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Dreaming and the brain: Toward a cognitive neuroscience of conscious states

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Abstract: Sleep researchers in different disciplines disagree about how fully dreaming can be explained in terms of brain physiology. Debate has focused on whether REM sleep dreaming is qualitatively different from nonREM (NREM) sleep and waking. A review of psychophysiological studies shows clear quantitative differences between REM and NREM mentation and between REM and waking mentation. Recent neuroimaging and neurophysiological studies also differentiate REM, NREM, and waking in features with phenomenological implications. Both evidence and theory suggest that there are isomorphisms between the phenomenology and the physiology of dreams. We present a three-dimensional model with specific examples from normally and abnormally changing conscious states.

Keywords: consciousness, dreaming, neuroimaging, neuromodulation, NREM, phenomenology, qualia, REM, sleep

1. Introduction

Dreaming is a universal human experience that offers a unique view of consciousness and cognition. It has been studied from the vantage points of philosophy (e.g., Flanagan 1997), psychiatry (e.g., Freud 1900), psychology (e.g., Foulkes 1985), neural network modeling (Antrobus 1991, 1993a; Foulton & Antrobus 1992), psychophysiology (e.g., Dement & Kleitman 1957b), neurobiology (e.g., Jouvet 1962), and even clinical medicine (e.g., Mahowald & Schenck 1999; Mahowald et al. 1998; Schenck et al. 1993). Because of its broad reach, dream research offers the possibility of bridging the gaps in these fields.

We strongly believe that advances in all these domains make this a propitious time to review and further develop these bridges. It is our goal in this target article to do so. We will study dreams (defined in the American Heritage Dictionary [1992] as “a series of images, ideas, emotions, and sensations occurring involuntarily in the mind during certain stages of sleep”) and REM sleep, as well as the numerous forms of wake-state and sleep-state mentation. We will also review polysomnographically defined wake and sleep states. Our analyses will be based on comparisons and correlations among these various mental and physiological states.

1.1. An integrative strategy

Three major questions seem to us to be ripe for resolution through constructive debate:

1. Are the similarities and differences in the conscious experiences of waking, NREM, and REM sleep defined with sufficient clarity that they can be measured objectively? If so, do the measures establish clear-cut and major differences between the phenomenological experience of these three physiological states?

2. Are the similarities and differences between the brain...
substrates of the states of waking, NREM, and REM sleep defined with sufficient clarity that they can be measured objectively? If so, do the measures establish clear-cut differences between these states at the level of brain regions, as well as at the cellular and molecular levels?

3. To the extent that affirmative answers can be given to the two preceding questions, can a tentative integration of the phenomenological and physiological data be made? Can models account for the current results and suggest experiments to clarify these issues?

Hoping to stimulate a useful debate, we will answer all three of the preceding questions affirmatively, documenting our responses with appropriate data drawn from our own work and from that of our colleagues. Referring to this evidence, we will advance the thesis that the conscious states of waking, NREM, and REM sleep differ in three clear and important ways which are measurable at both the psychological and physiological levels. The three parameters will become the axes of a state space model that we introduce only briefly here but discuss in more detail in concluding this article.

1.2. A state space model of the brain-mind

In essence, our view is that the brain-mind is a unified system whose complex components dynamically interact so as to produce a continuously changing state. As such, any accurate characterization of the system must be multidimensional and dynamic and must be integrated across the neurobiological and psychological domains. Both neurobiological and psychological probes of the system must therefore be designed, applied, and interpreted so as to recognize and clarify these features.

As a first step in that direction, we have created a three-dimensional state space model (AIM) that allows us to represent the system according to variables with referents in both the neurobiological and psychological domains as is shown in Figure 1. They are activation (A), information flow (I), and mode of information processing (M). Each of these terms has meaning both at the cognitive and neurobiological levels. Roughly speaking, these dimensions are meant to capture respectively: (1) the information processing capacity of the system (activation); (2) the degree to which the information processing comes from the outside world and is or is not reflected in behavior (information flow); and (3) the way in which the information in the system is processed (mode).

