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TEMPORAL DELAYS IN INCORPORATION OF EVENTS INTO DREAMS [1]

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Summary.—20 subjects viewed an emotionally arousing video and then recorded their dreams at home for seven nights. Dreams were subsequently rated for the likelihood that some aspect of the video had been incorporated. For subjects who showed strong evidence of incorporation, mean likelihood of incorporation ratings followed a U-shaped pattern, with significantly higher scores on Nights 1, 6, and 7 than on Night 4. The similarity of this temporal pattern with REM sleep patterns observed in rats exposed to various learning experiences is noted, and the role of the hippocampus as a possible neural mechanism for delayed incorporations is discussed.

The tendency for events from the preceding day to be incorporated into dreams is well established (e.g., Epstein, 1985; Harlow & Roll, 1992; Nielsen & Powell, 1992). In fact, Freud (1900/1953) believed that all incorporations can eventually be traced to this "day residue" effect: "Whenever it has seemed at first that the source of a dream was an impression two or three days earlier, closer inquiry has convinced me that the impression had been recalled on the previous day" (p. 166).

While the importance of day residues in dream formation has been confirmed, there is also evidence that dreams may systematically incorporate more temporally distant events. For example, Jouvet (1979), in an analysis of his own dreams, found frequent incorporations of events that had occurred nine days earlier. He also found that, during extended trips, his dreams began to incorporate features of the changed environment an average of 7.8 days after leaving home and 6.5 days after returning home.

Nielsen and Powell (1989) conducted two experiments which were explicitly designed to test for the occurrence of delayed incorporations. In the first experiment, 69 subjects recorded their dreams for seven days and then retrospectively described the most important event they had experi-

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enced during that period. Judges' ratings of the likelihood that the events were incorporated in the subjects' dreams indicated a sinusoidal pattern with peaks on Nights 1 and 6 following the events. A second experiment utilized the dream reports of 34 subjects who had one year earlier slept in a sleep laboratory and then recorded their dreams at home for the following seven nights. Judges' ratings showed significantly greater incorporations of the laboratory experience on Night 6 than on Nights 2 and 3 following the experience. In summary, results from these two experiments showed that, in addition to the day-residue effect, there may also be a substantial "dream-lag effect," a systematic resurgence in the incorporation of a daytime event following a period of several days.

In a more recent study, Nielsen and Powell (1992) assessed incorporations of subjects' self-reported events across a 14-day period. While a strong day-residue effect was found, there was only slight evidence of a dream-lag effect, specifically, at Nights 6 and 12 following the events. However, the subjects in this experiment had been asked to record their most significant event of the day just prior to retiring each evening, a procedure which may have biased them toward emphasizing that same event in their dream reports the following morning. A further problem with this study is that there was poor interjudge reliability for the ratings of incorporation, possibly because the self-reported events lacked sufficient detail to assess incorporations reliably. Therefore, in the present study, the dream-lag effect was tested using a single standardized event.[2]

Method

Subjects

Ten men and 10 women, unaware of the dream-lag hypothesis, consented to participate after they had been informed of the procedure. They were also informed that the videotape they were to watch contained scenes which could be disturbing and that they could withdraw from the study at any time. One subject chose not to hand in her dream booklet. The remaining subjects ranged in age from 20 to 52 years ($M = 24.9$, $SD = 8.4$). Sixteen of the subjects were enrolled as university undergraduates or had recently graduated.

Procedure

The 30-min. videotape was shown on a 21-in. color monitor to groups of 10 subjects at a time on a Friday evening. It depicted the ceremonial

[2]Also noteworthy is a recent report by Sophie and Gross (1994) who examined the dream records of parachute jumpers following their first jump and found evidence of a resurgence in incorporation on Nights 9 and 10.

slaughter of water buffalo by Naji villagers in Indonesia. Subjects were also instructed to write down their dreams over the next seven nights.

All the dreams that a subject recorded in one night were treated as a single report. These were transcribed and printed in a format which masked both information about the subject and the night on which the dream occurred. The order of reports for all subjects and all days was completely randomized. Two judges independently rated each report on a scale from 0 to 10 for the likelihood that some aspect of the videotape had been incorporated, with 0 indicating a very low likelihood and 10 indicating a very high likelihood of incorporation. For example, one dream report of "skating with other skaters" received a rating for likelihood of incorporation of 0 insofar as it contained no elements similar to the content of the videotape. On the other hand, another dream report of seeing a friend "tied to a tree [while] straw people poked at her with what appeared to be marshmallow sticks" received a rating of 10 insofar as the videotape contained several scenes in which a buffalo was tethered to a tree and subjected to spear thrusts.

