, very important) of vivid conscious experiences. The point is that the neuroscientific data push credible theory in a certain direction. If these data bring us closer to the answer to one question they open a host of others, suggesting occasional answers—a sure sign of a progressive research program.

One might wonder, for example, whether 40Hz oscillation patterns will turn out to be necessary or sufficient for experience or enable us to differentiate different kinds of experiences. There is the possibility that alive human beings might always be in some experiential state or other, that is, that we are never wholly unconscious—if, that is, 40Hz patterns are sufficient for experience. If this sounds like an incredible prospect, remember that persons awakened from NREM sleep often report having experiences—albeit experiences lacking the vividness of post-REM reports. And sleep talking and sleepwalking are well known to take place during NREM sleep (postural muscles are turned off during REM sleep) and it is obscure whether, or in what precise sense, sleepwalkers and talkers are experiential blanks. Globality of 40Hz activity may turn out to be the relevant feature of robust conscious experiences, not the mere presence or absence of some 40Hz activity ("On Being in the Dark, and the Mind," p. 527). Now, one worry for the 40Hz necessary condition hypothesis is this: the mentation occurring during NREM when measured by EEG does not appear to involve the 40Hz oscillations despite involving mentation, i.e., p-dreaming. So 40Hz oscillations may be a reliable marker of certain kinds of conscious mentation but not necessary for all mentation (see M. Steriade, D. A. McCormick, and T. J. Sejnowski, "Thalamocortical Oscillations in the Sleeping and Aroused Brain," Science, Colxii (1993): 678-85). On the other hand, when measured with MEG, one does find 40Hz oscillations, but much attenuated in amplitude and we do not pick up much in the way of amplitude modulations.

"See the exchange between Kathleen Emmett, "Oneritic Experiences," Philosophical Studies, xxxiv (1978): 445-50, and Bennett, "The Onus Re Experiences," Philosophical Studies, xxxv (1979): 315-18. Dreams are fodder for skeptics about the prospects for a theory of consciousness for a number of reasons. One route to skepticism is simple and straightforward. Common sense says that 'conscious' involves,
eye movements after development of the visual system is secured) are likely candidates of epiphenomena. Since I think that all mental phenomena supervene on neural events, I do not mean that p-dreams are nonphysical side effects of certain brain processes. I mean in the first instance that p-dreaming was probably not selected for, that p-dreaming is neither functional nor dysfunctional in and of itself, and thus that whether p-dreaming has a function depends not on Mother Nature’s work as does, for example, the phenomenal side of sensation and perception. It depends entirely on what we as a matter of cultural inventiveness—memetic selection, one might say—do with p-dreams, and p-dream reports. We can, in effect, create or invent functions for dreams. Indeed, we have done this. But as temporally significant aspects of conscious mental life, they are a good example, the flip side, say, of awake perceptual consciousness, which is neither an evolutionary adaptation nor ontogenetically functional or dysfunctional until we do certain things with “our dreams”—for example, use them as sources of information about what’s on our mind,” utilize dream mentation in artistic expression, and the like.

Despite being epiphenomena from an evolutionary perspective, the way the brain operates during sleep guarantees that the noise of p-dreams is revealing and potentially useful in the project of self-understanding. Thus, many things stay the same on the view I am staking out. But there is a paradox: p-dreams are evolutionary epiphenomena, noise the system creates while it is doing what it was designed to do, but because the cerebral cortex is designed to make sense out of stimuli, it tries half successfully to put dreams into narrative structures already in place, structures that involve modes of self-representation, present concerns, and so on. But the cortex is not designed to do this for sleep stimuli, it is designed to do it for stimuli period and it is ever vigilant. The idea is that it did us a lot of good to develop a cortex that makes sense out of experience while awake, and the design is such that there are no costs to this sense maker’s always being ready to do its job. So it works during the chaotic neuronal cascades of part of the sleep cycle which activate certain sensations and thoughts. So p-dreams, despite their bizareness and epiphenomenal status, are meaningful and interpretable up to a point.

among other things, being awake. But dreaming takes place during sleep, and, thus, by the distinguished deliverances of conceptual analysis, dreams cannot be conscious experiences. But common wisdom also says that dreams are experiences that take place during sleep, so our common sense taxonomy of ‘consciousness’ is worse than a hodgepodge; it is riddled with inconsistency from the start.

