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# Lucid Dreaming as Metacognition: Implications for Cognitive Science

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Evidence of reflective awareness and metacognitive monitoring during REM sleep dreaming poses a significant challenge to the commonly held view of dream cognition as necessarily deficient relative to waking cognition. To date, dream metacognition has not received the theoretical or experimental attention it deserves. As a result, discussions of dream cognition have been underrepresented in theoretical accounts of consciousness. This paper argues for using a converging measures approach to investigate the range and limits of cognition and metacognition across the sleep–wakefulness cycle. The paradigm developed by LaBerge and his colleagues to study "lucid-control" dreaming offers one such framework for relating phenomenological, cognitive, and physiological measures. In a lucid-control dream, the dreamer is both aware that the experimental context is a dream (lucidity) and has the ability to intentionally regulate aspects of the dream (control). Subjects can make patterns of deliberate eye movements to signal from the dream and thus index significant events such as the time of lucidity onset and the completion of previously agreed-upon tasks in the dream. Lucid dreaming and other examples of reflective awareness during dreaming have important implications for models of human cognition. The existence of these phenomena raises fundamental questions about current assumptions regarding "state" constraints on consciousness and cognition (i.e., the notion that dreaming involves exclusively nonconscious processing while waking involves conscious processing). 

Although people spend a third of their lives asleep, virtually all current models of human cognition are built upon evidence derived exclusively from the waking state. Discussions of dream cognition are rarely included in recent texts of cognitive psychology or cognitive neuropsychology. This paper describes some reasons why evidence from studies of dream cognition has not been adequately considered by cognitive scientists and why it should be integrated into comprehensive models of human cognitive processes. The phenomenon of lucid-control dreaming highlights the potential for reflective consciousness during dreaming, suggesting that evidence of sleep metacognition must be considered when developing models of human cognition. Furthermore, lucid-control dreams offer an important methodological opportunity for mapping the psychophysiological, cognitive, and phenomenological features of dreaming and waking consciousness.

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## DREAM COGNITION AS TRADITIONALLY VIEWED BY COGNITIVE AND DREAM PSYCHOLOGY

The varieties of dream cognition have not yet been incorporated into the empirical foundation underlying current theories of human cognition, despite a large body of research on the nature, forms, and accomplishments of cognition during sleep (Cartwright, 1981; Ellman & Antrobus, 1991; Foulkes, 1985; Gackenbach & LaBerge, 1988; Globus, 1987; Hobson, 1988; Hunt, 1989). In David Foulkes' (1991) words, there is "the widespread perception that dream research is peripheral to the major concerns of today's cognitive science" (p. 246). Haskell (1986) discusses several factors which have contributed to this attitude, notably the difficulties dream psychology has encountered in extricating itself from its unscientific origins, the long-held view of dreaming as pathological and fundamentally different from waking cognition, and the tendency to regard dream data as not amenable to information processing models of cognition. The field of dream psychology is itself divided on many of these issues, two of which are addressed in the current paper: the level of analysis appropriate to dreaming and the theoretical importance of lucid dreaming.

## LEVELS OF ANALYSIS

A major dispute within dream psychology concerns the appropriate level of analysis for investigating and explaining dreaming: idiographic, phenomenological, psychological, or physiological (e.g., Foulkes, 1985; Haskell, 1986). Hobson (1988) captures some of this tension:

> In the controversies that divide the field of sleep and dream research even after thirty years of intense scientific effort, psychologists and psychiatrists accuse physiologists of being reductionistic, while physiologists accuse psychologists of being dualistic and mystical. (p. 299)

Research on dreaming and consciousness has tended to rely on introspective reports. As Hobson's comments indicate, this phenomenological approach has been denounced by experimentalists (e.g., Nisbett & Wilson, 1977). The bias against narrative dream reports is curious considering the extent to which contemporary studies of cognition and perception rely upon subjects' reports of conscious experience (Baars, 1988; Ericsson & Simon, 1980; Lieberman, 1979). Even recent research in waking metacognition (Nelson, 1991) and consciousness (Baars, 1988; Pekala, 1991) has successfully employed introspective techniques. True, the study of sleep cognition does not generally permit the same systematic control of the stimulus conditions as is heralded in studies of waking cognition. This may partially explain the lack of attention paid to dream research by cognitive scientists. Ignoring dream data would be more difficult if the reliability of subjective reports were better established by providing converging cognitive and physiological measures (e.g., Stoyva & Kamiya, 1968). For example, Martha Farah has utilized a cognitive–neuropsychological approach to investigate whether common representations underlie visual imagery and visual perception. Farah correlated cognitive measures of tasks performed under imaginal and per-

ceptual conditions with measures of psychophysiology (Farah, 1988a), cerebral blood flow (Farah, 1989), and neuropsychological impairment (Farah, 1988b). Her findings provide strong evidence that imagery and perception activate common brain systems (see also Finke, 1980).