The resulting state space model, while still necessarily overly simplistic, is nonetheless a powerful tool for studies of consciousness. It captures many aspects of the neurobiological, cognitive, and psychological dynamics of wake-sleep states, and is unique in several important respects that we will discuss in light of the controversial conceptual and empirical issues that have stymied the study of waking, sleeping, and dreaming.

1.3. Caveat lector

In setting the stage for a full explication of our integrative AIM model (sect. 4), we will review the evidence regarding the differentiation of brain-mind states at the levels of psychophysiology (sect. 2) and basic and clinical neuroscience (sect. 3). Although these reviews are extensive, they do not broach many of the fundamental questions of sleep research. For example, we do not consider the biological functions of REM sleep as we do elsewhere (Hobson 1988a) nor do we address the equally interesting question of how psychological and cognitive factors impinge upon sleep neurobiology, a subject which has been the focus of our most recent work (Stickgold et al. 1996a, 1996b; 2000a; Xie et al. 1996). As has often been shown, cognitive activity affects sleep as well as vice versa (e.g., Smith & Lapp 1991) reflecting, certainly, a reciprocal effect of psychological factors and their neural substrates. Additionally, we sidestep entirely the intriguing but difficult issue of whether dreaming itself, as a conscious experience, has a psychological function over and above the postulated benefits of sleep to homeostasis and heteroplasy (Hobson 1988a). Finally, it is important to note that we deal here exclusively with those Chalmers (1995b) has termed the “easy problem” of consciousness, that is, the mechanisms of the cognitive components of consciousness, rather than the “hard problem” of how consciousness itself could arise from a neural system (see, e.g., Tononi & Edelman 1998; Woolf 1997).

2. The phenomenology and psychophysiology of waking, sleeping, and dreaming

In this section we discuss the evidence which has been gathered over the past 40 years in an effort to define the conscious states of waking, sleeping, and dreaming and to measure their formal features quantitatively. With respect to the first question raised by us in the introduction, we will defend the position that these three states can be defined, that their components can be analyzed and measured, and that they are significantly different from one another. After presenting our justification for this claim, we will
address the claims made by many psychologists that differences between REM and NREM mentation – and even differences between REM and waking mentation – are much smaller than we believe. In the course of this discussion, we will identify several areas of disagreement and then suggest some new approaches to their resolution.

Definitions of dreaming have ranged from the broadest “any mental activity occurring in sleep” to the narrower one that we prefer:

Mental activity occurring in sleep characterized by vivid sensorimotor imagery that is experienced as waking reality despite such distinctive cognitive features as impossibility or improbability of time, place, person and actions, emotions, especially fear, elation, and anger; a sense of autonomy; and guilt and sometimes reach sufficient strength to cause awakening; memory for very vivid dreams is evanescent and tends to fade quickly upon awakening unless special steps are taken to retain it.

We believe that this highly specified definition serves both folk psychology and cognitive neuroscience equally well. It captures what most people mean when they talk about dreams and it lends itself admirably to neurocognitive analysis as we now intend to show.

2.1. Early findings of distinct differences between REM and NREM mentation

Before proceeding, we provide definitions of “REM” and “NREM” sleep for those unfamiliar with these terms. These two clearly distinguishable types of sleep are defined by convention in terms of electrophysiological signs detected with a combination of electroencephalography (EEG), electrocorticography (EOG), and electromyography (EMG) whose measurement is collectively termed “polysomnography” (see Rechtschaffen & Kales 1968). First described by Aserinsky and Kleitmann in 1953, REM sleep (also known as “paradoxical,” “active” or “desynchronized” sleep) is characterized by: (1) wake-like and “activated” (high frequency, low amplitude or “desynchronized”) activity in the EEG; (2) singlets and clusters of rapid eye movements (REMs) in the EOG channel; and (3) very high levels of muscle tone (atonia) in the EMG channel.

