trial latencies of mice which were not given foot shock on the first trial.

The results obtained for the two groups of mice given electroshock 25 seconds after the foot-shock indicate that electroshock produced amnesia even when it was administered while the animals were anesthetized. The latencies of the two groups were similar; for both groups they differed significantly from those of all the other four foot-shocked groups ($p < .01$), but they did not differ significantly from those of the four groups which were not given foot shock on the first trial ($H = 8.03$, $df = 5$, $p > .05$).

These results indicate quite clearly that the retrograde amnesia produced by electroshock is due to the current and does not depend upon the elicitation of a behavioral convulsion. The findings are, of course, completely inconsistent with the suggestion that the retrograde effect of electroconvulsive shock is due to conditioning of competing responses which are elicited by the shock (*3*). The findings of this study are consistent with other evidence (*8*) that prevention of tonic convulsions does not attenuate retrograde amnesia induced by electroconvulsive shock. Subsequent attempts to understand the basis of the amnesic effect of such shocks should focus on the neurophysiological and biochemical effects of electroshock stimulation.

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11 March 1966

Response during Sleep with Intervening Waking Amnesia

Abstract. *During stage 1 sleep, subjects responded to suggestions on two or more nights, up to 5 months apart. While they were awake they did not recall the material to which they successfully responded while asleep on a subsequent night.*

If a response has been established in the waking condition, subjects will respond during sleep to meaningful cognitive stimuli. Material presented during sleep alone, defined by electroencephalographic (EEG) criteria, is not recalled on awakening (*1*). However, some subjects respond while asleep to cue words associated with meaningful verbal suggestions that had been previously administered during sleep. Throughout administration of the suggestion and subsequent response to the cue, the subject remains in stage 1 sleep, defined by conservative EEG criteria (*2, 3*). Independently, Beh and Barratt (*4*) conditioned and extinguished EEG responses to mild shock in sedated sleeping subjects.

Objective response to meaningful material may be acquired during sleep and retained during periods of stage 1 sleep, but studies of sleep-learning imply that material presented during sleep is not retained after awakening. It is unlikely that the failure of retention after awakening is due to the time interval between sleep-acquisition and waking-recall. Delay between acquisition and response during sleep has been up to 5 hours, in several instances, without intervening awakening; a longer interval than that is frequently employed in sleep-learning studies (*3, 5*). Portnoff *et al.* (*6*) report that material presented during transient wakefulness is not learned unless it is followed by several minutes of wakefulness, which suggests that acquisition occurs only if consolidation occurs, or that any acquisition of responses during sleep cannot be accounted for by the occurrence of transient wakefulness during the acquisition process.

No attempt has been made in the sleep-learning studies to test whether acquisition had actually ever occurred. This could be done by testing retention during sleep. If acquisition and successful sleep-response are demonstrated during sleep, only then is it possible to investigate retention of the acquired response after awakening. Once these conditions are satisfied, waking retention may occur. If it does not, it is possible that material acquired during sleep remains relatively unavailable to waking-recall processes, in much the same way as dreams are often relatively unavailable to waking recall. This hypothesis may be tested by retesting the critical cue words during a subsequent sleep period.

Eighteen paid, male, student nurses each slept in a laboratory for two full nights. They were told only that *E* would be in the room occasionally.

Monopolar occipital, parietal, and frontal EEG were recorded with the use of standard procedures with an Offner Type-R 8-channel dynograph, which provided the sole basis for diagnosing ongoing stage 1 sleep according to criteria described by O'Connell *et al.* (*7*). Suggestions were repeated twice by *E* in a low monotone, and no attempt was made to determine whether *E*'s words were presented above sleeping auditory thresholds. No suggestion or cue word was spoken if the technician signaled the presence of visually detectable alpha-frequency activity superimposed on the otherwise flat, desynchronous, emergent stage 1 EEG record. Although rapid eye movements (REM), inferentially associated with dream reports, occur during this stage of sleep, the presence or absence of REM activity was not considered in the diagnosis of ongoing stage 1 sleep. Stage 1 (descending) sleep following awakening was not used.

The suggestions required a clearly identifiable overt response, and a subjectively experienced (usually negative) affect. A typical suggestion was, "Whenever I say the word 'leg,' your left leg will feel extremely cramped and uncomfortable until you move it." The suggestion was tested by repeating once the cue word "leg." Subsequent repetitions of the cue word were not made for at least 60 seconds. A response was considered successful only if the suggested specific movement was made.

The first suggestion was administered during the first emergent stage 1 period and was then tested. During the next stage 1 period, the same suggestion was tested again, and a new suggestion was administered. Both suggestions were tested, with the appropriate cue word alone, during all subsequent periods of stage 1 sleep that night. Frequency of testing the suggestions varied, depending partly on the subject's level of arousal during the night.