A similar cognitive–neuropsychological approach would be useful for relating individual reports of subjective experiences with the psychophysiological measures used to define rapid-eye movement sleep (REM), non-REM sleep, and other states of consciousness (e.g., Globus, Maxwell, & Savodnik, 1976; Laughlin, McManus & d'Aquili, 1990). In a later section of this article, we describe the potential value of a converging measures approach for investigating dream metacognition.

## RETHINKING THE 'DEFICIENCY' VIEW OF NOCTURNAL COGNITION

Many cognitive scientists seem to believe that the cognitive activities of dreaming are deficient relative to waking cognition (e.g., Hobson, 1988; Koukkou & Lehmann, 1983; Kunzendorf, 1987–1988; Rechtschaffen, 1978). Thus, research on dream cognition is thought to contribute little to our understanding of waking mentation. "Deficiency views" of dreaming echo Freud's claim that dreaming and waking are discontinuous: that dreaming is characterized by primary process thinking, which involves magical thinking, symbolic displacement, and condensation, while waking mentation is characterized by secondary processes such as adult logic and rationality (Freud, 1953) (see also Purcell, Moffitt, & Hoffmann, 1993, for a recent discussion of deficiency views of dreaming).

One problem with deficiency views of dreaming is that they are based on a stereotypical view of waking cognition as characterized by a high degree of reflective awareness (e.g., Freud, 1953; Rechtschaffen, 1978). "Reflective awareness" is awareness that is focused on subjective experience—awareness of ongoing thoughts, feelings, or actions (cf., James, 1890; see also Globus, 1987, Chap. 2; Pollio, 1990). "On reflecting, my reflection bears upon an unreflective experience as lived and it is just this unreflective experience of a world which is at times indistinguishable across waking and dreaming" (Globus, 1987, p. 68). In fact, the occurrence of reflective awareness in waking cognition has recently been shown to vary much more than previously assumed (e.g., Foulkes & Fleisher, 1975; Langer, 1989; Purcell, Mullington, Moffitt, Hoffmann, and Pigeau, 1986). Furthermore, the frequency of reflective awareness in dream cognition has probably been underestimated because the subjects in most laboratory studies of dreaming are college students unpracticed at recalling and reporting dream content. For example, Rechtschaffen's (1978) argument for the "nonreflectiveness" of dreams is based on his own dream experience and the study of dream reports from just four undergraduate students (see pp. 98–100). Rechtschaffen argues that, during dreaming, there is a suspension of ego control that results in the inherent nonreflectiveness of dreaming consciousness, including the typical absence of lucidity (awareness of dreaming). Rechtschaffen also writes of dreams as isolated from waking cognitive systems, presleep and external stimuli, and the organismic condition of the dreamer. In a similar vein, Hobson (1988) claims:

"Both orientation in the world and self-critical perspective are lost [due to the] loss of aminergic modulation" associated with REM dreaming (p. 210). However, findings from studies of reflective awareness during dreaming indicate that differences between waking and dream cognition have been exaggerated and that the quality of the cognitive activity in dreaming has been underestimated. For example, Snyder (1970), in an extensive study of REM dreams, noted a degree of ongoing reflectiveness that was similar to waking cognition.

A recent study provided evidence suggesting that typical dreaming and waking experiences do not differ greatly in the amount and kind of metacognition they contain (LaBerge, Levitan, & Kahan, 1993). The subjects in this study were either undergraduates or members of a high-dream-interest group ($N$ = 167). Each subject contributed one waking and one dreaming sample. For the recent dream experience sample the subjects described in writing, in as much detail as possible, the last 15 min of a dream from which they had just awakened. Recent waking experience was sampled in a similar way by having the subjects record, at an aribitrary time of day, as much detail as possible about their experiences during the previous 15 min of waking. After recording each sample, the subjects answered a series of questions about the experiences they had described, assessing whether they included any of a number of cognitive and other activities. These were: deliberate choice between alternatives, reflection, sudden distraction of attention, focused intention, self-consciousness, emotion, difficulty with achieving goals, task-irrelevant thought, and unusual actions or experiences. The questionnaire requested that the subjects provide an example of each activity they reported recalling, for verification.

Paired $t$ tests revealed differences between waking and dreaming samples in deliberate choice (48.5% of subjects reported it from dreaming vs 74.3% from waking, $p < .001$), public self-consciousness (41.3% of subjects reported it from dreaming vs 29.9% from waking, $p < .05$), and emotion (86.2% reported it from dreaming vs 74.3% from waking, $p < .01$). However, it is notable that significant differences between dreaming and waking were not evident for other cognitive activities and that none of the measured cognitive functions were absent or rare in dreams.

## REFLECTIVE AWARENESS IN DREAMING

As discussed above, it is commonly assumed that reflective awareness occurs only during waking. However, consider the following dream report:

> I'm in a crowded library walking towards a large desk. The heels of my shoes make a clicking sound on the stone floor that echoes through the room. I'm thinking to myself 'I hope this noise doesn't distract the people around me' (Kahan, 1990).