III. WHAT IS A DREAM?

I have been using "p-dreaming" so far to refer to any mentation that occurs during sleep. But the term "p-dreaming", despite being useful for present purposes, ultimately will not carve things in a sufficiently fine-grained way. An example will help see why. Until I started working on dreams a year or two ago, I often woke up remembering and reporting dreams like this: "A late tenure letter (ten years late) was just received by the provost, it was negative, and my tenure has been taken away." Now, to say that this is a dream is to use the term 'dream' as it is commonly used to refer to any mentation occurring during sleep. But research has shown that this sort of perseverative fearful thought is most likely to occur during non-REM sleep, the sleep standardly divided into four stages which occupies about 75% of the night. Sleepwalking, sleep talking, and teeth-grinding are also NREM phenomena—and no one knows for certain whether we should say person walking and talking in sleep are p-conscious or not.

Night terrors, a common affliction of young children, are very puzzling since the child seems totally awake, eyes wide open, running about speaking alternately sense and nonsense, but almost impossible to comfort and wake up entirely and, on most every view, suffering terrifying hallucinations (which even if the child is finally awakened are remembered much less well than hallucinatory REM dreams). But, and here is the anomaly, the terrorized child is almost certainly in stage III or IV NREM sleep.

The first point is that mentation occurs during NREM sleep as well as during REM sleep, and we report mentation occurring in both states as "dreams." Now, since the discovery of REM sleep, and its close association with reports of vivid fantastic dreaming, some have simply identified dreaming with REMing or with mentation occurring during REM sleep. But this goes against the grain of our folk-psychological usages of the term 'dream'.

"Exciting work—by M. Jouvet, "Recherches sur les structures nerveuses et les mécanismes responsables des différentes phases du sommeil physiologique," Archives Italiennes de Biologie, 1 (1962): 125-206; E. Aserinsky and N. Kleitman, "Two Types of Ocular Motility Occurring in Sleep," Journal of Applied Physiology, VIII (1955): 1-10; and W. Dement, "The Occurrence of Low Voltage, Fast, Electroencephalogram Patterns during Behavioral Sleep in the Cat," Electroenceph Clinical Neurophysiology, X (1958): 291-96—in the late 1950s led to the identification of "dream mentation" with REM sleep. But this, it appears, is a mistake: NREM sleep is also associated with reports of mentation, and although the phenomenological content of such mentation is mundane and fairly non-sensical, involving such things as worries about something that needs to be done the next day, subjects do not say they were just thinking about what they needed to do the next day, but that they were "dreaming" about it (D. Foulkes, "Recherches les structures nerveuses et les mécanismes responsables des différentes phases du som-
So much the worse for the folk-psychological term, one might say. But if one wants to regiment language in this way, the stipulation must be made explicitly and there are costs with the explicit stipulation. To the best of my knowledge, only one dream research team has made any explicit sort of definitional maneuver along these lines. Allan Hobson’s group at Harvard University (sometimes) defines “dreams” as the bizarre fantastic, image rich mentation that occurs during REM sleep. Hobson’s group leaves the logically perseverative tenure dream, worries about tomorrow’s agenda, that the car needs gas first thing in the morning, and the like, on the side of conscious but nondreaming mentation associated with NREM sleep. This definitional maneuver cleans things up and helps in general to draw a helpful distinction between different kinds of sleep mentation. We can imagine people—I now do this—reporting as real

