

CHAPTER 8

LUCID DREAMING: PSYCHOPHYSIOLOGICAL STUDIES OF CONSCIOUSNESS DURING REM SLEEP

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Although we are usually not explicitly aware that we are dreaming while we are dreaming, at times a remarkable exception occurs, and we become conscious enough to realize that fact. "Lucid" dreamers (the term derives from van Eeden, 1913) report being able to remember the circumstances of waking life freely, to think clearly, and to act deliberately upon reflection, all while experiencing a dream world that seems vividly real (Green, 1968; LaBerge, 1985; Gackenbach & LaBerge, 1988). This contrasts with the usual characterization of dreams as states that typically evince no reflective awareness or true volition (Rechtschaffen, 1978).

Lucid dreaming is normally a rare experience. Though most people report having had a lucid dream at least once in their lives, only about 20% of the population reports having lucid dreams once a month or more (Snyder & Gackenbach, 1988).

Although most people have experienced lucid dreams, some theoreticians have considered them impossible and even absurd (e.g., Malcolm, 1959). In the absence of empirical evidence, most sleep researchers have been inclined to accept Hartmann's (1975) "impression" that lucid dreams are "not typical parts of dreaming thought, but rather brief arousals" (p. 74; see also Berger, 1977). Schwartz and Lefebvre (1973) noted that frequent transitory arousals are common during REM sleep and proposed that these "microawakenings" are the physiological basis for lucid dream reports. Although no one has found any evidence for this mechanism, their proposal has been the predominant opinion (cf. Foulkes, 1974) until the last few years.

LUCID DREAMING PHYSIOLOGICALLY VERIFIED

Empirical evidence began to appear in the late 1970s suggesting that lucid dreams occur during REM sleep. Based on standard sleep recordings of 2 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, no proof was given that the reported lucid dreams had in fact occurred during the REM sleep immediately preceding the awakenings and reports. What was needed to establish the physiological status of lucid dreams unambiguously was a behavioral response that would signal to the experimenter the exact time at which the lucid dream was taking place.

LaBerge, Nagel, Dement, and Zarcone (1981) provided the necessary verification by instructing subjects to signal the onset of lucid dreams with specific dream actions that would be observable on a polygraph (i.e., eye movements and fist clenches). Using this approach, they reported that the occurrence of lucid dreaming during unequivocal REM sleep had been demonstrated for 5 subjects. After being instructed in the method of lucid dream induction (MILD) described by LaBerge (1980c), subjects were each recorded from 2 to 20 nights. In the course of the 34 nights of the study, 35 lucid dreams were reported subsequent to spontaneous awakening from various stages of sleep as follows: REM sleep, 32 times; non-REM (NREM) Stage 1 sleep, 2 times; the transition from NREM Stage 2 to REM sleep, 1 time. The subjects reported signaling during 30 of these lucid dreams. After each recording, the reports mentioning signals were submitted along with the respective polysomnograms to a judge uninformed of the times of the reports. In 24 cases (90%), the judge was able to select the appropriate 30-s epoch on the basis of correspondence between reported and observed signals. All signals associated with lucid dream reports occurred during epochs of unambiguous REM sleep scored according to the conventional criteria (Rechtschaffen & Kales, 1968).

A later analysis extending these data with 2 additional subjects and 20 more lucid dreams produced identical results (LaBerge, Nagel, Taylor, Dement, & Zarcone, 1981). LaBerge et al. argued that their investigations demonstrated that lucid dreaming usually (though perhaps not exclusively) occurs during REM sleep. This conclusion was supported by research carried out in several other laboratories (Dane, 1984; Fenwick et al., 1984; Hearne, 1978; Ogilvie, Hunt, Kushniruk, & Newman, 1983).

Ogilvie et al. (1983) reported that the physiological state preceding 14 spontaneous lucidity signals was unqualified REM in 12 (86%) of the cases; of the remaining 2 cases, 1 was reported to be "ambiguous" REM and the other was reported to be wakefulness. Hearne and Worsley collaborated on a pioneering study of lucid dreaming in which the latter spent 50 nonconsecutive

nights in the Hull University sleep laboratory while the former monitored the polygraph. Worsley reported signaling in 8 lucid dreams, all of which were described by Hearne (1978) as having occurred during REM sleep.

However, demonstrations that the signaling of lucid dreams occurs during REM sleep raise another kind of question: What exactly do we mean by the assertion that lucid dreamers are "asleep?" Perhaps these "dreamers" are not really dreamers, as some have argued in the last century; or perhaps this "sleep" is not really sleep, as some have argued in this century. How do we know that lucid dreamers are really asleep when they signal? If we consider perception of the external world as a criterion of being awake (to the external world), we can conclude that they are actually asleep (to the external world) because, although they know they are in the laboratory, this knowledge is a matter of memory, not perception. Upon awakening, lucid dreamers report total immersion in the dream world and no sensory contact with the external world.