In phenomenological terms (e.g., Merleau-Ponty, 1962), this dreamer reported participating in the dream (unreflective experience) and simultaneously thinking about the experience (reflective experience). Using slightly different terminology to describe a concept similar to reflective awareness, Alan Moffitt and his colleagues use the term "self-reflectiveness" to describe the concurrent examination

of one's thoughts, feelings, and behaviors. Moffitt's concept of self-reflectiveness includes the notion of a set of "self-organizing and self-regulating processes [that] occur within dreaming as well as waking" (Moffitt, Hoffmann, Mullington, Purcell, Pigeau, & Wells, 1988, p. 431). Globus (1987) makes the critical point that, regardless of the terminology used, reflection during dreaming involves an awareness of the conditions within the dream: "Dream reflection takes place within the dream horizon" (p. 82). The awareness of lying in bed asleep is not a criterion for dream self-reflectiveness. Given these minimal criteria for identifying reflective awareness in dreams, the question remains of how frequently it occurs and how its manifestations compare to waking state reflective awareness. In a laboratory study of dream self-reflectiveness, Purcell, Mullington, Moffitt, Hoffmann, and Pigeau (1986; experiment 1) rated the overall level of self-reflectiveness present in subjects' narrative dream reports using a scale based on Rossi's (1972) theoretical self-reflectiveness continuum. Reports obtained following awakenings from REM sleep evidenced a higher level of self-reflectiveness than those from sleep stages 2 and 4, which did not differ. These investigators also compared the effectiveness of four techniques for increasing the level of dream self-reflectiveness over a 3-week period. These four procedures employed different strategies for exercising reflective cognition. Members of all groups recorded narrative dream reports which the experimenters analyzed for level of self-reflectiveness. A baseline group did not practice any reflection exercises. Subjects in the mnemonic group were trained to regularly question their current state of awareness (whether awake or asleep), and, when awake, to set an intention to become lucid while dreaming the following night. Dream self-reflectiveness and the number of lucid dreams reported were significantly higher for the "mnemonic" group relative to the other conditions. Unfortunately, Moffitt and colleagues provide no direct systematic comparisons of waking versus dreaming cognition. Therefore, no conclusions are possible regarding similarities and differences between levels of self-reflectiveness in waking and dreaming. Nonetheless, their findings indicate that self-reflectiveness occurs during the dreams of REM sleep and that the practice of certain exercises can increase the frequency and level of self-reflectiveness in dreams.

Bradley, Hollifield, and Foulkes (1992; study 1) also report on the frequency of reflection during REM dreaming from a study with 10 subjects. The authors' definition of reflection or "reflective self-consciousness" (after Farthing, 1992) during dreaming was restricted to those instances in which subjects gave "reports of having reflected, during the dream, on the plausibility of the events experienced" (p. 162). Eight of the 10 subjects reported at least one instance of dream reflection, and the "median incidence per subject of dreams with at least one instance of reflection was 33%" (p. 162). Subjects were also asked to judge whether they *would* have reflected on events described in the dream report had those events occurred during waking. This question was included to provide a comparison across waking and dreaming of the incidence of this aspect of reflective awareness (noticing anomalies). However, this is not a valid comparison of reflection in waking and dreaming because the subjects were merely speculating about what they believed they would have noticed in waking. Additional and

more controlled research of reflective cognition across waking and dreaming is clearly needed. It is important to assess the frequency and variety of reflective activities in dreaming *relative to* waking cognition.

## LUCID DREAMING AS METACOGNITION

Dreams in which the dreamer becomes aware of dreaming while continuing to dream are known as "lucid dreams" (the term derives from van Eeden, 1913). As has been discussed elsewhere (LaBerge, 1980a, 1985; Moffitt et al., 1988; Purcell et al., 1986), attaining lucidity in dreams requires evaluation of experiences as they happen in the dream, a process termed "metacognitive monitoring" in the cognitive psychology literature (e.g., Flavell, 1979; Nelson & Narens, 1990). Metacognition includes, but is not limited to, the monitoring of one's thought processes and the deliberate direction of them (Nelson & Narens, 1990). For example, "I noticed that I was mentally criticizing my tennis serve before I initiated it, so I decided to just 'thank' my internal critic, ignore what it said, and direct my attention back to preparing to serve" (Kahan, 1992). As with waking metacognitive monitoring, dream lucidity is often accompanied by the ability to deliberately affect the nature of the experience by choosing between alternative courses of action. In the dream state, such choices can take a variety of forms, from deciding to move in a particular direction within the hallucinated dream environment to thinking about events with a different attitude, to attempting to alter the imagery by willing it to change. The dreamer's decisions affect the subsequent imagery and course of events (LaBerge, 1985). For example,

> I was flying over a beautiful place in bright sunshine with green lawns and pretty buildings. I had the thought that if this were a lucid dream I could try out various sensory experiences like we were discussing for the Waking and Dreaming experiment. Then I realized that I was definitely dreaming and repeated to myself, 'This is a lucid dream,' several times, as I continued to fly. There were some white flowers on a tree and I smelled them—they smelled like the flowers that bees like, but not very strong. I flew up to the roof of a house, looking for any sensations. I pinched my hand, and felt it, but rather dull, no pain. On the roof, I happily found a box of big red chili peppers—something to taste! I bit one and it tasted hot and sour. . ." (Levitan, 1993) (see also LaBerge, 1985, pp. 106–108).