Non-REM (NREM) sleep includes all sleep apart from REM sleep and is, by convention, divided into four stages corresponding to progressively dominant (also termed “syncronized”) wave activity. Such low frequency waves dominate the deepest stages of NREM (stages 3 and 4) which are also termed “slow-wave” or “delta” sleep. We refer the reader to Hobson (1989) for a comprehensive primer on sleep physiology.

Aserinsky and Kleitmann’s (1955) report of the correlation of REM sleep with dreaming began an intense period of research on the relation of brain to mind that lasted well into the 1970s. In the early days of the human sleep-dream laboratory era, much attention was paid to the specificity, or lack thereof, of the REM-dream correlation using the newly available sleep laboratory paradigm. Normal subjects, usually students, were awakened from either the REM or NREM phase of sleep in the sleep laboratory and asked to report their recollection of any mental experience preceding the awakening.

During this period, the similarities and differences in mentation between the brain states of waking, NREM, and REM sleep were lavishly documented (e.g., Foulkes 1962; Foulkes & Fletcher 1975; Goodenough et al. 1959; Herman et al. 1978; Monroe et al. 1965; Nielsen 1999; Pivik & Foulkes 1968; Rechtschaffen 1973; Rechtschaffen et al. 1965; Vogel 1991). We have summarized these REM-NREM differences in Table 1. Some of the important conclusions from this cross-sectional normative paradigm are:

1. Following REM sleep awakenings, variously defined dream reports are obtained much more frequently (Aserinsky & Kleitman 1955; 1957; Dement 1955; Dement & Kleitman 1957b; Kales et al. 1967; Wolpert & Trostan 1958) or at least substantially more frequently (Foulkes 1962; Goodenough et al. 1965a; Hobson et al. 1965; Moli-nari & Rechtschaffen 1965; Rechtschaffen et al. 1963; Strova 1965) than after NREM awakenings. For reviews of this early work see Foulkes (1966, 1967), Herman et al. (1978), Nielsen (1999), Pivik (1991), Rechtschaffen (1973), and Snyder (1967). In an extensive review of 29 REM and 33 NREM recall rate studies, Nielsen (1999) found an average REM recall rate of 81.8 (±7.7%) compared to an average rate for NREM of 42.5 (±21.0)%.

2. The frequency of dream recall rapidly drops off as awakenings are delayed beyond the end of a REM period (Dement & Kleitman 1957b; Goodenough et al. 1965b; Wolpert & Trostan 1958), a finding which has recently been both supported (Stickgold et al. 1994a) and challenged (Rosenlicht et al. 1994). Subjects who are able to indicate that they are dreaming during sleep more often indicate dreaming during REM than during NREM (Antrobus et al. 1963).

3. There exists a positive relationship of both report word count and subjectively estimated dream duration with the length of preceding REM sleep (Dement & Kleitman 1957b) and this relationship has been recently replicated for word count (Stickgold et al. 1994a). Moreover, some dream recall rate studies suggest that there exists a positive relationship between the length of time dream events would occupy in real time and the duration of the preceding REM sleep epoch (Dement & Wolpert 1958). Hence, some incorporation studies suggest that there exists a positive relationship between the length of time dream events would occupy in real time and the duration of the preceding REM sleep epoch (Dement & Wolpert 1958).

4. Judges are able to distinguish unaltered REM mentation reports from NREM reports (Monroe et al. 1965), a finding that has been recently replicated (e.g., Herman et al. 1978; Rechtschaffen et al. 1978; Rechtschaffen et al. 1963; see Nielsen, 1999 and Table 1 for summaries). In addition, there is linguistic evidence for greater consolidation of dream elements in REM (Salzarulo & Cipolli 1979).

