

THE NON-RECALL OF MATERIAL
PRESENTED DURING SLEEP

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GLOSSARY

E	Experimenter
S	Subject
EEG	Electroencephalograph, or electroencephalogram

THE NON RECALL OF MATERIAL PRESENTED
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A number of studies have examined the possibility of learning material presented during sleep. The present authors reviewed these studies and found them to be inconclusive due to a failure to satisfactorily determine the S's sleep state while presenting the training material.¹

In an earlier experiment, the present authors used the EEG as a means of continuously monitoring the sleep states of their Ss. Ninety-six questions and answers were presented one time each at five-minute intervals over an eight-hour sleep period, no matter what the S's sleep state was at the time. It was found that sleep states, as indicated by the EEG, correlated highly with the S's ability to recall the material. Practically no recall could be measured when material was presented during periods in which alpha frequencies (8-13 cps) were absent from the EEG record. Learning during actual sleep did not seem possible nor learning during the deep drowsy state too practical.²

Could this have been due to a failure to give repetitive training?

The present study was designed to supplement the first one. In this case, the material was repeated as many times as possible,

but only when the EEG indicated the S was asleep. It was hypothesized that material presented under these conditions would not be recalled.

METHOD

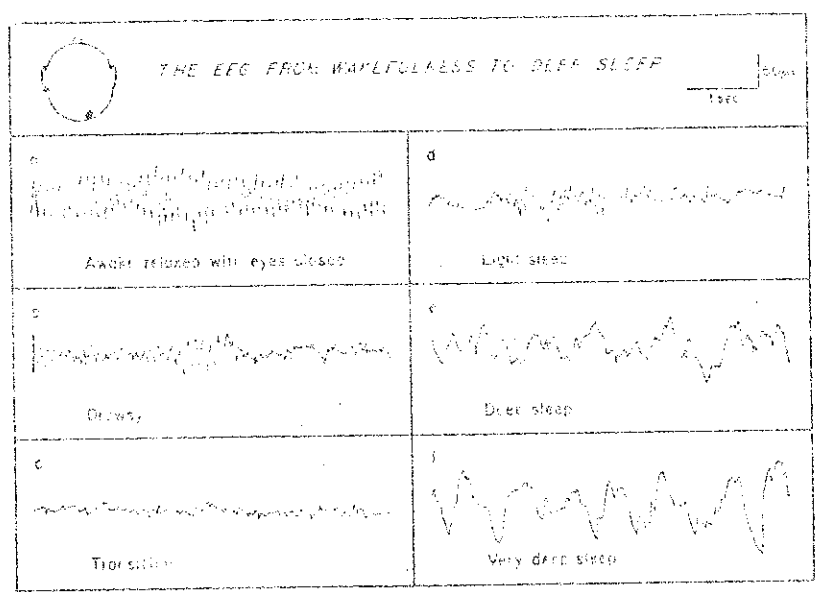
Subjects

Nine male Ss were used. Their ages ranged from 18 to 31 with a mean of 24.9. Their mean IQ as measured by the Otis Self-Administering Test, Form D, was 112 with a range from 102 to 123. All of the Ss had participated in an earlier sleep-learning study and were familiar with the experimental environment. In order to make the fine discriminations from the EEG records at the borderline between wakefulness and sleep, only Ss with persistent waking occipital alpha rhythms were used. Figure 1-a is typical of the waking patterns of the Ss used.

Insert Figure 1 about here

There is no reason to suspect that selection on the basis of the alpha rhythm has any effect on learning while awake or asleep.³

A second group of 113 male college students was used to establish measures of preference for words being used as training material.



Apparatus

Ss slept in clean, comfortable beds in three separate sound-proof air conditioned, electrically-shielded booths. EEG electrodes were applied to the right occipital area, the vertex, and the left mastoid process. The electrode wires were arranged to allow the Ss relatively free movement during sleep. Ss suffered no discomfort from the electrode arrangement. Two monopolar recordings (right occipital and vertex) were made from each S using a six channel Offner electroencephalograph. A marker pen mounted on the ink writer automatically marked the exact time each word was presented to the Ss. The learning material was recorded on magnetic tape and played through loudspeakers placed in the booths. A two-way intercommunication system allowed the Es to communicate with the Ss.

Criterion of Sleep

Figure 1 illustrates characteristic EEG patterns appearing during stages of waking and sleeping. These patterns correspond to those first described by Loomis, et al, and recently elaborated upon in a previous paper by the authors.⁴

The EEG of each S was continuously monitored by the E and the training material was played only when alpha frequencies (as illustrated by Figure 1-a) were absent for 30 seconds prior

to and during stimulation. As a further precaution, the training material was turned off if muscle potentials or movement artifacts were observed in the record, for they tended to obscure cortical potentials.