In reports of their lucid dreams, people describe being able at times to freely remember the circumstances of waking life, to think clearly, and to act deliberately upon reflection, all while experiencing a dream world that seems vividly real (e.g., Green, 1968; LaBerge, 1985). These accounts sharply contrast with the common characterization of dreams as typically lacking any reflective awareness (e.g., Rechtschaffen, 1978), or true volition (e.g., Freud, 1953; Mamelak & Hobson, 1989). For example, the following lucid-control dream was reported by van Eeden:

> I dreamt that I was lying in the garden before the windows of my study and saw the eyes of my dog through the glass pane. I was lying on my chest and observing the dog very keenly. At the same time, however, I knew with perfect certainty that I was dreaming and lying on my back in my bed. And then I resolved to wake up slowly and carefully and observe how the sensations of lying on my chest would change into the sensations of lying

> on my back. And so I did, slowly and deliberately, and the transition—which I have since undergone many times—is most wonderful" (1913).

LaBerge (1985) also cites numerous lucid-control dreams, including the following from the early 20th century dreamer Moers-Messmer:

> From the top of a rather low and unfamiliar hill, I look out across a wide plain towards the horizon. It crosses my mind that I have no idea what time of year it is. I check the sun's position. It appears almost straight above me with its usual brightness. This is surprising, as it occurs to me that it is now autumn, and the sun was much lower only a short time ago. I think it over: The sun is now perpendicular to the equator, so here it has to appear at an angle of approximately 45 degrees. So if my own shadow does not correspond to my own height, I must be dreaming. I examine it: It is about 30 centimeters long. It takes considerable effort for me to believe this almost blindingly bright landscape and all of its features to be only an illusion. (pp. 38–39)

These examples illustrate the highly rational, reflective thinking and the intentional action often possible during lucid-control dreams (see also Hunt, 1989; LaBerge & Rheingold, 1990). In lucid-control dreaming, dreamers are explicitly aware that their current experience is occurring within the global context of a dream, and they possess the ability to intentionally regulate aspects of the dream experience. The explicit awareness of "state" holds the potential to change the experience in many ways, depending upon the clarity of the dreamer's subsequent reasoning about the state. For example, after having realized that an experience is occurring in the context of a dream, an individual may intend to carry out some specific task, as in the previously cited lucid-control dreams. Furthermore, the dreamer may reason that because the experience is a dream, the consequences of behavior are likely to differ from those expected in the waking state (e.g., "Since this is a dream, I can jump off the balcony and not get hurt"). As Purcell and her colleagues note: "The recognition of state can create a complex reorganization of consciousness within the dream in terms of maintaining the balance between observing and participating within the apparently paradoxical context of being both awake and dreaming" (1986; p. 424). Whether people are actually able to fully regulate their behavior in dreams may depend, to some extent, on the degree of lucidity (understanding of the ramifications of being in a dream rather than awake) they maintain. In dreams, control appears to be highly correlated with, but not an inevitable consequence of, lucidity (Alexander, 1988; Hunt, 1989; Gackenbach, 1991; Kahan, in press). Thus, important features of lucid-control dreaming include metacognitive monitoring leading to explicit awareness of being in the dream state and the ability to intentionally regulate the course of the experience (dream behavior and imagery) based on this knowledge. Such executive functions are considered high level cognitive activities during waking (e.g., Baddeley, 1986). Metacognitive experiences observed during *dreaming* would seem to be of considerable theoretical import for general cognitive models, but these examples of high order cognition during sleep have been underrepresented in recent treatises on consciousness (e.g., Baars, 1988; Dennett, 1991; Milner & Rugg, 1992; Wallace & Fisher, 1991). In addition, dream metacognition has yet to receive the experimental attention it deserves. A complicating factor is that dream psychology itself is divided on the question of whether lucid-control

dreaming is an aberration of normal dreaming or represents one end of a continuum of cognitive abilities available in the dream state. In the first case, lucid dreaming would not be representative of normal human cognition, while from the latter perspective, lucid dreaming would be a significant capability within the range of human cognitive endowments. For example, some dream theorists take the position that lucid dreaming is not really relevant to dream theory because it occurs too infrequently, is a difficult skill to develop, or is the product of personality type or demand characteristics (e.g., Foulkes, 1991; Weinstein, Schwartz, & Ellman, 1988). The concept of "conscious dreaming" is also antithetical to psychodynamic models of dreaming (e.g., Freud, 1953) as well as to recent models of consciousness and cognition which "contrast" the assumed nonconscious, unmonitored processing involved in dream cognition with the assumed conscious, monitored processing involved in waking cognition (see, especially, Haskell, 1986; Kunzendorf, 1987–1988).