Results

The mean number of reports per subject was 5.4 ($SD = 1.7$). Dream recall decreased only slightly across the seven nights—total reports for the 19 subjects declining from 17 to 13—and did not vary significantly as a function of gender or level of incorporation (see below).

Although ratings by Judge 1 ($M = 4.6$, $SD = 3.9$) were generally higher than those by Judge 2 ($M = 3.5$, $SD = 3.2$), the two sets of ratings were highly correlated ($r_{(100)} = .80$, $p < .001$, $R^2 = 0.64$). The two judges' mean ratings for each night were also highly correlated ($r_s = .92$, $p < .01$), indicating very similar trends across nights. Reliability was deemed adequate, and likelihood of incorporation ratings by Judge 1, the most experienced one, were used for the remaining analyses.

Covariance estimates of the mean were inserted for the 31 subject-nights for which no dreams were recalled, with one degree of freedom subtracted from the residual error term for each estimated value used in subsequent analysis of variance procedures (Steel & Torrie, 1980). Because preliminary analyses indicated that subjects' level of incorporation may be an important factor, subjects were categorized as either high incorporators (High, $n = 9$) or low incorporators (Low, $n = 10$) on the basis of whether at least one of their dream reports had received a maximum rating of 10. A three-way analysis of variance (with Huynh-Feldt adjustments in degrees of freedom) was conducted with gender and level of incorporation as between-group factors and nights as a repeated-measures factor.

The incorporation patterns for high and low incorporators and combined subjects are presented in Fig. 1. Likelihood of incorporation scores for

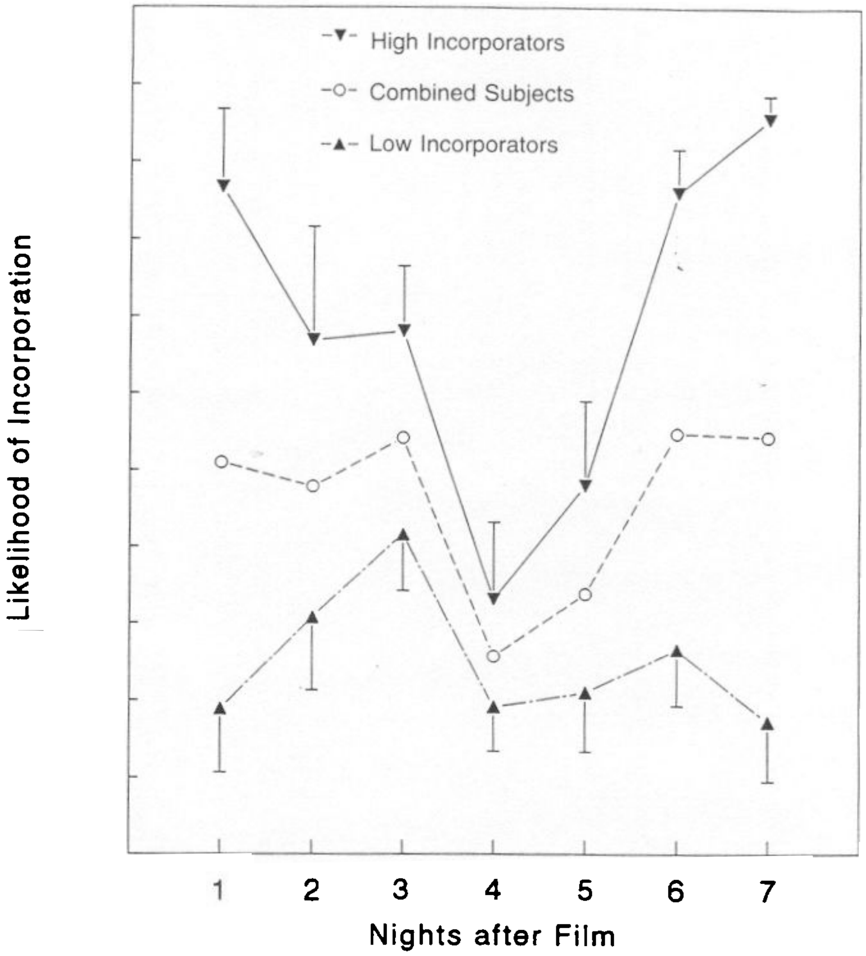

FIG. 1. Mean likelihood of incorporation ratings for high incorporating ($n = 9$), low incorporating ($n = 10$), and combined subjects ($N = 19$) (Vertical lines for high incorporating and low incorporating subjects represent ± 1 *SE*)