niel physiologique,” Archives Italiennes de Biologie, c. (1962): 125-206; J. H. Herman, S. J. Ellman, and D. P. Roffwarg, “The Problem of NREM Dream Recall: Re-examined,” in A. Arkin, J. Antrobus, and S. Ellman, eds., The Mind in Sleep (Hillsdale, NJ: Erlbaum, 1978). Indeed, if one thinks that mentation is dreaming only if it occurs during REM sleep, then people are even more disastrously bad at giving dream reports than most have thought: for many reported dreams are of the “I was supposed to do x, but did not” sort and the evidence points to greater likelihood that such mentation occurs during NREM sleep than during REM sleep. It was Foulkes who led the credible movement, not yet won, to dissociate the virtually analytic connection that had been drawn and continues to be drawn by most researchers between REM and dreaming. Indeed, someone—I cannot remember who it was—founded “The Society for the Prevention of Cruelty to NREM Sleep.” The idea was to let dreaming be, as a first pass, any mentation that takes place during sleep, and go from there. The frequency of NREM mentation casts doubt on the idea that dreaming is a natural kind, although we may well be able to discern differences between NREM mentation and REM mentation. Nonetheless, some researchers (Herman, Ellman, and Roffwarg) suggest that the conclusion to be gained from expanding the concept of dreaming is this: “The hope that one stage of sleep, or a given physiological marker, will serve as the sole magic key for vivid dream mentation has all but faded from view” (op. cit., p. 92). The overall point is this: p-dreams as we normally think of them include both the perseverative, thought-like mentation of NREM sleep and the bizarre and fantastic mentation of REM sleep, but the foregoing scientific considerations suggest reasons for restricting the use of the term ‘dreams’ for certain scientific and philosophical purposes only to REM mentation, but there are some reasons against doing this—e.g., the hallucinatory night terrors of stage III and IV NREM sleep. A further issue is this: we are always either NREM or REM sleep or awake, it is possible that we are never unconscious. Alternatively, it is possible that there are times in both NREM and REM sleep when virtually nothing thought-like is happening—or perhaps we are informationally sensitive (this could explain how sleepwalking without awareness could be possible—similar to the way blindsight patients process some information about what is in the blind field without being aware of, or experientially sensitive to what is in that field). No one knows for sure.

dreams only the really weird sleep mentation, and thinking of the recurring thought of failing the exam as NREM mentation—a "dream" in raised eyebrow quotes. But the definitional maneuver has costs for it does not deal well with the NREM states, like night terrors, that (probably) involve hallucinations and bizarre mentation. These will turn out to be *nondreams* because they occur during NREM sleep, but, at the same time, *dreams* because they are bizarre and hallucinatory. And there are, of course, day dreams which, at least, phenomenally may be closer to the old wish-fulfillment model than the mentation of NREM or REM sleep. So everything does not become neat and tidy once we use the natural method to make principled distinctions. One reason is that terms that have their roots in folk psychology, though often helpful, are not designed to specify scientific kinds or natural kinds, if there are such kinds in the science of the mind.

Having recognized the benefits and costs of the definitional maneuver, it will do no harm for present purposes if I continue to use *p*-dreams to refer to any mentation occurring during sleep, recognizing full well that since mentation occurs in all stages of NREM and REM sleep, *p*-dreaming is not precise enough ultimately to type mentation during sleep from either a phenomenological or neuroscientific point of view.

IV. SLEEP

Now, some of the essential questions that any good theory of sleep and dreams will need to explain are these:

(1) Why (and how), despite involving vivid experiences, do *p*-dreams involve shut-downs of the attentional, motor, and memory systems and (relative) insensitivity to disturbance by external stimuli?
(2) Why do the phenomenology of NREM and REM mentation differ in the ways they do?
(3) What function(s) does sleep serve and how do the clocklike cycling of NREM and REM sleep contribute to these functions?

There are numerous additional questions that need addressing but these are the ones which are both somewhat tractable at the present time and most useful for pressing the epiphenomenalist suspicion.

The short answers to (1) and (2) are these: sleeping in general is controlled by a clock in the *suprachiasmatic nucleus of the hypothalamus*—the hypothalamus is an area importantly implicated in the manufacture of hormones and thermoregulation. This clock gets us into NREM sleep, a hypometabolic form of sleep, and moves us through its four stages. There appears to be a second clock in the
pons (the pontine brainstem) that sets off REM movements and its accompanying mentation (see figure 2).