## EMPIRICAL RESEARCH ON LUCID DREAMING

The concept of "self-conscious sleep" appears so paradoxical to certain ways of thinking that some philosophers have considered lucid dreams impossible and even absurd (e.g., Malcolm, 1959). In the absence of empirical evidence bearing on the question, many sleep researchers apparently agreed with Hartmann's initial suggestion that lucid dreams were "not typical parts of dreaming thought, but rather brief arousals" (Hartmann, 1975, p. 74; Berger, 1977). Schwartz and Lefebvre (1973) noted that frequent transitory arousals were common during REM sleep and speculated that these "micro-awakenings" might provide the physiological basis for lucid dream reports. In spite of the fact that no one had provided evidence for this mechanism, this speculation seems to have been accepted by many prominent sleep researchers as the "explanation" for lucid dreaming (cf. Foulkes, 1974) until contradictory evidence emerged in the early 1980s. In the late 1970s, experimental evidence began to appear indicating that lucid dreams occur during REM sleep. Based on standard sleep recordings of two subjects who reported a total of three lucid dreams upon awakening from REM periods, Ogilvie, Hunt, Sawicki, and McGowan (1978) cautiously concluded that ". . . it may be that lucid dreams begin in REM." However, the evidence was not sufficient to conclude that the reported lucid dreams had in fact occurred during the REM sleep immediately preceding the awakenings in which the reports were collected.

## VERIFYING LUCID DREAMING

To determine that lucid dreams occur in unambiguous REM sleep a measurable physiological indicator was needed—a deliberate behavioral response made by a dreaming subject marking the onset of lucidity in a dream. LaBerge (1980a) and colleagues met this challenge by instructing subjects to signal the onset of lucid dreams with preselected dream actions that would be observable on a polygraph recording (i.e., eye movements or fist clenches). Using this approach, LaBerge, Nagel, Dement, and Zarcone (1981) demonstrated the occurrence of lucid dream-

ing during unambiguous REM sleep for five subjects. LaBerge et al. concluded that lucid dreaming usually (although perhaps not exclusively) occurs during REM sleep (see also LaBerge, Levitan, & Dement, 1986) without the presence of micro-awakenings. This conclusion is supported by research carried out in several other laboratories (Dane, 1984; Fenwick, Schatzman, Worsley, Adams, Stone, & Baker, 1984; Hearne, 1978; Ogilvie, Hunt, Kushniruk, & Newman, 1983) (see LaBerge, 1988, for an extensive discussion of this research).

LaBerge and colleagues have also discovered that lucid dreams are generally initiated during phasic REM: periods of elevated central and autonomic nervous system activity as measured by decreased finger pulse amplitude, increased respiration rate and irregularity, and increased eye-movement activity relative to the levels of average REM sleep (Brylowski, Levitan, & LaBerge, 1989; LaBerge, Levitan, & Dement, 1986). These findings indicate that dream lucidity begins during periods of relatively high central nervous system (CNS) activation. One possible interpretation is that sufficient CNS activation is necessary before lucidity can be attained (LaBerge, 1988). This accords with Antrobus's (1986) adaptation of Anderson's (1983) ACT* model of cognition to dreaming, which postulates that working memory capacity is proportional to the theoretical construct, "cognitive activation," which in turn is proportional to cortical activation. Becoming lucid may require a capacity of working memory sufficient to access the presleep intention or to support the high level self-reflective processes necessary to recognize the dream state. In sleep, this degree of cortical and cognitive activation is apparently normally available only during phasic REM. Another potential explanation for the elevated brain activation associated with lucidity onset is that the processes of self-organization and self-regulation associated with the attainment of self-reflective consciousness during dreaming may themselves induce changes in brain state (cf. Moffitt et al., 1988).

Although many cognitive psychologists prefer to operate on a purely psychological level of analysis, models of human cognition must be consistent with the emerging understanding of the functional organization of the brain and underlying neural mechanisms (e.g., Schacter, 1990; Squire, 1987). In light of recent research indicating that systematic variations in cognitive and phenomenal experience correlate reliably with neuropsychological and electrophysiological measures (e.g., Farah, 1985, 1988a, 1988b), the application of a similar converging measures approach to comparisons of waking and dream cognition is likely to result in significant findings applicable in a wide range of fields concerned with brain and mind functions (see also Antrobus, 1986, 1990, 1991). The next section makes a case for reconceptualizing the psychophysiological approach to dream cognition and for extending a paradigm developed by LaBerge and his colleagues to the investigation of psychophysiological and cognitive rhythmicities over the sleep–wakefulness cycle.