5. Reports from REM sleep awakenings are typically longer (Antrobus 1983; Casagrande et al. 1990; 1996b; Foulkes & Rechtschaffen 1964; Foulkes & Schmidt 1985; Stickgold et al. 1994a; Waterman et al. 1993), more perceptually vivid, more motorically animated, more emotionally charged, and less related to waking life than NREM reports (Antrobus et al. 1987; Cavallo et al. 1992; Foulkes 1962; Herman et al. 1978; Ogilvie et al. 1982; Rechtschaf- fen et al. 1963; see Nielsen, 1999 and Table 1 for summaries). In addition, there is linguistic evidence for greater consolidation of dream elements in REM (Salzarulo & Cipolli 1979).

6. In contrast to REM reports, NREM reports contain thought-like mentation and representations of current concerns more often than do REM sleep reports (Foulkes 1962; Rechtschaffen et al. 1963).
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**Table 1. Phenomenological differences between REM and NREM dream reports**

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**Table 1. Phenomenological differences between REM and NREM dream reports**
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*Cicogna et al. (1998) actually found significantly more “space-time distortions” and a trend toward more “dimensional distortions” in Stage 2 versus REM reports, while the trend in global bizarreness (implausibility) went in the usual REM > Stage 2 direction. R = REM, N = NREM, spont. = spontaneous awakenings from identified sleep stage.
tistinguishing REM from NREM reports) indicates that phys-
iological sleep phase, REM or NREM, is highly diagnostic of
the presence, amount, and quality of reported sleep men-
tation (p. 456). In discussing the findings of this study,
Rechtschaffen (1975) concluded that “these figures – dis-
 crimination ability ranging from about 70 to 90% – probably rep-
resent one of the best correlations ever discovered between
psychological and physiological variables” (p. 163).

In REM sleep, the integrated conscious experience that is
commonly referred to as dreaming is characterized by the
following remarkably consistent set of features (see Hobson
1988b; 1994 for reviews):

1. Dreams contain formed hallucinatory perceptions,
 espically visual and motoric, but occasionally in any and all
 sensory modalities (Hobson 1988b; McCarley & Hoffmann

2. Dream imagery can change rapidly, and is often
 bizarreness having to do with waking and, when present, often involves
 weak, post hoc, and logically flawed explanations of
 improbable or impossible events and plots (Hobson 1988b,
 1993; Nielsen et al. 1991), which appear to integrate bizarre
 phenomena in everyday life (Dorús et al. 1971; Snyder 1970).

3. Dreams are delusional; we are consistently duped into
 believing that we are awake unless we cultivate lucidity
 (Barrett 1992; Hobson 1979b; Kahan 1994; LaBerge 1986,
 1992; Purcell et al. 1986).

4. Self-reflection in dreams is generally found to be ab-
sent (Rechtschaffen 1975) or greatly reduced (Bradley et al.
 1996). In contrast to waking and, when present, often involves
 weak, post hoc, and logically flawed explanations of
 improbable or impossible events and plots (Hobson 1988b,
 Hobson et al. 1987; Williams et al. 1992). It has been cen-
trally asserted, however, that self-reflection, self control and
 other forms of metacognition are more common in
 dreams than previously thought (Kahan 1994; Kahan &
 LaBerge 1994).

5. Dreams lack orientational stability; persons, times, and
 places are fused, plastic, incongruous and discontinuous
 (Hobson 1988b; 1997b; Hobson & Stick-
gold 1994a; Hobson et al. 1997; Manelak & Hobson 1980a,
 McCarley & Hoffman 1981; Porte & Hobson 1986; Rein-
 sel et al. 1992; Revonsuo & Salinvali 1990; Williams et al.
 1992). It has also been noted that dreams reports contain a
great many images and events which are relatively com-
 monplace in everyday life (Dorús et al. 1971; Snyder 1970).

6. Dreams create story lines to explain and integrate all
 the dream elements in a single confabulatory narrative (Bla-
gold 1994).

7. Dreams show increased incorporation of instinctual
 content that are found relatively rarely in NREM
 dreams (Kahan 1994).