In REM sleep, pulsing signals originate in the brainstem and reach the lateral geniculate body of the thalamus. When awake, this area (G) is a relay between the retina—on certain views part of the brain itself—and visual processing areas. Other pulses go to the occipital cortex—the main visual processing area of the brain. So PGO waves (see figure 3) are the prime movers of REMing. This much accounts for the saliency of visual imagery in the dreams of sighted people. But the PGO noise is going to lots of different places and reverberating every which way. This is why people who work at remembering dreams will report loads of auditory, olfactory, tactile, kinesthetic, and motor as well as visual imagery. There is a nice convergence of neuroscientific and phenomenological data here. Recent studies have shown that the parts of the brain that

---

The visual brain stimulates itself in REM sleep via a mechanism reflected in EEG recordings as PGO waves. Originating in the pons (P) from the neurons that move the eyes, these signals are conducted both to the lateral geniculate (G) body in the thalamus and to the occipital cortex (O).

Figure 5: PGO Waves

reveal robust activity on PETs, MRIs, or magnetoencephalographs indicate that "mentation during dreaming operates on the same anatomical substrate as does perception during the waking state." But the main point is that PGO waves are dominant during REM sleep and quiescent during NREM sleep, and this explains by inference to the best available explanation a good deal about why the mentation of REM sleep involves vivid, bizarre, and multimodal imagery.

The answer to another piece of the puzzle—namely, why we in fact do not get up and do or try to do the things we dream about doing—has to do with the fact that a certain area in the brainstem containing the bulbar reticular formation neurons sends

"Hobson, Sleep, p. 82.

"Llinás and Paré, "Of Dreaming and Wakefulness," Neuroscience, xliv, 3 (1991): 521-35. This helps explain why prosopagnosics do not report dreaming of faces and why people with right parietal lobe lesions who cannot see the left side of the visual field report related deficits in their dream imagery (p. 524). On the other hand, it tells us something about memory that visual imagery sustains itself better in both the dreams and the awake experiences of people who develop various kinds of blindness in later life.

"Once such imagery is overrated, dreaming is equated with REMing and the sensorily dull, but thought-like, mentation of NREM sleep is overlooked. This then leads to the assumption that NREM sleep, especially stage IV, is a period of unconsciousness.
hyperpolarizing signals to the spinal cord blocking external sensory input and motor output. People with certain sorts of brainstem lesions do get up in the middle of the night and play linebacker to their dresser—presumably imagined to be an oncoming fullback. (Figure 4 gives two sorts of pictures of how REM dreaming works.)

V. THE FOURTH DREAM PROBLEM AND FUNCTIONAL EXPLANATION
So far I have tried to answer questions (1) and (2) about the differences between REM sleep and NREM sleep and the accompanying mentation. The answer to (3)—the question of the function(s) of sleep and sleep cycling—is not as well understood as some of the matters just discussed. Based on my reading, I have a list of over fifty distinct functions that have been attributed to sleep and dreams in the last decade alone! Using the best-theory-in-town principle, here is how things look to me regarding the function question.

First, some facts. (1) Fish and amphibians rest but do not sleep at all. The most ancient reptiles have only NREM sleep, while more recent reptiles and birds have robust NREM sleep and some REM sleep. All mammals save one, the egg laying marsupial echidna of Australia, have REM sleep. (2) In creatures that REM, REMing is universally more frequent at the earliest stages of development. So for humans, newborns are REMing during half the sleep cycle, this drops to 38% at three months, and at puberty REM sleep comprises about 25% of all sleep. It decreases in relative amount as we age, as does stage III and IV NREM sleep.

The fact that NREM is the oldest form of sleep and is hypometabolic suggests the following hypothesis: NREM sleep was selected for to serve restorative and/or energy conservation and/or body building functions. Now, some people find this hypothesis empty—akin to saying sleep is for rest, which, though true, is thought to be uninformative. But things are not so gloomy if we can specify some of the actual restorative/conservatory/building mechanisms and processes in detail. And we can. The endocrine system re-adjusts all its levels during sleep. For example, testosterone levels in males are depleted while awake regardless of whether any sexual or aggressive behavior has occurred, and are restored during sleep; indeed, levels peak at dawn. Pituitary growth hormone does its work in NREM sleep. Growth hormone promotes protein synthesis throughout the body—new cell growth helps with tissue repair—for example, cell repair of the skin is well-studied and known to be much greater while sleeping than awake. Protein synthesis in the cerebral cortex and the retina fol-
low the same pattern of having a faster rate in sleep than while awake. And, of course, the amount of food needed for survival is lowered insofar as metabolic rate is. To be sure, much more needs to be said, and can be found in medical textbooks about the