## THE PSYCHOPHYSIOLOGICAL APPROACH REVISITED

The psychophysiological approach, in which reports of psychological events are correlated with concurrent physiological measures, was responsible for the flourishing of dream research in the decades following the discovery of REM

sleep (Aserinsky & Kleitman, 1953) and the subsequent association of REM sleep with dreaming (Dement & Kleitman, 1957). However, this approach and the attempt to explain dreaming via REM mechanisms lost favor when the proposed isomorphism between REM sleep and dreaming was not fully supported (Foulkes, 1985, 1990; Hunt, 1989). Foulkes has written, "Moreover, although there seems to be more dreaming in REM sleep than in non-REM sleep, recent evidence (Antrobus, 1983; Foulkes & Schmidt, 1983) suggests that it is not a different kind of dreaming" (Foulkes, 1990, p. 41). Nonetheless, numerous researchers, including Hobson, have persisted in their attempts to formulate theories of dreaming that explain the formal dimensions of dreams in terms of neurobiological events specific to REM sleep (e.g., Crick & Mitchison, 1983; Hobson & McCarley, 1977; Hobson, 1988; Winson, 1990). The traditional psychophysiological approach has not been of much value for investigating hypothesized associations between physiology and dream phenomenology because of the difficulty of predicting what subjects will dream about and the difficulty of making precise time correlations between dreamed experiences and physiological events. As Foulkes (1990) points out, "[Without] the possibility of demonstrating such point-for-point, brain-event-to-mind-event correspondences, it is difficult to imagine how one could ever determine the relative plausibility of different reductionist theories" (p. 41). Indeed, Foulkes has called for abandoning the psychophysiological method in favor of a purely mentalistic approach. This call may be justified in reference to the psychophysiological approach as traditionally practiced, using reports from nonlucid dreamers. However, the use of practiced lucid dreamers able to carry out specific experimental tasks in dreams overcomes the basic difficulty of the old methodology and could revitalize the psychophysiological approach to dream research by investigating precisely the brain-event-to-mind-event correspondences Foulkes demands.

## PSYCHOPHYSIOLOGICAL STUDIES OF LUCID-CONTROL DREAMS

The fact that lucid dreamers can remember to perform predetermined actions and signal to the laboratory suggested to LaBerge (1980a) a new paradigm for psychophysiological dream research. In lucid dreams, subjects could use eye movement signals to mark strategic points during the experience such as the initiation of lucidity and the completion of preagreed upon tasks such as singing, counting, rapid breathing, or sexual activity (LaBerge, 1985).

Figure 1 illustrates what these eye movement signals look like on a polygraph record in the context of a study requiring the subject to estimate a 10-s interval during waking (top) and lucid REM sleep (bottom) (LaBerge, 1985). "REM" indicates right eye movement and "LEM" indicates left eye movement.

This strategy permits precise correlations between dreamers' phenomenological reports and physiological measures obtained before, during, and after lucid episodes. Such comparisons are not possible with nonlucid dreaming. While this paradigm will not yield a physiological explanation for dreaming any more than an understanding of psychophysiological correlates "explains" waking mental imagery (e.g., Farah, 1988a, 1988b), it offers the potential for a fuller understanding of the physiological correlates of waking and sleeping cognition. Through

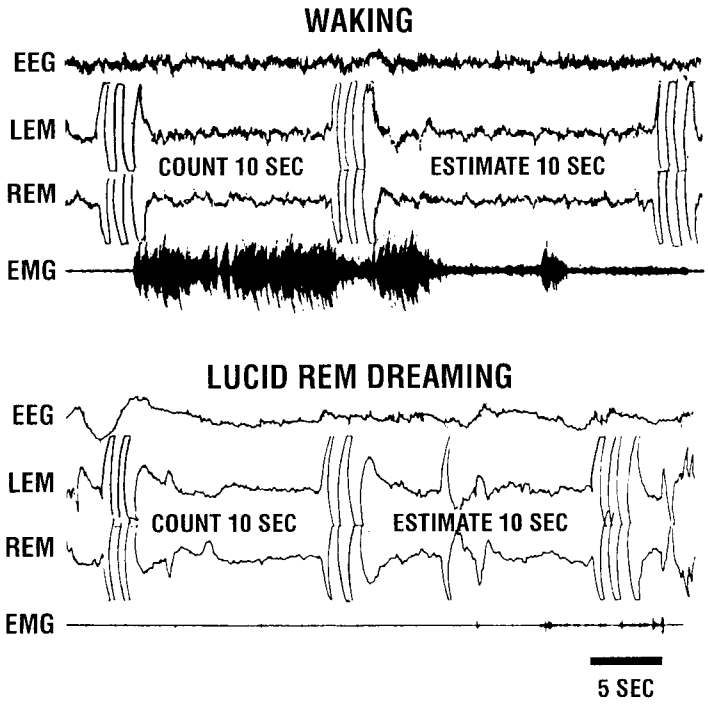


FIG. 1. Time estimates during waking and REM lucid dreaming. While awake (top) the subject signaled with eye movements, estimated 10 s by counting, signaled again, estimated 10 s without counting, and signaled a third time. (Bottom) The subject carrying out the same task in lucid REM sleep. The time estimates are very similar in both states (LaBerge, 1993).