When alpha frequencies were absent as in Figure 1-c,d,e, the S was considered asleep and the training material was played. These patterns have been related to the sleep state. Davis, et al., observed that Ss typically signalled that they had "floated" or "drifted off" during the period when alpha was absent.⁵ In a later paper, they reported that people no longer turned off a tone as instructed when patterns such as in our Figure 1-d or below were observed.⁶ Blake, et al., found that Ss lost the ability to remember dropping an object shortly after alpha had disappeared.⁷

Kleitman recently reported finding no dreams occurring when patterns such as Figure 1-d or e were observed.⁸

Lindsley reviewed the numerous studies on this subject and concluded that Ss were asleep when patterns similar to our Figure 1-d was observed, although some investigators believed the onset of sleep began when patterns such as Figure 1-c were present.⁹

In order to give the benefit of the doubt to sleep-learning, the lighter level (Fig. 1a, where alpha has disappeared and 14 cycle spindle activity has not yet appeared) was selected as indicating the onset of sleep.

Training Material

A list of 50 one syllable nouns was given to a group of 113 untrained college students who were told that it was a test of ESP. They were asked to pick the 10 words they believed the E had previously chosen by chance. This method made it possible to obtain an estimate of the probability of each word being selected. By chance it would be expected that each word of the 50 would be selected 23 times. The ten words of the 50 that were chosen to be on the training list had a mean frequency of selection of 22.9 with a range from 20 to 25. The order of presentation of the words on the training list during sequential repetitions was varied as the positions in a row of a homogeneous latin square.

Procedure

The Ss retired between 10 P.M. and 12 P.M. The loudness level was regulated in all three booths so that a recording, equated in loudness to the test material could be heard clearly, yet would not be loud enough to materially disturb a soundly sleeping S. The EEG was continuously monitored during stimulus presentation.

Before going to sleep, Ss were given the following instructions: "We are going to play a list of words to you while you sleep. We want you to learn them. If you should awaken during the night, say your name and booth number. If you should awaken and hear anything, say all of the words that you heard."

No attempt was made to play the test material until one hour after the final instructions had been given. If the EEG indicated that a S was asleep and no alpha had been present for the previous 30 seconds, a recording of irrelevant material was played; then, if the S still showed no signs of awakening, the test list was played. It was immediately turned off if there was reason to doubt that the Ss were still asleep. In some instances the S would tend to awaken each time the irrelevant material was played. In these cases the loudness was progressively diminished until it no longer awakened the S, although it was never reduced below the previously determined level of intelligibility.

The material was played to each S as many times as possible. If the S tended to awaken easily, the material was turned off long enough to allow him to go into a deep sleep. The number of times the Ss awoke and whatever they said at these times were recorded.

Because of the necessity of turning off the material when the S showed signs of awakening, it was not possible to present each word an equal number of times. However, it seemed safe to assume that the procedure was a random one and an examination of the number of times each word was presented supported this assumption.

Upon awakening in the morning and before leaving his booth, each S was asked to write down any words he heard or thought he

heard during the night. The papers were collected and the Ss were given the same list of 50 nouns used to select the ten training words. Ss were instructed to read every word on the list and to select the ten words that were played during the night. Upon completing their selections, the Ss were allowed to dress and wash up. After this they were given the same list of 50 words a second time and again instructed to select the ten words played during the night. Ss were further instructed that they could either choose the same words they selected the first time or they could change their selections, whichever they wished.

The Ss then returned to their booths and the list was played through once at the minimum loudness which it had been played during the night. The Ss were asked to repeat each word as it was played. Every word was correctly repeated by all Ss.

RESULTS AND DISCUSSION

The results of this experiment gave no evidence that auditory material could be recalled after being presented a number of times during sleep. From Table I (A), it is evident that the trained experimental group failed to select significantly more correct words than the untrained control group.¹⁰

Insert Table I about here

Table I
 Significance of Differences between Mean Percentage
 Correctly Selected by the Control Group and Various
 Experimental Group Analyses

	Mean % Correct	S.D.	N	t*	d.f.	Level of Significance
CONTROL	20.3	11.8	113	-	-	-
EXPERIMENTAL						
(A) All training items	24.4	8.8	9	1.32	120	<20%
(B) Items with no alpha following within 10 secs.	12.0	19.1	9	-1.28	120	<25%
(C) Items with alpha following within 10 secs.	33.4	17.8	9	2.18	120	<4%
(D) Items with alpha following, but items reported heard removed.	23.9	18.2	9	.58	120	<50%

* When the data from all Ss were combined and the X^2 tests were made, the same conclusions were reached as those drawn from the t tests.