The hypothalamus, the basal forebrain, and pontine brainstem are believed to control the states of waking, REM sleep, and NREM sleep. As we go from one state to another, a series of coordinated changes occur in EEG signals, neurotransmitter level of activity, posture, and mental activity. Posture shifts occur during the transitions to and from REM sleep. The vivid perceptions of reality in waking shift to thoughtlike, nonvisual cognition in NREM sleep and then to the bizarre imagery of dreams.

Figure 5: Ratios of Neurotransmitters

restorative/conservatory/building processes that are fitness enhancing and associated with NREM sleep.

Regarding REM sleep, two functions suggest themselves. First, the much larger percentage of REMing in development across mammals suggests that it is important in helping build and strengthen brain connections, particularly ones in the visual system, that are not finished being built in utero. On the other side, the prominence of significantly greater time spent in REM sleep as an infant—where one

---

9 Hobson, Sleep, p. 24, fn. 6.
does not know or care about right and wrong—than as an adolescent bubbling over with vivid and new socially acceptable wishes should go the other way, one would think, if anything like the orthodox Freudian view of dream function were true. What instinctual impulses, what sexual and aggressive fantasies are being released by a newborn, or even less credibly by thirty-week old fetuses which, according to some experts, go through phases of REMing twenty-four hours a day?

Now, the biggest difference between waking and NREM sleep and REM sleep has to do with the ratios of different types of neurochemicals, modulators, and transmitters in the soup. In particular, the ratios of cholinergic and aminergic neurochemicals flip-flop. Neurons known to release serotonin and norepinephrine (noradrrenalin) shut off in the brainstem during REM and neurons secreting acetylcholine are on (see figure 5).

What good could this do? Here is one possible answer. The best theory of attention, namely, M.I. Posner and S.E. Petersen's, says that norepinephrine is crucial in getting the frontal and posterior cortical subsystems to do a good job of attending. Furthermore, both norepinephrine and serotonin are implicated in thermoregulation, as well as in learning, memory, and attention; and dopamine has been shown to play an essential role in learning at least in sea slugs. Now, what happens in REM sleep that is distinctive in addition to the dream-mentation part is that there is a complete shift in the ratios of certain classes of neurochemicals. In particular, in waking serotomin is working hard, as are dopamine and norepinephrine. The aminergic neurons that release these neurochemicals quiet down in NREM sleep and turn off during REM sleep—this helps explain why memory for dreams is degraded. Meanwhile, cholinergic neurons—for example, those releasing acetylcholine—turn on. Here is a credible hypothesis for why this might be: by a massive reduction in firing during REM sleep, the neurons releasing the neurochemicals most directly involved in attention, memory, and learning get a rest. While resting, they can synthesize new neurotransmitters. The evidence points to a major function of REM sleep as involving "stockpiling" the neurotransmitters that the brain will need in the morning for the day's work.

Another hypothesized function of sleep and of REM sleep in particular, which I have not yet mentioned, is that something like disk maintenance, compression, trash disposal, and memory consolida-


Hobson, Sleep, fn. 6.
tion take place. These seem like good things for the system to do. But it is pie in the sky hypothesizing until some mechanism is postulated that could do the job. How could such memory consolidation or junkyard functions work? What sort of mechanism could govern such a process or processes? One idea is this: for memories to be retained, they must be converted from storage in the halfway house of distributed electrical patterns into stable protein structures within neurons, in particular at the synapses. To get a feel for the need here: imagine your computer crashing and the difference "saves" make. The idea is that memory reactivation involves the reactivation of the neural networks whose synaptic strengths have been altered. What happens during REM sleep is that the cholinergic neurons that are on and releasing acetylcholine interact with the temporary but connected electrical synaptic hot spots constituting a memory from the day, and change those hot spots to a more stable form—to some sort of protein structure.