their laboratory research conducted with lucid-control dreamers capable of signaling from the dream state, LaBerge and colleagues have demonstrated that actions performed in lucid-control dreams are associated with physiological changes more typical of the performance of the same actions in a waking state than of imagination of the actions (see especially LaBerge, 1985, pp. 78–99; 1988). Evidence of parallel physiological changes for actions performed under waking and REM lucid-control dreaming conditions has been obtained for singing and counting (LaBerge & Dement, 1982a), time estimation (LaBerge, 1980a, 1985), direction of eye gaze shifts (LaBerge, Nagel, Dement, & Zarcone, 1981a; LaBerge, Nagel, Taylor, Dement, & Zarcone, 1981b), voluntary control of respiration (LaBerge & Dement, 1982b), and sexual activity (LaBerge, Greenleaf, and Kedzierski, 1983). Each of these studies found dreamed actions to produce physiological effects very similar to those produced by corresponding waking actions. For example, the data reported by LaBerge and his colleagues revealed a direct and reliable relationship between gaze shift reported in lucid dreams and the direction of polygraphically recorded eye movements (LaBerge et al., 1981a, 1981b). When the subject reported looking left–right–left–right in the dream, the respective polygraph showed exactly that pattern of eye movement. The results obtained

for lucid-control dreams are much stronger than the generally weak correlations obtained in previous tests of the hypothesis that the eye movements of REM sleep correspond to the dreamer's gaze within the hallucinated dream scene (see also Dane, 1984; Fenwick et al., 1984; Hearne, 1978; Ogilvie, Hunt, Tyson, Lucescu, & Jeakins, 1982). Previous investigations relied on the chance occurrence of highly recognizable eye-movement patterns that were readily matchable to subjects' reported dream activities (e.g., Roffwarg, Dement, Muzio, & Fisher, 1962). The lucid-control dream findings demonstrate that eye movements made intentionally within a dream are accompanied by corresponding actual eye movements. This is not to imply that all the eye movements of REM sleep reflect scanning within a dream.

## EXTENDING THE PSYCHOPHYSIOLOGICAL APPROACH

The paradigm just described represents a potentially important methodological approach to mapping the psychophysiological features of dreaming and waking consciousness (Gackenbach & LaBerge, 1988; LaBerge, 1990). For example, comparisons of the psychophysiology of lucid-control dreaming and intentionally directed waking fantasy may help determine whether the central nervous system activation associated with lucid-control dreaming is also characteristic of other types of imaginal experience involving heightened reflective awareness and volitional control (see also Antrobus, 1991).

## IMPLICATIONS OF LUCID DREAMING FOR COGNITIVE SCIENCE: A CHALLENGE TO DEFICIENCY VIEWS OF SLEEP COGNITION

Lucid dreaming reveals high order cognitive skills during sleep—skills previously assumed to be unique to waking cognition. In fact, lucid dreaming and other examples of reflective awareness during sleep pose a significant challenge to the "deficiency" views of dreaming found in cognitive science and sleep research. For example, the existence of lucid dreaming directly contradicts Kunzendorf's (1987–1988) claim that self-consciousness is a defining characteristic of waking but not dreaming experience and Hobson's (1988) assumption that self-reference and a self-critical perspective are lost during dreaming.

The existence of lucid dreaming also raises fundamental questions about the supposed "state" constraints on consciousness and cognition and the relationship among attention, self-consciousness, and behavioral self-regulation. For example, reports of lucid-control dreams reveal the capacity for dual levels of awareness (participant/observer) during sleep coupled with the ability to intentionally regulate aspects of the dream experience, indicating that the monitoring and regulation of internal states are not unique to waking experience. The following lucid-control dream report illustrates a sophisticated interplay of self-reflectiveness, memory, intentionality, and behavior regulation:

> I am with my mother and sister. I look out a window and see a man open fire on another man. The man slowly falls backwards. I remark, 'I've never seen someone shot before.' Then I add, 'Except in dreams.' Saying that, I realize I am dreaming. I add, 'But this is a dream,' relieved that none of this is really happening. I will myself fully lucid and leave the

> cafe. I intend to fly so I won't be distracted by the family members. I lift off and then look down at the city from above. Soon I turn on my back and soar higher. The scene is blotted out. I turn back on my stomach but still can't see the ground. I say 'I want to see the objects below me.' Soon I land. I am standing on a sidewalk in a city. I recall a waking intent for the next lucid dream—to call a particular type of cat to me—the sort of cat I would want to have if cats were allowed in my building—a black tortie cat with cream and orange markings. Already, I see a small black and white cat on some stone steps. I call, 'Here, kitty,' hoping to call the particular cat I was imagining to me. Soon I am surrounded by 7 or 8 cats, including the black and white cat. I see a tortie cat that is close but not exactly like my ideal and pick it up out of the group." (Sacksteder, 1993)

This example also demonstrates that the intention to control an aspect of the dream experience—such as intending to attract a particular type of cat—may be followed by an experiential variation of the intended behavior, not by an entirely predictable sequence of dream events.