8. Dreams show increased intensification of emotions,
especially fear-anxiety (Domhoff 1996; Merritt et al. 1994,
 Nielsen et al. 1991), which appear to integrate bizarre
 dream features (Merritt et al. 1994), and may even shape
 the narrative process (Seligman & Yellin 1987). Although
 the trend toward a predominance of negative emotion is
 prominent in most studies, other workers have found more
 balanced amounts of positive and negative emotion (for a
 good review, see Schredl & Doll 1998). Emotion also ranks
 as a prominent explanatory focus in functional theories of
 dreaming (e.g., Cartwright et al. 1993a; Greenberg et al.

9. Volitional control is greatly attenuated in dreams
 (Hartmann 1986b). The dreamer rarely considers the pos-
sibility of actually controlling the flow of dream events (Pur-
cell et al. 1986) and, on those infrequent occasions when
 this does occur, the dreamer can only gain lucidity with its
 concomitant control of dream events for a few seconds
 (LaBerge 1990). Unlike the rarer form of dream control of-
 fered by lucidity, however, the more mundane self-control of
 thoughts, feelings and behavior may be fairly common in
 dreams (Kahan 1994).

All of these features can be found in REM dreams, and
 most REM dreams contain a majority of these features.
 Contrastingly, they are found relatively rarely in NREM
 reports (see Nielsen 1999). This is the empirical basis of our
 contention that all of these features will eventually be ex-
 plained in terms of the distinctive physiology of REM
 sleep.

We interpret the foregoing evidence as strongly support-
ing our conclusion that there are clear-cut and objective dif-
f erences among the states of waking, sleeping (NREM) and
 dreaming (REM) at the phenomenological level. We take
 the robust evidence for quantitative differences in amount
 of NREM and REM sleep mentation as convincing proof
 of the validity of an important role for not only activation
 (factor A) but for the two other factors, information source
 (I) and modulation (M) in our AIM model. In addition, we
 take the evidence that state transitions are gradual rather
 than discontinuous and the evidence that correlations be-
 tween phenomenology and physiology are statistical rather
 than absolute as further support of this model.

2.2. Overview of the NREM-REM sleep
 mentation controversy

Although the discovery of REM sleep and its strong corre-
 lation with dreaming (Aserinsky & Kleitman 1953) initially
 led to the strong hypothesis that dreaming occurred only
 during REM sleep (Dement & Kleitman 1957), this hy-
 pothesis was clearly refuted by the discovery that reports of
 dreaming could be elicited from NREM sleep (Foulkes
 1962) and that reports of dream-like mentation could also
 be obtained at sleep onset (Foulkes & Vogel 1965) and even
 from quiet waking (Foulkes & Flencher 1975; Foulkes &
 Scott 1973). Given dreaming’s lack of absolute state speci-
ficity, some investigators sought the psychophysiological
 correlates of specific dream features in the phasic events
 of REM and NREM sleep (Molnari & Foulkes 1969; see
 but consistently positive quantitative relationships were
 found (Kahan et al. 1997; Fivc 1991).

This lack of specificity led at least some investigators ul-
timately to conclude that investigations of REM sleep neu-
rophysiology could provide no data helpful to understand-
ing the genesis of dreaming (e.g., Bosinelli 1995; Foulkes
 view was encouraged by reports suggesting that in fact the
 differences between REM and NREM mentation were not
 nearly as great as had first been reported (e.g., Cavallero
 et al. 1992). In this section, we will present our reasons for
 rejecting these conclusions (see also Nielsen, target article).

How could the firm conclusions of the pioneer era
 (1955–1975) have apparently dissolved in the subsequent
 era of growing controversy (1975–1999)? In this section,
 we will analyze some of the scientific problems that led to
 the decline of the sleep-laboratory paradigm as this psy-

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Hobson et al.: Dreaming and the brain

chrophysiological approach lost much of its initially enthusiastic support. In the subsequent section we will turn our attention to the concomitant development of cellular and molecular neurobiology and show how the findings of basic research provided an alternative approach.