One might object that lucid dreamers are simply not attending to the environment; rather than being asleep, perhaps they are merely absorbed in their private fantasy worlds as are those, for example, who are deeply immersed in a novel or daydream. However, according to the reports of lucid dreamers (LaBerge, 1980b, 1985), if they deliberately attempt to feel the bedcovers they know they are sleeping in or try to hear the ticking of the clock they know is beside their bed, they fail to feel or hear anything except what they find in their dream worlds. Lucid dreamers are conscious of the absence of sensory input from the external world; therefore, on empirical grounds, they conclude that they are asleep.

Conversely, if subjects claim to have been awake while showing physiological signs of sleep (or vice versa), we might have cause to doubt their subjective reports. However, when the subjective accounts and objective physiological measures are in clear agreement (as they are here), it is embarrassingly awkward to assert (as some critics have done) that subjects who report being certain that they were asleep while showing physiological indications of unequivocal sleep were actually awake (cf. LaBerge, Nagel, Dement, & Zarcone, 1981).

Some critics have suggested that demand characteristics might account for our results. It is true that our subjects were under demand to have, signal, and report lucid dreams, but could demand alone account for their actions if they were not lucid in the first place? If they merely unconsciously signaled, we would have found REM periods with signals without subsequent reports of lucidity, but we did not. If they merely reported having signaled without actually having done so, we would have found reports without signals, which we did not. Further, by this account, where would the reported and observed signals have come from?

The evidence is clear: Lucid dreaming is an experiential and physiological reality; though perhaps paradoxical, it is clearly a phenomenon of sleep.

PHYSIOLOGICAL CHARACTERISTICS OF LUCID DREAMING

The preceding studies have shown that lucid dreams typically occur in REM sleep. However, REM sleep is a heterogeneous state that exhibits considerable variations in physiological activity, ordinarily distinguished by two distinct phases. In its most active form, REM is dominated by a striking variety of irregular and short-lived events such as muscular twitching, including the rapid eye movements that give the state one of its most common names. This variety of REM is referred to as *phasic*, whereas the relatively quiescent state remaining when rapid eye movements and other phasic events temporarily subside is referred to as *tonic*. On first thought, one might expect lucid dreams to be associated with decreased phasic activity (Pivik, 1986). However, research described later has shown lucid dreaming to be associated instead with increased phasic activity.

LaBerge, Levitan, and Dement (1986) analyzed physiological data from 76 signal-verified lucid dreams (SVLDs) of 13 subjects. The polysomnograms corresponding to each of the SVLDs were scored for sleep stages, and every SVLD REM period was divided into 30-s epochs aligned with the lucidity onset signal. For each epoch, sleep stage was scored, and rapid eye movements (EMs) were counted; if scalp skin-potential (SP) responses were observable as artifacts in the electroencephalograph (EEG), these were also counted. Heart rate (HR) and respiration rate (RR) were determined for SVLDs recorded with these measures.

For the first lucid epoch, beginning with the initiation of the signal, the sleep stage was unequivocal REM in 70 cases (92%). The remaining 6 SVLDs were less than 30-s long and, hence, were technically unscorable according to standard criteria (Rechtschaffen & Kales, 1968). For these cases, the entire SVLD was scored as a single epoch; with this modification, all SVLDs qualified as REM. The lucid dream signals were followed by an average of 115 s (range = 5–490) of uninterrupted REM sleep. Physiological comparisons of EM, HR, RR, and SP for lucid versus nonlucid epochs revealed that the lucid epochs of the SVLD REM periods had significantly higher levels of physiological activation than the preceding epochs of nonlucid REM from the same REM period. Similarly, H reflex amplitude was lower during lucid than nonlucid REM (Brylowski, Levitan, & LaBerge, 1989).

To study the temporal variations of physiology as they correlated with the development and initiation of lucidity, for each SVLD REM period, the physiological variables were converted to standard scores and averaged across dreams and subjects. Figure 1 shows the resultant mean standard scores for the 5 min before and the 5 min after the initiation of lucidity. Note the highly significant increases in physiological activation during the 30 s before and after lucidity onset.

Physiological data (EM, RR, HR, and SP) were also collected for 61 control nonlucid REM periods, derived from the same 13 subjects, to allow comparison with SVLDs. Mean values for EM and SP were significantly higher for REM periods with lucid dreams than nonlucid control REM periods (RR and HR did not differ).