## METHODOLOGICAL IMPLICATIONS

Studies of waking cognition favor experimental investigations of how externally presented stimuli influence human information processing (pattern recognition, attention, memory, reasoning, and decision making, etc). Cognitive psychologists also have generally presented waking cognition as unitary throughout the day, with occasional discussions of the biological variations associated with, for example, attentional mechanisms (Kahneman, 1973; Klatzky, 1984).

The use of a converging measures approach for mapping cognitive and physiological rhythmicities across the sleep–wakefulness cycle offers several benefits. This approach permits verification of subjective data on mental states via correlation with physiological measures, as was demonstrated by Farah's aforementioned studies of the neural and functional mechanisms of visual perception and imagination. In addition, this approach employed with lucid-control dreamers offers greater control over the experimental conditions, thus increasing the experimental rigor associated with investigations of dream cognition. Direct comparisons of waking and dreaming cognition and metacognition are then possible. Also, comparisons of the physiological correlates of varieties of cognitive experiences, lucid and non-lucid, from waking and sleeping, can serve as a framework for testing hypotheses from models of cognition that propose particular relationships between "mind/brain architecture" (e.g., Johnson & Hirst, 1991, 1992; Shallice, 1982) and from models of dreaming claiming a formal isomorphism between the psychological features of dreams and the physiological features of REM sleep (e.g., Hobson, 1988; Hobson & McCarley, 1977).[2]

[2] The relative rarity of spontaneous lucid dreams need not be an obstacle to the employment of lucid dreams for dream psychophysiology studies. Research on the development of lucid dreaming skills indicates that the most reliable predictor of this ability is not personality type, but dream recall frequency (LaBerge & Rheingold, 1990; Price & Cohen, 1988; Tholey, 1983). In fact, personality variables account for little of the variance in lucid dreaming (Gackenbach, 1988a, 1988b). Further, lucid-control dreaming is clearly a learnable skill (LaBerge, 1980b) that may be developed via a variety of cognitive, motivational, and biofeedback techniques (Hearne, 1978; LaBerge, 1980a; LaBerge & Rheingold, 1990; Price & Cohen, 1988; Tholey, 1983).

## THE QUESTION OF "SELF"

Evidence of reflective awareness during dreaming raises questions not only about consciousness but also about self-representation and self-awareness over the sleep–wake cycle. Lucid dreaming involves the activation of multiple self-representations: an experiencing self, an observing–monitoring–reflecting self, and a "global context" of self (see Baars, 1988). Most current models of cognition (information processing, levels of processing, connectionist) do not assign a central role to the "self" at all, even in discussing so-called "executive" functions of the cognitive system (e.g., Baddeley, 1986; Martindale, 1991; Rumelhart & McClelland, 1986).

One recent general model of cognition that addresses the issue of self-awareness is the "Multiple-Entry, Modular Memory" (MEM) model developed by Marcia Johnson (Johnson, 1983; Johnson & Hirst, 1991, 1992). The MEM framework describes 16 component processes grouped into four functional subsystems, two composed of perceptual processes and two composed of reflective processes. Of the two reflection subsystems, "R-1" processes are relatively more automatic (e.g., reactivating information), while "R-2" processes are defined as more deliberate or systematic processes (e.g., discovering relations among inputs). This model proposes that self-awareness and the sense of a unitary self arise from metacognitive processing associated with the interaction of these two reflective subsystems (Johnson, 1991; Johnson & Reeder, 1993). The study of lucid dreams in the laboratory offers a powerful methodological framework for testing these and other recent hypotheses regarding the proposed relationship between awareness and self (e.g., Johnson-Laird, 1988; Kihlstrom, 1987). For example, the psychophysiological correlates of increased reflective awareness, such as the onset of lucidity during dreaming, could reveal whether self-awareness is associated with increased frontal lobe activity as hypothesized by Johnson and Reeder (1993) and Stuss (1991).

## CONCLUSIONS

Our central tenet is that dreaming consciousness is closer to waking consciousness than usually assumed; that both dreaming and waking cognition encompass a broad range of cognitive and metacognitive experiences, including reflective awareness, intentionality, and behavioral self-regulation. Evidence accumulating about the sophistication of dream cognition and metacognition suggests a reconsideration of what constitute the "hallmarks" of human cognition. "Consciousness" and "self" are likely to be as central to what is thought of as human cognition as is memory or language.

We have also argued that an important task of contemporary models of human cognition will be to account for the variety, forms, and accomplishments of waking and sleep cognition, including "lucid-control" dreaming, which exemplifies metacognitive experience during sleep. Just how should current models be changed in light of lucid dream research? Minimally, by expanding the empirical base to include data from studies of sleep cognition and from converging measures of physiology, phenomenology, and performance (attention, memory, etc) across

the sleep–wake cycle. Lucid dreaming, in particular, challenges models of cognition to address the stereotyped notion of "waking" as the only state involving metacognitive processing. "Waking" and "sleeping" may even come to be viewed as purely relative terms not adequate for describing the combination of functional and organismic conditions associated with different cognitive skills (see Antrobus, 1991; Hunt, 1989). The ultimate goal, in any case, is to develop a truly 24-h model of cognition.

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