VI. NATURAL FUNCTIONS

Enough theory and data are now on the table to see how I intend the argument for the hypothesis I floated at the beginning of the paper to go. The hypothesis can be formulated somewhat more precisely, given what has been said so far. It is that sleep and the phases of the sleep cycle—NREM and REM sleep—were selected for and are maintained by selective pressures. They are adaptations in the biological sense. The mental aspects of sleep, however, the thoughts that occur during NREM sleep, as well as the dreams, and lucid dreams (dreams that contain the awareness that one is dreaming) which occur during REM sleep are probably epiphenomena in the sense that they are serendipitous accompaniments of what sleep is for.

Now, some things that were originally selected to serve a certain function end up being able—with some engineering modifications—to serve another function. Selection pressures then work, as it were, to select and maintain the adaptation because it serves both purposes, or, to put it another way, both the original pheno-


See Hobson, Sleep, fn. 6.

typic feature and the extended one serve to increase fitness. For example, feathers were almost certainly selected for thermoregulation, but now selective pressures work to maintain feathered wings because they enable flight. Insect wings are an even better example, since it is known that it was aerodynamically impossible for the first wings to serve to get insects aloft. Initial selection was for thermoregulation.

It is standard in evolutionary biology to say of some “automatic sequelae,” pleiotropic or secondary characteristic, that it is a non-adaptation only if it is a concomitant of a trait that was selected for and if, in addition, no concurrent positive selection or independent modification operate on the trait. So the capacity to fly may have been a sequelae of selection pressures to design efficient thermoregulation, but feathered wings are an adaptation because, despite being a secondary characteristic, they were (and are) subject to positive selection and modification pressures. But the color of blood and the human chin are common examples of sequelae that are nonadapta-

The biological notion of an adaptation and even a nonadaptation needs to be marked off from the concept of adaptiveness or functionality. The biological notion is tied to selection pressures that contribute to reproductive success in a particular environment or set of environments. But we also say of mechanical devices, intentional human acts, act types, and cultural institutions that they are adaptive or functional. Here we mean that the device, act, act type, institution does what it is designed to do.

We need to draw one further distinction within the nest of meanings of the terms ‘function’ and ‘functional’: between (1) a causal contribution sense of function and (2) a functional versus dysfunctional sense. So to use Kitcher’s example, mutant DNA causing tumor growth is functioning as it is supposed to from the point of view of the relevant cell lineages; it is making the causal contribution we expect, but it is dysfunctional—bad biologically and psychologically for the organism in which the tumor is growing.

Now, my argument is this: sleep and sleep cycling is an adaptation for reasons given above—it restores, conserves, and builds and we can specify some of the specific things it does and the mechanisms

Kitcher argues that this idea unifies attributions of function across biological and nonbiological contexts. See his forthcoming paper "Function and Design."
by which these are done. There is some reason to wonder whether REMing and NREMing (that is the moving or nonmoving of eyes) is an adaptation. And there is very good reason to be positively dubious about the adaptive significance of the phenomenal experiences that supervene on REM and NREM sleep. Dreaming, broadly construed, is pleitropic, an automatic sequelae, a spandrel. It is doubtful that dream consciousness once in play as a sequelae of causal processes originating in the brain stem which tickle the visual areas producing REMs was subjected to positive selection pressures and modification. Actually, I should put it this way: for reasons discussed earlier, the brain stem is designed to activate the visual system to finish building it during the first year of life. Once the system is built, the continuation of the activation of the visual system serves no obvious further developmental function. Furthermore, whereas the PGO waves of REM sleep are implicated in the processes of stockpiling neurochemicals for the next day’s work, for making what is learned more stable so that it can be remembered, and possibly for trash disposal, there is no reason to believe that these jobs require mentation of any sort.