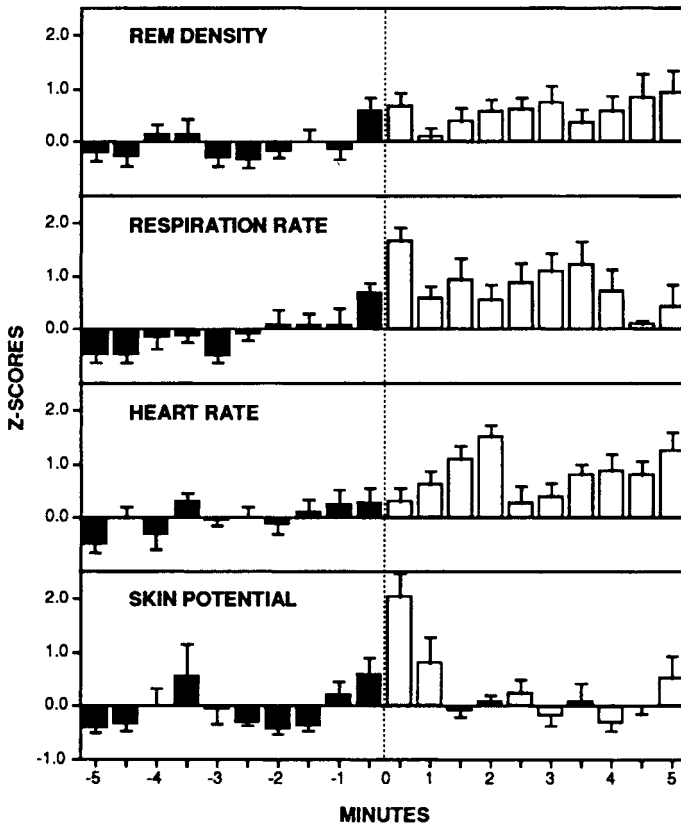
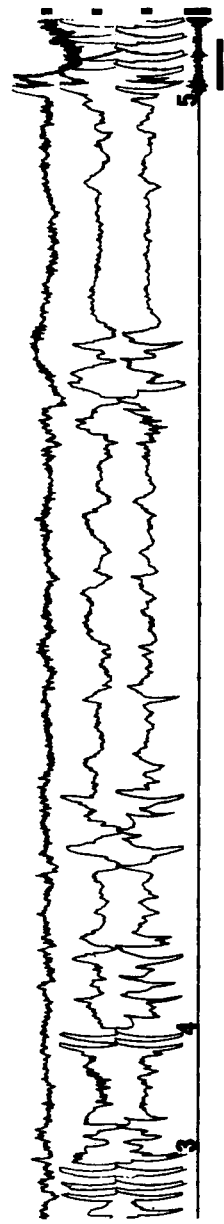
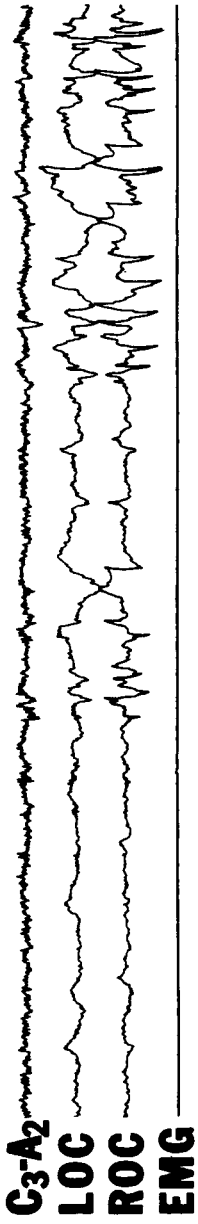


Figure 1 Grand mean z-scores and standard errors for REM density (EM), respiration rate (RR), heart rate (HR), and scalp skin potential responses (SP) during the 5 min before the onset of lucidity (black bars) and the 5 min after the onset of lucidity (white bars). Epochs are 30 s in length and the dotted line represents the signaled onset of lucidity. Sample sizes vary with variable and epoch, but all values are averaged across lucid dreams and subjects.

Given the finding that lucid dreams reliably occur during activated (phasic) REM, measures of central nervous system activation, such as eye movement density, should contribute something to the pattern of lucid dream distribution. Because it has been observed that eye movement density starts at a low level at the beginning of REM periods and increases until it reaches a peak after approximately 5–7 min (Aserinsky, 1971), we (LaBerge et al., 1986) hypothesized that lucid dream probability should follow a parallel development. Accordingly, we found that mean eye movement density correlated positively and significantly with lucid dream probability ($r = .66, p < .01$).

Lucid dreams have most commonly been reported to occur late in the sleep cycle (Green, 1968). LaBerge et al. (1986) tested this hypothesis by first determining for each of their 12 subjects the time of night that divided their total REM time into two equal parts. All but 1 of the subjects had more lucid dreams in the second half of their REM time than in the first half (binomial



test, $p < .01$). For the combined sample, relative lucidity probability was calculated for REM Periods 1–6 of the night by dividing the total number of lucid dreams observed in a given REM period by the corresponding total time in the REM stage for the same REM period. A regression analysis clearly demonstrated that relative lucidity probability was a linear function of ordinal REM period number ($r = .98$, $p < .0001$).