combined subjects varied significantly across nights ($F_{5.8,57.2} = 3.03$, $p < .03$), and subjects categorized as high incorporators had generally higher scores than subjects categorized as low incorporators ($F_{1,15} = 64.94$, $p < .0001$). There was also a significant interaction for level of incorporation × nights ($F_{5.8,57.2} = 3.05$, $p < .03$). Newman-Keuls *post hoc* comparisons indicated that high incorporators had significantly higher scores on Nights 1, 6, and 7 than for Night 4, and for Nights 6 and 7 than for Night 5 ($p < .05$). There were no significant differences across nights for low incorporators. High incorporators had higher incorporation scores than low incorporators for Nights 1, 6, and 7 ($p < .05$).

There was a significant quadratic trend across nights for combined sub-

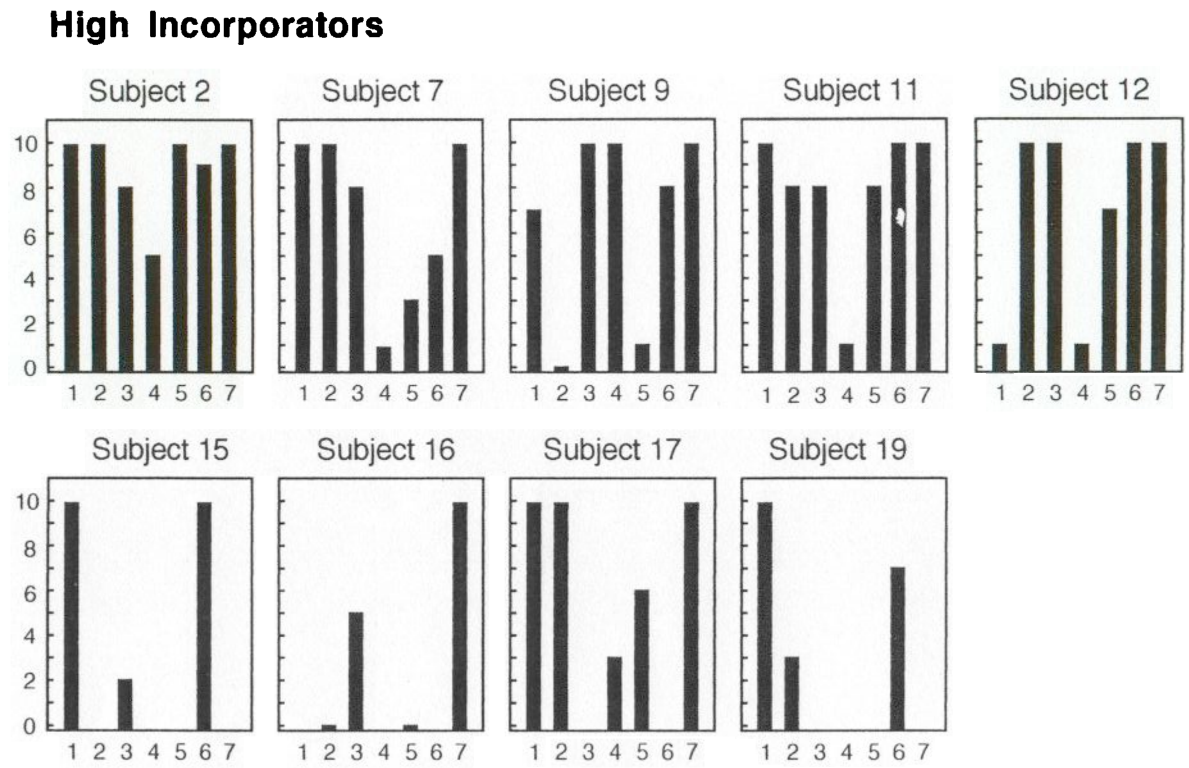

FIG. 2. Likelihood of incorporation ratings across nights for the dream reports of individual high incorporating and low incorporating subjects (Vertical axis = Likelihood of Incorporation; horizontal axis = Nights after Film) (continued on next page)