2.2.1. REM sleep dreaming is not qualitatively unique. While dream studies generally agree that REM reports are more frequent, longer, more bizarre, more visual, more anec
dotal and more emotional than NREM reports (Table 1), a pair of papers published in 1983 (Antrobus 1983; Foulkes & Schmidt 1983) led some researchers to the remarkable conclusion that the “characteristics of dreaming are really nothing more than sleep ...” (Foulkes 1995). Because these papers are so central to the REM-NREM dreaming debate, we now offer a detailed review and critique of their findings and interpretations.

At the outset, it is important to point out that neither article actually concluded that REM and NREM dreams are indistinguishable, or even substantially the same, in either their qualitative or their quantitative features. In regard to qualita
tive features, Antrobus (1983) reported that when judges rated 154 REM and NREM reports for their relative “dreaminess” (using scales based on “visual imagery, bizarreness, hallucinatory quality and storylikeness”), they correctly identified 93% of the reports as either REM or NREM, indicating that REM dream reports were much more dreamlike than NREM reports. Similarly, Foulkes and Schmidt (1983, p. 276) concluded that “REM reports are likely to be signifi

cantly more dreamlike qualitatively (e.g., in character density, setting clarity) than typical NREM” reports, even when elicited after only five minutes of stage REM.

In regard to quantitative features, when Foulkes and Schmidt (1983) looked at 160 REM and NREM reports and characterized their lengths by the number of “temporal units” (narrative events), their data showed that temporal sequences (sequential events measured in temporal units −1) were 3.4 times more common in REM reports than in NREM re
ports. In a similar way, Antrobus analyzed total recall frequency (TRF), which reflects the number of words in a report used to describe sleep mentation, and reported that word count significantly distinguished REM from NREM reports (F(1, 95.52) = 95.52). Using the same reports (J. Antrobus, personal communication), we have determined that the REM/NREM effect on bizarreness, visual imagery, and several other dream features in spite of normalization for report length has recently been confirmed (Casagrande et al. 1996b; Faucher et al. 1999; Nielsen 1999; and his target article.) For example, when analysis of covariance (with report length as the covariate) is used to partial out the effect of report length on dream features, REM reports were still judged significantly more visual and bizarre than sleep onset or stage 2 reports (Casagrande et al. 1996b) and more visual than NREM reports (Waterman et al. 1993).

Even when dream features appear to be specifically linked to distinctive REM physiology, interpretations can still be cast toward either camp. Hong et al. (1997) reported an impressive correlation between visual imagery and REM density (r = 0.5), which we would argue as evidence for a dependence of dream imagery on a qualitative feature of REM sleep. But Antrobus et al. (1995) consider this to be another example of the simple dependence of dream content on levels of brain activation, arguing that rapid eye movements are not under strict brainstem cholinergic control, but come increasingly under the control of the frontal eye fields as general cortical activation increases.

Whatever one’s assessment of the similarity versus dif
difference argument, it is clear that none of the analyses in these two papers can distinguish between two competing sequent writers to claim that “when the quantitative char
acteristics of reports from REM and nonREM sleep are adjusted for length there are no differences in the char
acteristics of the reports” (Moffitt 1995, p. 19). The normaliza

tion-for-length technique has been subse
quent

quence rather than using the similarities as a rationale for rejecting the cognitive neuroscience paradigm in favor of a purely cognitive description of mental states. (A simi

lar critique of purely cognitive descriptions can be found in Nielsen 1999, and his target article.)