Assuming, tentatively, that the stabilizing idea is right, there is no phenomenological evidence that as electrical patterns are transformed into protein structures that the associated mentation involves the activation of the thoughts worth remembering. People remember nonsense syllables better after sleep than if tested right after learning but before sleep. But, to the best of my knowledge, people never report dreaming about nonsense syllables. Nor do students of mathematics work through the proofs of the previous day in dreams. It may well be that the proof of the Pythagorean theorem would go in one ear and out the other if we did not sleep in between. But I would place large bets that one will have trouble getting any phenomenological reports of sophomore geometry students dreaming through the steps of the theorem in REM sleep. The point is that PGO waves are causally implicated in the neurochemical stockpiling of amines (serotonin, norepinephrine, etc.) and in setting acetylcholine and its friends to the task of bringing stability to what has been learned. But there is no reason, so far as I can see, to think that the mentation caused by the PGO waves is causally relevant to these processes. The right circuits need to be worked on, but no mentation about the

*I have not even mentioned some of the other systems that are being worked on in sleep, e.g., the immune system. People who are kept from sleeping die, not from lack of sleep as such, but from blood diseases. Without sleep the immune system appears to breakdown.
information that those circuits contain is needed; and typically such mentation does not occur. The visual, auditory, propositional, and sensory-motor mentation that occurs is mostly noise. One might be drawn to a different conclusion if the mentation was, as it were, about exactly those things one needs to stabilize for memory storage, but phenomenologically that seems not to be the case. It cannot be the actual thoughts that occur during the bizarre mentation associated with REMing which the system is trying to stabilize, remember, or store—most of that is weird. Sure, some is not weird and, of course, the so-called day’s residue makes occasional appearances in dreams. It would be surprising if it did not. It is on your mind. The incorporation of external stimuli is also easily explained—the system is designed to be relatively insensitive to outside noise, but it would be a pathetic survival design if it were completely oblivious to outside noise. So dripping faucets and cars passing on the street outside are being noticed but in a degraded way, they will not wake you, but a growling predator at your campsite will.\footnote{31}

*P*-dreams are a special but by no means unique case where the epiphenomenalist suspicion has a basis. *P*-dreaming is to be contrasted with cases where phenomenal awareness was almost certainly selected for. Take normal vision, for example. It is, I think, a biological adaptation. Blindsight persons who have damage to area V1 in the visual cortex get visual information but report no phenomenal awareness of what is in the blindfield. They behave in degraded ways toward what is there if asked to guess what is there, or reach for it, which is why we say they are getting some information. But the evidence suggests that the damage to V1 which is essentially implicated in phenomenal visual awareness explains why the performance is degraded.\footnote{32} And this suggests that the phenomenal side of vision is to be given an adaptationist account along with, and as part of, an adaptationist account of visual processing generally. This is not so with *P*-dreaming.

**VIII. INVENTED FUNCTIONS**

The phenomenal aspects associated with sleeping are nonadaptations in the biological sense. The question remains: Does *P*-dreaming serve

\footnote{Rats that have learned certain spatial tasks have the relevant neural circuits worked on during sleep. Why the rat would need to be thinking the "right" spatial thoughts in addition to having the "right" circuits worked on is utterly obscure, a tempting inference, but totally unwarranted as best I can tell. See M.A. Wilson and B. L. McNaughton, “Reactivation of Hippocampal Ensemble Memories during Sleep,” *Science* (in press), and “Dynamics of the Hippocampal Ensemble Code for Space,” *Science*, CCLXII (August 20, 1993): 1055-58.}

\footnote{See N. Block, in *Brain and Behavioral Sciences* (forthcoming), for an objection to this sort of reasoning; and see my response in my *Consciousness Reconsidered*, pp. 149-92.}
a function? If it does it is a derivative psychological function constructed via mechanisms of cultural imagination, and utilization of the fact that despite not serving a direct biological or psychological function, the content of dreams are not totally meaningless, and thus dreams can be used to shed light on mental life, on well-being, and on identity. What I mean by the last remark is this: the cortex's job is to make sense out of experience and it does not turn off during sleep. The logically perseverative thoughts that occur during NREM sleep are easy for the cortex to handle since they involve real, but possibly "unrealistic" ideation about hopes, worries, and so on. Indeed, from both a phenomenological and neuroscientific perspective, awake mentation and NREM sleep mentation differ more in degree than in kind.