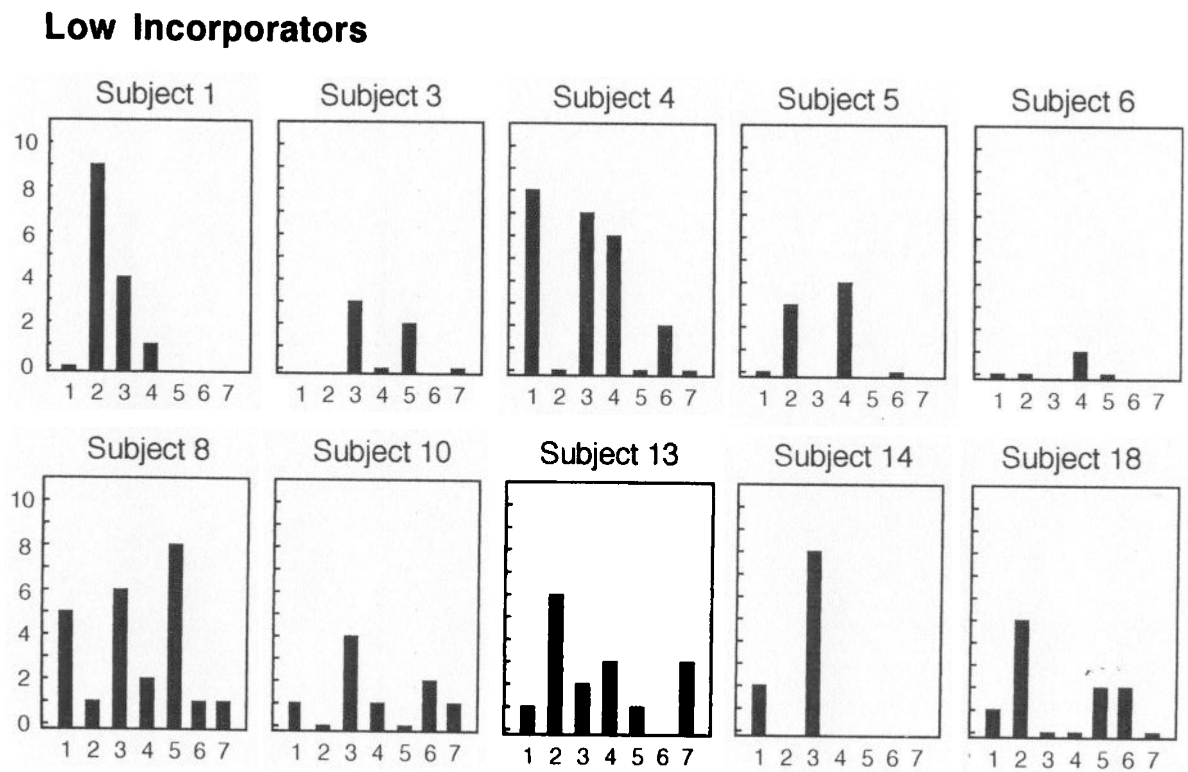

FIG. 2. (Cont'd) Likelihood of incorporation ratings across nights for the dream reports of individual high incorporating and low incorporating subjects (Vertical axis = Likelihood of Incorporation; horizontal axis = Nights after Film)

jects ($F_{1,15}=13.77$, $p<.003$), with a significant interaction for nights × level of incorporation ($F_{1,15}=64.94$, $p<.0001$). Separate analyses for each incorporation level indicated a strong quadratic trend for high incorporators only ($F_{1,7}=21.6$, $p<.003$).

The likelihood of incorporation ratings across nights for the individual subjects categorized as high and low incorporators are presented in Fig. 2. A clear U-shaped pattern is present for six out of the nine high incorporators (Subjects 2, 7, 11, 15, 17, and 19) and is absent for all of the low incorporators.

Discussion

The present results are similar to those obtained in previous research on the dream-lag effect (Nielsen & Powell, 1989)—an initial tendency to incorporate was followed by a decrease in incorporation and then a resurgence toward the end of the one week recording period. Moreover, this pattern was found only for those subjects who showed strong evidence of incorporation. For six of these subjects, the U-shaped pattern for likelihood of incorporation was apparent even in their individual data.

A possible criticism of the present study is that the subjects were aware the researchers were expecting the content of the videotape to be incorporated into their dreams. While such a demand characteristic may have increased the over-all level of incorporation, it does not obviously explain the U-shaped pattern of scores over time—a pattern which was predicted and of which the subjects were unaware. Further, the results are similar to those obtained in the two earlier experiments by Nielsen and Powell (1989), in which subjects were, at the time they recorded their dreams, blind as to which event would be rated for likelihood of incorporation. Finally, if the resurgence in scores toward the end of the week was somehow the result of a renewed interest in the study as the recording period drew to a close, then dream recall should likewise have increased toward the end of the week—a pattern which was not obtained.