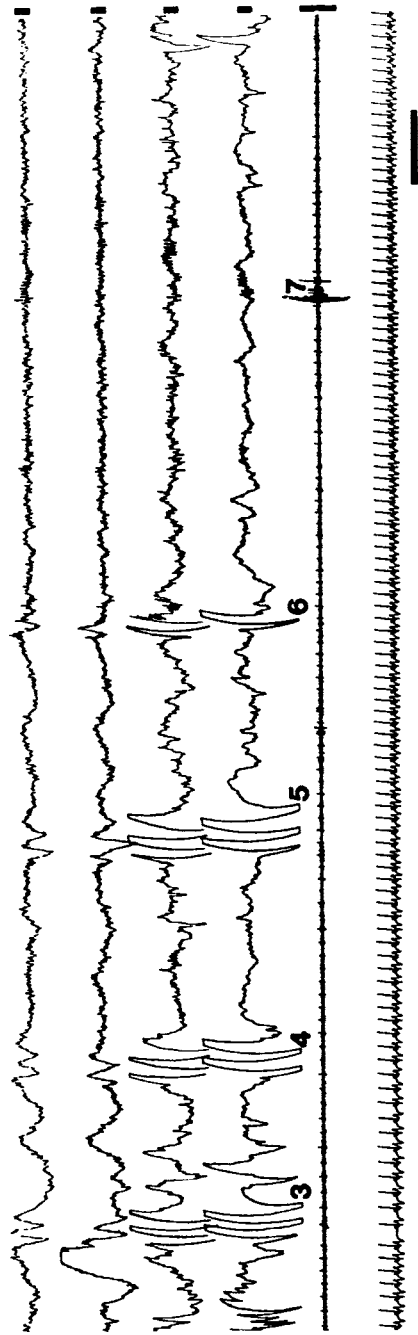
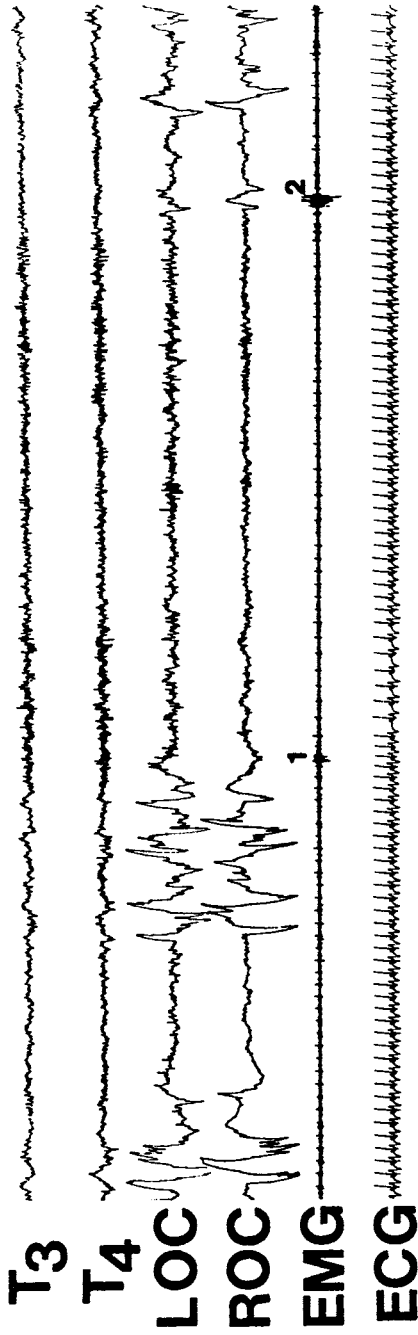
Lucid dreams are initiated in two distinct ways. Subjects usually report having been in the midst of a dream when a bizarre occurrence causes sufficient reflection to yield the realization that they are dreaming. Less frequently, subjects report having briefly awakened from a dream and then, falling back asleep, directly entering the dream with no (or very little) break in consciousness (Green, 1968; LaBerge, 1985). Here is an example of a wake-initiated lucid dream:

I was lying awake in bed late in the morning listening to the sound of running water in the adjoining bathroom. Presently an image of the ocean appeared, dim at first like my usual waking imagery. But its vividness rapidly increased while, at the same time, the sound of running water diminished; the intensity of the internal image and external sound seemed to alter inversely (as if one changed a stereo balance control from one channel to the other). In a few seconds, I found myself at the seashore standing between my mother and a girl who seemed somehow familiar. I could no longer hear the sound of the bath water, but only the roar of the dream sea. (LaBerge, 1980b, p. 85)

Note that the subject was continuously conscious during the transition from wakefulness to sleep. This fact suggests that Foulkes (1985) was overstating the case by claiming that it is “a necessary part of the experience we call ‘sleep’ that we lose a directive and reflective self. You can’t fall asleep, or be asleep, if your waking self is still regulating and reflecting upon your conscious mental state” (p. 42).