REM mentation is a different story. It differs in kind. Phenomenologically and brainwise it is a radically different state—closer to psychosis than to any other mental-state types. Still, the cortex takes what it gets during REM sleep and tries to fit it into the narrative, script-like structures it has in place about how my life goes and how situations go, for example, restaurant scenes, visits to amusement parks, to the beach, and so on. Indeed, Hobson's group is now studying the underlying grammar of dream mentation and the evidence is fascinating. Settings and scenes are fairly unconstrained, plot is intermediate, and characters and objects tend to be transformed in the most gradual ways. So one's true love might be in China one second and Brazil the next, there will be some work to make the plot coherent which will be hard, so what she is doing in China and Brazil might involve an odd plot shift but not a completely incoherent one. But you may also find that she has turned into an old true love, but probably not into a sofa, in the transcontinental scene shift.

Now, mentation about one's current true love and one's old true love might be informative about what is on your mind, or it might be uninformative, just the best story line the cortex can bring to the materials offered up; but this could be true and such a dream could still be a good place to start from in conversation with a psychiatrist if your love life is going badly, or if you are suffering from any psychological malady. This may be because the content itself is revealing—remember there is a top-down/bottom-up struggle going on between

---

a. I need to be clear here that the very same processes that produce p-dreaming as an effect produce the switch in neurotransmitter ratios that do serve an important psychological function. But p-dreams do not serve this function.

the noise from below and the cortex which is trying to interpret the noise in terms of narrative structures, scripts, and self-models it utilizes in making sense of things while awake. It could be that the dream is uninterpretable, or is meaningless as an intentional narrative construct, or has nothing like the meaning we are inclined to assign, but is nonetheless a good conversation starter for someone trying to figure out the shape of his life. Obviously, from what I have said, the cortex is expressing what is on your mind, how you see things. Your dreams are expressions of the way you uniquely cast noise that someone else would cast differently. This view leaves plenty of room for dream symbolism and even for something like the distinction between manifest and latent content. During REM sleep, the cortex must, to the extent that it can, work up a story that builds largely on the contents activated by the PGO waves. But these contents are hardly the building blocks with which a teller of literal tales would start. These contents will enter into the dream narrative, but it will be up to the cortex to determine what, if anything, the image of, for example, the Museum of Modern Art means, and this will be determined and will be interpretable (if it is interpretable) by seeing how this image is situated within the larger narrative structure of which it is a part.

So things remain the same, phenomenal dreams make a difference to your life. They may get you thinking in a certain way upon waking. You may find yourself in a hard to shrug-off mood despite learning that the imagined losses of loved ones causing that mood were dreamed and did not really happen. You may be inspired to write a poem or a mystical text, and you may work on the project of interpretation. This is not silly. What you think while awake or while asleep is identity expressive. The project of self-knowledge is important enough to us that we have learned to use the serendipitous mentation produced by a cortex working with the noise the system produces to further the project of self-knowledge and identity location. This is resourceful of us.

"I have talked very little about the activation of limbic areas during dreams. Hobson’s group finds that emotions and moods are coherently coordinated with dream content. This, it seems to me, is good evidence of cortical domination of the plot line and of limbic cooperation.

Inventing a new function for a biological characteristic might or might not change the characteristic in some one. Using the sound of heart beats has not, I assume, changed the nature of heart beating. The case may be somewhat different with dreams. Using dreams for gaining self-knowledge, creative projects, and the like has probably not had an effect on dreaming, but it may well have affected the content of dreams, and the abilities of individuals to remember or even to control dream plot and content. The literature on lucid dreams (dreams that involve awareness that one is dreaming) contain some evidence that individuals can learn to control dream plot and content. See, e.g., Tracey L. Kahan and Stephen LaBerge, "Lucid Dreaming as Metacognition," Consciousness and Cognition, 3 (1994): 246-64.
Spandrels serve functions even though they are sequelae of the design the architect is focused on putting in place. Being a spandrel does not make something nonfunctional. Spandrels are beautiful accompaniments of done and arch designs. They are probably nice enough to look at as a matter of structural geometry if left plain but putting frescoes on them makes the world more beautiful. So it is with dreams. They are mental spandrels, but we can work them into all sorts of useful, creative, and fun things we have learned to do in our lives. One final point, purely informational: after the hormonal poisoning accompanying adolescence returns to normal levels, only about 6 in 100 dreams have romantic or sexual content and involve feelings of affection or eroticism. I thought I would tell you that because you were probably wondering.

Owen Flanagan

Duke University