One problem that remains is that all of the subjects in the present study viewed the videotape on a Friday evening; therefore, day of week may in some manner have influenced the findings. For example, had a television episode on the following Wednesday evening contained scenes of wildlife, especially water buffalo, this could have restimulated the subjects' thoughts of the videotape and increased the likelihood of the videotape content being incorporated into subjects' dreams over the next few nights. Nevertheless, it must also be noted that the pattern of results in this study was similar to those obtained in earlier studies in which day of week could not have acted as a confounding variable (Nielsen & Powell, 1989).

A possible function of the dream-lag effect is that it might facilitate the process of adaptation to stressful events. Wright and Koulack (1987) have proposed a disruption-avoidance-adaptation model of dreaming in which a period of "mastery" dreams—in which repeated incorporation of a stressful stimulus provides opportunities for activation of coping responses and integration with earlier material—alternates with a period of "avoidance" dreams—in which prolonged nonincorporation of the stressful event provides the dreamer brief respite to ensure that sleep patterns are not consistently disrupted. In support of this model, Stewart and Koulack (1993) found some evidence of an oscillating pattern in the unpleasantness of subjects' dreams during the week following a stressful experience (a difficult aptitude test) with the most unpleasant dreams occurring on Nights 3, 4, and 7. They found no effect for incorporation of elements, however, although it may be that differences between these results and results obtained in the dream-lag studies (e.g., Nielsen & Powell, 1989) may be a function of the different presleep stimuli which were used.

The dream-lag effect also has implications for the possible role of dream content in learning (Jouvet, 1979; Nielsen & Powell, 1989; Smith, 1993). For example, Smith noted similarities between the dream-lag effect and delayed increases in REM sleep in rats following two days of training on a shock-avoidance task (Smith & Lapp, 1986; see also Leconte, 1983). The fact that fluctuations in REM sleep may sometimes show a temporal pattern similar to that for dream incorporations suggests that delayed incorporations might be similarly involved in processes of learning associated with stressful or novel events.

Several lines of evidence suggest the possible involvement of the hippocampus as a neural substrate for delayed incorporations. Hippocampal long-term potentiation (LTP) is widely believed to be the neural mechanism underlying declarative memory (Squire, 1992). It has been shown that LTP in rats is enhanced during paradoxical sleep and wakefulness but not during slow wave sleep (Bramham, Maho, & Laroche, 1994; Bramham & Srebro, 1989). In addition, Pavlides and Winson (1989) recorded the activity of CA1 neurons in the hippocampus which had different place fields, i.e., which fired when the rat moved to a particular location, and found that neurons which mapped space as the awake animal moved about also fired at a high rate during subsequent REM sleep. They suggested that during REM sleep individual neurons reprocessed or strengthened information encoded when the animal was awake, a process which Winson (1990) related directly to dreaming.[3]

[3]But note that recent evidence indicates that consolidation of declarative memories is also dependent on slow wave sleep (Wilson & McNaughton, 1994) and that REM sleep is also involved in the consolidation of procedural memories (Karni, Tanne, Rubenstein, Askenasy, & Sagi, 1994).

Insofar as the role of the hippocampus in memory formation changes over time, with its importance diminishing as the neocortex alone becomes capable of supporting usable memory (Squire, 1992), it is conceivable that the dream-lag effect might reflect some aspect of this gradual process of hippocampal/neocortical consolidation and elaboration (see also Maurizi, 1987). Interestingly, some experiments on the effect of hippocampal lesions in animals following a stressful learning experience (e.g., Flexner, Flexner, & Stellar, 1963; Uretsky & McCleary, 1969) have shown temporal patterns similar to those reported for increases in REM sleep (e.g., Smith & Lapp, 1986) and those reported for the dream-lag effect (e.g., Nielsen & Powell, 1989). For example, Flexner, *et al.* reported that bitemporal injections of puromycin up to three days after training caused a persistent amnesia in rats for an avoidance discrimination task; however, four or five days after training, the effects were inconsistent, while at six or more days, amnesia could only be induced by making extensive injections of puromycin in diffuse areas of the brain.

In sum, the results of this study provide further evidence for the existence of the dream-lag effect, that is, a resurgence in the incorporation of a daytime stimulus into dream content following a period of several days. It must be noted, however, that the results were somewhat confounded by the fact that all subjects viewed the videotape on the same day of the week—a factor which needs to be more carefully controlled in further research. Such research should also include assessment of incorporation patterns over extended periods of time as well as use of sleep laboratory procedures to assess dream content throughout the night. The latter is particularly important, as all the research to date on the dream-lag effect has utilized home diary reports which largely sample the final, spontaneously recalled dreams of the final sleep period. Therefore, it is impossible at present to generalize these findings to dreams occurring throughout the sleep period.

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