For example, Antrobus has recently shown that the REM/NREM distinction exerts a far greater effect on bizarreness than dis
r

sor activity (Antrobus et al. 1995). He attributed the observed increase in bizarreness in REM reports to the increased activation seen in that state (Antrobus et al. 1995). It is also noteworthy that purely vi

sual (versus verbal) imagery gave robust REM/NREM dif
f

ferences suggesting a differential sensory activation be
tween the two states (Antrobus et al. 1995). And even when REM and NREM dreams were adjusted for length (a pro

cedure we will shortly argue to be invalid), both Antrobus (1983) and Foulkes and Schmidt (1983) still found significa

d differences (e.g., in character density and setting clar

ity) between the two states. Notably, the persistence of a REM/NREM effect on bizarreness, visual imagery, and several other dream features in spite of normalization for report length has recently been confirmed (Casagrande et al. 1996b; Faucher et al. 1999; Nielsen 1999, and his target article.) For example, when analysis of covariance (with report length as the covariate) is used to partial out the effect of report length on dream features, REM reports were still judged significantly more visual and bizarre than sleep onset or stage 2 reports (Casagrande et al. 1996b) and more visual than NREM reports (Waterman et al. 1993).

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Whatever one’s assessment of the similarity versus dif
difference argument, it is clear that none of the analyses in these two papers can distinguish between two competing
hypotheses: (1) that dream features are dependent on report length; and its simpler converse (2) that report length is dependent on dream features. We now consider the arguments in favor of the second hypothesis, which we have adopted in our own work.

2.2.2. The relationship between dream features and dream report length. That report length depends on dream features was first implied by Hunt (1982) in his analysis of dreaming as fundamentally propositional and preverbal and as such propositional and was then explicitly proposed by Hunt et al. (1993). We agree with their logical assumption that reports with more dream features will require more words to describe them. Furthermore, they suggested that the differences as self-representation, visual hallucination, emotion, narrative plot, and bizarreness will almost certainly be longer than a Total Recall Frequency factor.1

Dreaming (i.e., judges’ idiosyncratic scales for “dreaminess”) picks up better than a Total Recall Frequency factor.1 Thus we agree with Antrobus when he pointed out that there is still a part of the REM/NREM variance that cannot be explained simply in terms of report length (Porte & Hobson 1986). Thus we agree with Antrobus when he pointed out that the relative paucity and superficiality of mnemonic units active during NREM sleep (p. 279) compared to REM sleep. The conclusion of Foulkes and Schmidt (1983) is strikingly similar to our position (p. 279) compared to REM sleep. The conclusion of Foulkes and Schmidt (1983) is strikingly similar to our position compared to REM sleep. The conclusion of Foulkes and Schmidt (1983) is strikingly similar to our position (p. 279) compared to REM sleep.

Similarly, Foulkes and Schmidt (1983) concluded that REM/NREM differences in temporal unit composition (e.g., in character density) persist even after report length is controlled. Residual stage differences following normalization for report length in these as well as additional studies have recently been reviewed by Nielsen (1999).

In the face of such unambiguous statements, it is critical to try to understand why these results have been so frequently and so passionately misinterpreted. In part, the erroneous interpretations were encouraged by the original authors. For example, Antrobus (1983, p. 565) concluded that “although there are slight differences . . . it is quite clear that the global judgment of Dreaming adds little, if anything, to Total Recall [Frequency] with respect to the association with the sleep stages REM and NREM.” Similarly, Foulkes and Schmidt (1983, p. 279) concluded that “most typically observed inter-stage differences in dream reports stem from different lengths rather than the different stages of the reports” (emphasis added). Because they have conflated causality with correlation, both Antrobus and Foulkes and Schmidt unjustifiably assume that most of the differences seen can be explained as correlates of report length. We disagree on the basis of the following studies.

Recent evidence provides strong support for Hunt’s position that report length reflects the number and intensity of a dreamer’s report. Hunt et al. (1993) have argued “it is not the length of the dream that somehow makes bizarreness more likely, but . . . it is more parsimonious to conclude that episodes of bizarreness within the dream are one major determinant of overall dream length . . . making length a necessary consequence of bizarreness and not the other way around” (p. 180). In addition, Hunt et al. (1993) note that Hunt et al.’s (1967) factor analysis of dreams found that bizarreness and report length significantly load on the same factor (and therefore strongly co-vary), “which would make their enforced statistical separation highly questionable” (Hunt et al. 1993, p. 181). In other words, if quantity follows quality and is, in fact, caused by it, then longer reports are needed to describe dreamer’s dreams. On this view, word count is perhaps even a direct measure of dreaminess and might well be taken as such.