Because lucid dreams initiated in these two ways ought to differ physiologically in at least one respect (i.e., an awakening preceding one but not the other), the SVLDs were dichotomously classified as either wake-initiated (WILD) or dream-initiated (DILD), depending on whether or not the reports

Figure 2 A typical dream-initiated lucid dream (DILD). Four channels of physiological data (central EEG [C_3-A_2], left and right eye-movements [LOC and ROC], and chin muscle tone [EMG]) from the last 8 min of a 30 min REM period are shown. Upon awakening, the subject reported having made five eye movement signals (labeled 1–5 in figure). The first signal (1, LRLR) marked the onset of lucidity. Note the skin potential artifacts in the EEG at this point. During the following 90 s the subject “flew about” exploring his dream world until he believed he had awakened, at which point he made the signal for awakening (2, LRLRLRLR). After another 90 s, the subject realized he was still dreaming and signaled (3) with three pairs of eye movements. Realizing that this was too many, he correctly signaled with two pairs (4). Finally, upon awakening 100 s later he signaled appropriately (5, LRLRLRLR). Calibrations are 50 μ V and 5 s.



mentioned a transient awakening in which the subject consciously perceived the external environment before reentering the dream state.

Fifty-five (72%) of the SVLDs were classified as DILDs, and the remaining 21 (28%) were classified as WILDs. For all 13 subjects, DILDs were more common than WILDs (binomial test, $p < .0001$). As expected, compared with DILDs, WILDs were more frequently immediately preceded by physiological indications of awakening, $\chi^2(1, N = 76) = 38.3, p < .0001$, establishing the validity of classifying lucid dreams in this manner. See Figures 2 and 3 for illustrations of these two types of lucid dream.

As was mentioned earlier, momentary intrusions of wakefulness occur very commonly during the normal course of REM sleep, and Schwartz and Lefebvre (1973) proposed that lucid dreaming occurs during these microawakenings. However, LaBerge, Nagel, Taylor, Dement, & Zarcone's (1981) and LaBerge et al.'s (1986) data indicate that, while lucid dreams do not take place during interludes of wakefulness within REM periods, a minority of lucid dreams (WILDs) are initiated from these moments of transitory arousal and continue in subsequent undisturbed REM sleep.

To summarize, an elevated level of central nervous system (CNS) activation seems to be a necessary condition for the occurrence of lucid dreams. Evidently, the high level of cognitive function involved in lucid dreaming requires a correspondingly high level of neuronal activation. In terms of Antrobus's (1986) adaptation of Anderson's (1983) ACT* model of cognition to dreaming, working memory capacity is proportional to cognitive activation, which in turn is proportional to cortical activation. Becoming lucid requires an adequate level of working memory to activate the presleep intention to recognize that one is dreaming. This level of cortical and cognitive activation is apparently available only during phasic REM.

PSYCHOPHYSIOLOGICAL RELATIONS DURING REM SLEEP

Psychologists attempting to apply rigorous scientific methodology to the study of such phenomena as mental imagery, hallucinations, dreaming, and conscious processes in general face a major challenge: The most direct account available of the private events occurring in a person's mind is his or her own

Figure 3 A typical wake-initiated lucid dream (WILD) following a transient awakening during REM. Six channels of physiological data (left and right temporal EEG [T_3 and T_4 ; C_z reference], left and right eye-movements [LOC and ROC], chin muscle tone [EMG], and electrocardiogram [ECG]) from the last 3 min of a 14 min REM period are shown. The subject awoke at 1 and after 40 s returned to REM sleep at 2, realized he was dreaming 15 s later, and signaled at 3. Next he carried out the agreed-upon experimental task in his lucid dream, singing between signals 3 and 4, and counting between signals 4 and 5. This allowed comparison of left and right hemisphere activation during the two tasks (LaBerge & Dement, 1982b). Note the heart-rate acceleration-deceleration pattern at awakening (1) and at lucidity onset (3), and the skin potential artifacts in the EEG (particularly T_4) at lucidity onset (3). Calibrations are 50 μ V and 5 s.

subjective report. Unfortunately, subjective reports are difficult to verify objectively, and introspection is far from an unbiased and direct process of observation. Two strategies are likely to increase our confidence in the reliability of subjective reports: (a) the use of highly trained (and in the context of dream research, lucid) subjects who are skillful reporters, and (b) the use of the psychophysiological approach, which proposes that the convergent agreement of physiological measures and subjective reports provides a degree of validation to the latter (Stoyva & Kamiya, 1968).

Indeed, the psychophysiological approach was responsible for the golden age of dream research in the decades following the discovery of REM sleep (Aserinsky & Kleitman, 1953) and the subsequent association of REM with dreaming (Dement & Kleitman, 1957). Although the psychophysiological paradigm of dream research has yielded an abundant harvest for many years (see Arkin, Antrobus, & Ellman, 1978), it possesses a fatal flaw: As long as the subjects are nonlucid, the researcher has no way of making certain that the subjects will dream about what the researcher might like to study. Presleep manipulations producing reliable effects on dream content have not been highly successful (Tart, 1988). One can only wait and hope that, eventually, a dream report will unearth what one is looking for. This is really no better than a shot-in-the-dark approach, and some researchers have proposed abandoning the psychophysiological method in favor of a purely psychological approach. Foulkes (1981) wrote that "psychophysiological correlation research now appears to offer such a low rate of return for effort expended as not to be a wise place for dream psychology to continue to commit much of its limited resources" (p. 249). This conclusion may well be justified, but only insofar as it refers to the psychophysiological approach as it is traditionally practiced, using nonlucid subjects. The use of lucid dreamers overcomes the basic difficulty of the old methodology and may revitalize the psychophysiological approach to dream research.