A further analysis was made with the Ss acting as their own controls. Ten new words were selected from the list of 50. From the performance of the control group, it was determined that these new words had the same probability of being chosen as the words in the training list. It was found that the experimental Ss selected on the average the same percentage of "correct" words from the untrained list as they did from the trained list. These results further negate the hypothesis of sleep-learning.¹¹

However, with continuous EEG monitoring while the stimulus was being presented, it was possible to partial out that material which had been presented just prior to the reappearance of alpha frequencies in the EEG; the input was turned off at this time. In an earlier experiment, the authors had found that a portion of the material presented under these conditions—representing a deep drowsy state—were reported heard and could be recalled.¹² When only this material is considered, the experimental group did select significantly more training words than the control group [Table I (C)]. There was no significant difference in the control and the experimental groups' selections on the material remaining after the items presented just prior to alpha were removed [Table I (B)].¹³

Other sleep-learning investigators have eliminated Ss who reported hearing the training material. In this experiment, four Ss reported hearing a total of eight words at the time

of presentation. Only two of these words were recalled correctly upon awakening the next day, five were correctly selected on both posttests and three were never correctly selected. When the words reported heard were removed from those items occurring just prior to the occurrence of alpha, the difference between the experimental and control groups was no longer significant [(Table I(D))]. Thus it would seem that a S must be in a state where he is able to report hearing the material before he is able to recall it.

These negative findings tend to refute the argument that the failure to demonstrate sleep-learning in the first experiment was due to the lack of repetition of the material. In this study, the mean number of repetitions for all Ss was 46.3 with a range from 16.0 to 81.6. Our results are in agreement with those of Stampfl and of Coyne who found no relationship between number of repetitions and amount of sleep-learning.¹⁴

Stampfl has suggested that negative findings in sleep-learning studies may be due to the fact that the Ss were in too deep a level of sleep during the presentation of the test material.¹⁵ In the present study an analysis was made of the EEG records during the presentation periods in accordance with the Sleep Level categories shown in Figure 1. It was found that no material was presented while the Ss were wide awake, (1a), 1.2% of the material was presented in the deep drowsy state, (1b), 15.9% was presented in the transition state where sleep begins, (1c), 57.3% occurred in light sleep, (1d), 22.2%

was presented in deep sleep, (1e), and 3.4% was presented in very deep sleep, (1f). It is unlikely that the negative results in this study are due to too deep a sleep level at the time of stimulus presentation, since 74.4% of the repetitions occurred at the borderline and in the lighter levels of sleep.

The importance of continuous EEG monitoring while presenting the test material in sleep-learning studies is shown by the fact that material could be played on the average of only 2.4 minutes without Ss showing some signs of awakening. Although this interval may increase after an additional adjustment period, it cannot be overlooked by future experimenters for the Ss in this study were already experienced, having spent one or more nights in the laboratory under similar conditions.

SUMMARY AND CONCLUSIONS

A list of ten one-syllable nouns was repeated as many times as possible to nine Ss during an eight-hour sleep period. A continuous EEG recording during the presentation of the training material was used to determine the sleep level at that time. The stimulus material was turned off as soon as cyclical activity within the alpha range was observed. The experimental Ss did not do significantly better than the control group in selecting the words on the training list from a list of 50 words. Nor

did they choose the training words any more frequently than they chose an equivalent list of untrained words. There was some indication that words presented during a period of deep drowsiness can be retained, but this was significant only when the S was also able to give an immediate response to the material being presented. The effects of sleep level and the importance of continuous EEG monitoring while presenting the training material are discussed in their relation to recall. It is concluded that material presented a number of times during sleep (using an EEG criterion) cannot be subsequently recalled.

Footnotes

- * The authors wish to acknowledge the valuable assistance of James L. Barnes and Louie W. Mason, Jr., on the analysis of the data in this study. Appreciation is expressed to the faculty and students of Santa Monica City College and members of the Santa Monica Police Department for their cooperation throughout the project.
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- [9] Lindsley, D. B., op. cit.
- [10] The results from the second posttest paralleled the results of the first so closely that it would have been redundant to have included them in this paper.
- [11] The recall of a group of 37 control Ss improved 47% after hearing a list of 10 words only once, with no instructions to learn and an intervening half-hour period filled with other activity.

- [12] Simon, C. W., and W. H. Emmons, op. cit, in footnote 2.
- [13] It is interesting to note that of the 15 items consistently selected correctly by the 9 Ss on posttests one and two of this experiment, 14 had been presented just before the appearance of alpha. Of those items changed between posttest one and two, only 3 out of 7 were presented just before the appearance of alpha. ($X^2 = 6.92$)
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