To support their position, Hunt et al. (1993) first demonstrated that awake subjects used more words to describe a visually bizarre picture than a mundane picture. They then showed that the bizarre scores correlated positively with the number of words devoted to describing the bizarre episode. They showed that the number of dream features for report length actually eliminated the correlations of bizarreness with non-verbal imagination test scores. Hunt et al. therefore concluded that bizarreness directly determines a major component of report length, and that controlling for total word count introduces an artificial dilution of bizarreness scores.

In summary, a critical review of the papers of Antrobus (1983) and Foulkes and Schmidt (1983) reveals that these papers report significant quantitative differences in the features of REM and NREM dreams. Both papers also find features such as dreaminess or character density to differ significantly between REM and NREM dreams even when report length is unjustifiably normalized. Neither study reports data that argue against the contention that the strong correlation between report length and dream features occurs because reports with more dream features require more words to describe them (Hunt et al. 1993; Nielsen 1999). We urge the collection of additional data to further clarify the nature of these REM/NREM differences. Such data should include ample numbers of reports, collected longitudinally in naturalistic settings, which are obtained from home awakenings psychologically monitored with unobtrusive devices such as the Nightcap (e.g., Rowley et al. 1998).

2.3. Methodological considerations in the study of dreaming

The study of mental states is replete with methodological shortcomings and conceptual confusions. We believe that...
some of these areas of confusion can be clarified in a manner that could increase consensus. In what follows, we address five methodological issues to point out the nature of the problems, offer clarifications, and suggest possible resolutions.

2.3.1. The reduction of psychological states to narrative reports.

The most profound problem in studying conscious states is the necessity of reliance on verbal reports. This method is problematic because these accounts are just reports, not the subject’s experience of the states themselves. This reduction of conscious experience to prose has at least three important ramifications.

1. The nature of the experience including pseudosensory perceptual, emotional, and notoric dimensions is reduced to only one mode, that of narration. (To emphasize this point, we merely point out that if a picture is worth a thousand words, we certainly are not getting the whole picture with a seven-word report?)

2. The narratives describing sleep state mentation are all generated during the waking state and are thus likely to mix, if not contaminate, the dreaming phenomenology with the phenomenology of waking (for a discussion of this point relative to dream meaning, see Hunt 1989, p. 9). (3) Analysis of narrative dream reports is extremely limited in its power to recreate or model the true underlying mechanism of dream production at any fundamental, neuronal level of explanation (be it cognitive-mnemonic, linguistic or neuropsychological) because narratives about experience display a high degree of what Pylyshyn (1990) terms “cognitive penetrability.”

Pylyshyn’s point can be applied to dreaming as follows. The behavior of the dream production system is highly malleable using the same cognitive processes invoked to explain its operation in the dreamless state. (see Pylyshyn 1989). For example, in the case of the dreamer’s goals, the frequency of overall dream recall as well as lucidity can be greatly increased by auto-suggestion techniques (Pylyshyn 1989). For example, in the case of the dreamer's goals, the frequency of overall dream recall as well as lucidity can be greatly increased by auto-suggestion techniques (Pylyshyn 1989). For example, in the case of the dreamer’s goals, the frequency of overall dream recall as well as lucidity can be greatly increased by auto-suggestion techniques (Pylyshyn 1989). For example, in the case of the dreamer’s goals, the frequency of overall dream recall as well as lucidity can be greatly increased by auto-suggestion techniques (Pylyshyn 1989). For example, in the case of the dreamer’s goals, the frequency of overall dream recall as well as lucidity can be greatly increased by auto-suggestion techniques (Pylyshyn 1989). For example, in the case of the dreamer’s goals, the frequency of overall dream recall as well as lucidity can be greatly increased by auto-suggestion techniques (Pylyshyn 1989).