The fact that lucid dreamers can remember to perform predetermined actions and can signal to the laboratory suggested to LaBerge (1980b) a new paradigm for dream research: Lucid dreamers, he proposed, "could carry out diverse dream experiments marking the exact time of particular dream events, allowing the derivation of precise psychophysiological correlations and the methodical testing of hypotheses" (LaBerge, Nagel, Dement, & Zarcone, 1981, p. 727). This strategy has been put into practice in a number of studies that are summarized later.

How long do dreams take? This question has intrigued humanity for many centuries. A traditional answer is that dreams take very little or no time at all, as in the case of Maury's famous dream in which he somehow got mixed up in a long series of adventures during the French Revolution and finally lost his head on the guillotine, at which point he awoke to find that the headboard had fallen on his neck. He therefore supposed that the lengthy dream had been produced in a flash by the painful stimulus. The idea that dreams occur in the moment of awakening has found supporters over the years.

We have straightforwardly approached the problem of dream time by asking subjects to estimate 10-s intervals (by counting "one thousand and one, one thousand and two," etc.) during their lucid dreams. Signals marking the beginning and end of the subjective intervals allowed comparison with objective time. In all cases, time estimates during the lucid dreams were very close to the actual time between signals (LaBerge, 1980b, 1985). However, this finding does not rule out the possibility of time distortion effects under some circumstances.

The data reported by LaBerge, Nagel, Dement, and Zarcone (1981) and LaBerge, Nagel, Taylor, Dement, and Zarcone (1981) indicate that there is a very direct and reliable relation between the gaze shift reported in lucid dreams and the direction of polygraphically recorded eye movements. The results obtained for lucid dreams (see also Dane, 1984; Fenwick et al., 1984; Hearne, 1978; Ogilvie, Hunt, Tyson, Lucescu, & Jeakins, 1982) are much stronger than the generally weak correlations obtained by previous investigators testing the hypothesis that the dreamer's eyes move with his or her hallucinated dream gaze, who relied on the chance occurrence of a highly recognizable eye movement pattern that was readily matchable to the subject's reported dream activity (e.g., Roffwarg, Dement, Muzio, & Fisher, 1962).

LaBerge (1985) reported related experiments in which 2 subjects tracked the tip of their fingers moving slowly from left to right during four conditions: (a) awake, eyes open; (b) awake, eyes closed, mental imagery; (c) lucid dreaming; and (d) imagination ("dream eyes closed") during lucid dreaming. The subjects showed saccadic eye movements in the two imagination conditions (b and d) and smooth tracking eye movements during dreamed or actual tracking (a and c).

In another study, LaBerge and Dement (1982b) demonstrated the possibility of voluntary control of respiration during lucid dreaming. They recorded 3 lucid dreamers who were asked either to breathe rapidly or to hold their breath (in their lucid dreams), marking the interval of altered respiration with eye movement signals. The subjects reported successfully carrying out the agreed-upon tasks a total of nine times and, in every case, a judge was able to predict correctly on the basis of the polygraph recordings which of the two patterns had been executed (binomial test, $p < .002$).

Evidence of the voluntary control of other muscle groups during REM was found by LaBerge, Nagel, Dement, and Zarcone (1981) while testing a variety of lucidity signals. They observed that a sequence of left and right dream-fist clenches resulted in a corresponding sequence of left and right forearm twitches as measured by electromyograph (EMG). However, the amplitude of the twitches bore an unreliable relation to the subjective intensity of the dreamed action. Because all skeletal muscle groups except those that govern eye movements and breathing are profoundly inhibited during REM sleep, it is to be expected that most muscular responses to dreamed movements will be feeble. Nonetheless, these responses faithfully reflect the motor

patterns of the original dream. Similar observations were made by Fenwick et al. (1984).

Following reports of cognitive task dependency of lateralization of EEG alpha activity in the waking state by many researchers, LaBerge and Dement (1982a) undertook a pilot study to demonstrate the feasibility of similar investigations in the lucid dream state. The two tasks selected for comparison were dreamed singing and dreamed counting, activities expected to result in relatively greater engagement of the subjects' left and right cerebral hemispheres, respectively.

Integrated alpha band EEG activity was derived from electrodes placed over right and left temporal lobes while 4 subjects sang and estimated 10 s by counting in their lucid dreams (marking the beginning and end of each task by eye movement signals). The results supported the hypothesized lateralization of alpha activity: The right hemisphere was more active than the left during singing; during counting, the reverse was true. These shifts were similar to those observed during actual singing and counting. In contrast, a control condition with imagined singing and counting showed no significant laterality shifts. Because of the small number of subjects, the conclusions of this study must be regarded as suggestive at best.