The subject was awakened after 5 to 7 hours of sleep; he was questioned closely about occurrences during the night and his memory for the suggestions. A 20-item word-association test was administered, in which the significant cue words were randomly intermixed with neutral words referring to sleep and parts of the body. Latency of response, and behavioral reactions, if any, were noted. Verbal recall for the suggestions was tested again before the subject went to sleep on the second night. Without readministering the suggestions, the critical cue words were repeated, in the same fashion, during emergent stage 1 periods. A similar procedure was followed when the subject was awakened, after which he was given an exhaustive test of memory.

About 5 months later, 7 of the 18 subjects returned for a third night and were tested in the same way.

Eleven of 18 subjects responded behaviorally while in stage 1 sleep to the appropriate cue words of suggestions administered during this stage 1 sleep period. Six of these subjects responded to the same cue word during a subsequent stage 1 period. The 11 responding subjects received at least two different suggestions during the first night. Eight of these 11 were unable to specify anything that had been said to them while they were asleep. Three subjects were able to recall one of the cue words, but they could not verbalize the complete suggestion and were not aware of the significance of the cue word that they recalled. All three subjects showed at least one instance of transient wakefulness (alpha activity) following at least one administration of the critical cue word (although several of the other subjects occasionally showed some transient alpha activity after cue words). In each case recall was vague and reltively nonspecific. One subject did not respond on either night to the particular cue word that he recalled.

Three of the 11 subjects who had responded to the particular suggestion during sleep also responded to the cue word in the word-association presentation of the cue when they were awake. Of the seven subjects who did not respond during sleep, four responded to the cue word when they were awake. However, six of the responders and five of the nonresponders gave "appropriate" behavioral responses to at least one of the noncritical words (for example, on the stimulus "arm," a subject raised his arm, although the word was unrelated to the suggestion given to that subject).

The mean reaction times to critical cue words and noncritical stimulus words during the word-association test (9.17 and 9.91 seconds, respectively) are not significantly different.

Of the 11 subjects who responded during the first night, seven responded to cue words during the second night. Successful second-night response to cue words during sleep occurred even though the suggestion itself was not readministered and even though the subjects had no intervening waking memory of the suggestions or their sleeping responses. In addition, two of the seven subjects who did not respond during the first night responded to one of the cue words on the second night, again without recalling the words that had been given during sleep.

After a period of about 5 months, seven subjects were retested on a third sleep night. None of the subjects recalled the suggestions of the previous two evenings; five of them had responded on both previous nights to the cue words of the first night. These five subjects responded while asleep to cue words from the two previous nights, even though the suggestions were not re-administered and in spite of waking amnesia during the intervening 5 months.

Subjects are capable of responding during sleep to subjectively affective suggestions that had been administered previously during stage 1 sleep. Behavioral responses are acquired and can be elicited during the night in stage 1 sleep, in stage 1 on a following night, and in stage 1 sleep even after a period of several months without further reinstatement of the suggestion. This retention occurs even though the subject is not able to verbalize these experiences when awake, and the acquired sleep behavior is not carried out by the waking subject.

Apart from the more empirical implications of the results, particularly in terms of the now-dormant issue of sleep-learning, these findings are conducive to several theoretical interpretations. It is possible that acquisition of new experiences must occur within a particular context of other ongoing experience, aspects of which are necessary at a later time to act as a "triggering mechanism" for the subsequent recall or reproduction of the acquired behavior.

Lack of an integrating context during sleep, other than the eliciting cue word, results in a partial autonomy of acquired material from the subsequent waking context (*8*). One such triggering mechanism may be an induced "set" to remember, established before the subject goes to sleep (see *9*).

The conditions under which the waking amnesia can be reversed and the relation between the phenomenon of sleep suggestion and posthypnotic suggestion and amnesia remain to be clarified in future studies.

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9. One subject, who responded to most suggestions during both the first and second nights and who had complete amnesia while awake, by the criteria adopted, on the third night, 5 months later, was hypnotized deeply before sleeping; during this time it was suggested that he would recall all that was said to him during that evening. While asleep he responded to old and new suggestions, and later, when awakened, recall for that evening's procedure was complete. So far this procedure has not been replicated: another possibility yet to be attempted is to establish such a "set" to remember before the subject goes to sleep, but without the use of hypnosis.
10. Supported by grant AF-AFOSR-707-65 from the Air Force Office of Scientific Research. We thank J. Dittborn, U. Neisser, Emily C. Orne, P. W. Sheehan, and R. I. Thackray for their valuable comments, and Mary J. Bryan and R. Lazar for technical assistance.

7 January 1966