LaBerge and Dement (1982a, 1982b) noted an important implication of their results for the interpretation of EEG alpha activity during REM sleep. Because continuous alpha activity occurs when a subject awakens, sleep researchers have usually assumed that increased alpha activity in the context of sleep is always a sign of wakefulness or relative cortical activation. The findings just discussed suggest the contrary: Alpha activity during REM sleep is, as in waking, inversely related to cortical activation. When a person awakens from a vivid dream to a dark room, his cortical (at least occipital) activation has decreased, not increased, with the resultant appearance of elevated alpha power.

In this view, it is a straightforward prediction that occipital alpha power during REM sleep will correlate negatively with subsequently reported dream vividness. This could provide the proper explanation for the finding that awakenings following REM periods with high levels of alpha activity are more likely to yield "thinking" reports than awakenings from low-alpha REM periods which yield more "dreaming" reports (Antrobus, Dement, & Fisher, 1964).

Sexual activity is a rather commonly reported theme of lucid dreams (LaBerge, 1985; Garfield, 1979). LaBerge, Greenleaf, and Kedzierski (1983) undertook a pilot study to determine the extent to which subjectively experienced sexual activity during REM lucid dreaming would be reflected in physiological responses.

Sixteen channels of physiological data, including EEG, electrooculogram (EOG), EMG, respiration, skin conductance level (SCL), heart rate, vaginal EMG (VEMG), and vaginal pulse amplitude (VPA), were recorded from a single subject. The experimental protocol called for her to make specific eye movement signals at the following points: When she realized she was dream-

ing (i.e., the onset of the lucid dream), when she began sexual activity (in the dream), and when she experienced orgasm.

The subject reported a lucid dream in which she carried out the experimental task exactly as agreed upon. Data analysis revealed a significant correspondence between her subjective report and all but one of the autonomic measures; during the 15-s orgasm epoch, mean levels for VEMG activity, VPA, SCL, and respiration rate reached their highest values and were significantly elevated compared with means for other REM epochs. Contrary to expectation, heart rate increased only slightly and nonsignificantly.

IMPLICATIONS FOR RESEARCH ON SLEEP AND COGNITION

Lucid dreaming presents conceptual difficulties for certain traditional beliefs about sleep and about the presumed limitations of dream mentation. In a certain sense, the anomalous appearance of lucid dreaming parallels that of the state that has been called "paradoxical sleep." The discovery of REM sleep required the expansion of our concept of sleep. The evidence we have reviewed associating lucid dreaming with REM sleep seems to require a similar expansion of our concept of dreaming as well as a clarification of our concept of sleep.

Fenwick et al. (1984) showed that a subject was able to perceive and respond to environmental stimuli (electrical shocks) without awakening from his lucid dream. This result raises a theoretical issue: If we take perception of the external world to be the essential criterion for wakefulness, then Worsley must have been at least partially awake. On the other hand, when environmental stimuli are incorporated into dreams without producing any subjective or physiological indications of arousal, it seems that the perception must have occurred during sleep.

Furthermore, it may be possible, as LaBerge (1980a) suggested, for one sense to remain functional and awake while others fall asleep. Similarly, Antrobus, Antrobus, and Fisher (1965) argued that "the question—awake or asleep—is not a particularly useful one. Even though we have two discrete words—sleep and wakefulness—this does not mean that the behavior associated with the words can be forced into two discrete categories. . . . not only do sleeping and waking shade gradually into one another but there is only limited agreement among the various physiological and subjective operations that discriminate between sleeping and waking. At any given moment, all systems of the organism are not necessarily equally asleep or awake." (pp. 398–399)

As long as we continue to consider wakefulness and sleep a simple dichotomy, we will lie in a Procrustian bed that is bound at times to be most uncomfortable. There must be degrees of being awake, just as there are degrees of being asleep (i.e., the conventional sleep stages). Before we find our way out of this muddle, we will probably need to characterize a wider variety of states

of consciousness than the few that are currently distinguished (e.g., dreaming, sleeping, waking, etc.).

It may be helpful to consider lucidity from a cognitive–developmental perspective. According to Piaget (1926), children pass through three stages of understanding of the concept *dream*. In the first stage, they believe that dreams take place in the same external world as all other experiences. In the second stage, children treat dreams as if they were partially external and partially internal. This transitional stage gives way to the third stage in which children recognize the dream is entirely internal in nature, a purely mental experience.

These foregoing developmental stages refer to how children think about dreams when they are awake. While asleep and dreaming, children, and also adults, tend to remain at the first stage, implicitly assuming that the dream events are external reality. Out-of-body experiences, with a contradictory mixture of material and mental (external and internal), may provide examples of the second stage (LaBerge, Levitan, Brylowski, & Dement, 1988). In the fully lucid dream, the dreamer attains the third stage, realizing that the dream world is distinct from the physical world.

Foulkes (1982, 1985) has emphasized the idea that the growth of the mind, whether dreaming or awake, shows parallel degrees of development: “there are ‘stages’ of dream development which individual children reliably pass through one after the other, and that the precise age at which they reach a new stage is at least partially predictable from independent measures of their waking mental development” (1985, p. 137).

In this view, lucid dreaming represents what ought to be a normal ability in adults. If this is correct, why are lucid dreams so rare, especially in cases such as nightmares, where lucidity would be extremely helpful and rewarding? A possible answer may be found by comparing lucid dreaming with another cognitive skill, language acquisition. All normal adults speak and understand at least one language. But how many would do so if they were never taught? Unfortunately, in this culture, with few exceptions, we are not taught to dream.

LaBerge (1980c) demonstrated that lucid dreaming is a learnable skill and that there are a variety of techniques available for inducing lucid dreams (LaBerge, 1985; Price & Cohen, 1988). LaBerge and colleagues have experimented with methods for helping dreamers realize that they are dreaming by means of external cues applied during REM sleep, which, if incorporated into dreams, can remind dreamers that they are dreaming (LaBerge, 1980b). They have tested a variety of stimuli, including tape recordings of the phrase “this is a dream” (LaBerge, Owens, Nagel, & Dement, 1981), conditioned tactile stimuli (Rich, 1985), olfactory stimuli (LaBerge, Brylowski, & Levitan, unpublished data, 1986), and light (LaBerge, Levitan, Rich, & Dement, 1988). The most promising results so far have resulted from light stimuli.

The psychophysiological studies reviewed here all support the following picture: During REM dreaming, the events we experience (or seem to experience) are the results of patterns of CNS activity that produce in turn effects on our autonomic nervous systems (ANS) and bodies, which are to some extent

modified by the specific conditions of active sleep but are still homomorphic to the effects that would occur if we were actually to experience the corresponding events while awake.

This conclusion may need further qualification and explanation. Although the events we appear to perceive in dreams are illusory, our feelings in response to dream content are real. Indeed, most of the events we experience in dreams are real; when we experience feelings like anxiety or ecstasy in dreams, we really do feel anxious or ecstatic at the time. When we think in dreams, we really do think (whether clearly or not is another matter). If we think in our dreams that Monday comes before Sunday, it is not the case, as some philosophers (e.g., Malcolm, 1959) assert, that we have only dreamed we thought; we may have thought incorrectly (to the usual way of thinking), but we thought nonetheless.

If we vividly imagined a detailed sequence of movements, like walking around the room, it is probable that motor areas of the brain would be activated in the same pattern that is activated in actual walking. However, they would presumably be less activated than when walking. Otherwise, what would prevent us from actually walking when we imagined doing so?

In REM sleep, a spinal paralysis causes the muscles of locomotion and vocalization to fail to completely execute the action orders programmed by the brain. Thus, in REM, unlike the waking state, nothing impedes the brain from issuing sequences of motor commands at normal levels of activation, and this probably contributes to the experienced reality of dreamed action.

As for the afferent side of the equation, a great deal of evidence suggests that imagery uses the same neural systems as perception in the corresponding sensory mode (e.g., see Farah, 1988; Finke, 1980). In this view, the essential difference between a perception and a corresponding image is how the identical neural system acquires sufficient activation to produce a conscious experience. In the case of perception, neural excitation (and the resultant experience) is generated by external input, driving activation of the particular schema to-be-perceived in a largely bottom-up process. In the case of imagining (likewise, hallucinating or dreaming), the experienced image is generated internally by top-down processes activating the appropriate neural network (schema).

Imaginations and perceptions are normally distinguishable by the fact that images are usually much less vivid than perceptions. Normally, perceptions seem real and images seem imaginary. How real something appears depends mainly on its relative vividness, and experienced vividness is probably a function of the intensity of neural activation. Thus, we may conjecture that images usually involve a lesser degree of neural activation than the corresponding perceptions, and this results in a lesser degree of experiential reality for imagination. At least two factors contribute to this state of affairs: One is that, while we are awake, sensory input produces much higher levels of activation than imaginary input. Imagination interferes with perception in the same modality (Perky, 1910; Segal, 1971), and we may suppose the reverse is true as well. Another more speculative factor favoring perceptual processes over imagination in the waking state is the existence of a neural system to inhibit

the activation (vividness) of memory images while perception is active. Evolutionary considerations make such a system likely; it would obviously be extremely maladaptive for an organism to mistake a current perceptual image of a predator for the memory of one (LaBerge, 1985). Mandell (1980) implicated serotonergic neurons as part of a system that normally inhibits vivid images (hallucinations) but is itself inhibited in REM sleep, allowing dreamed perceptions (i.e., images) to appear as vividly real as perceptions. In REM, sensory input is also actively suppressed to prevent competition from perceptual processes.

Perhaps this explains in part why we are so inclined to mistake our dreams for reality: To the functional systems of neuronal activity that construct our experiential world (model), dreaming of perceiving or doing something is equivalent to actually perceiving or doing it.

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