The Effect of Frequency of Repetition on the Retention of Auditory Material Presented During Sleep

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THE EFFECT OF FREQUENCY OF REPETITION ON THE
RETENTION OF AUDITORY MATERIAL
PRESENTED DURING SLEEP

by

Thomas G. Stampfl

A Thesis Submitted to the Faculty of the Graduate School
of Loyola University in Partial Fulfillment of
the Requirements for the Degree of
Master of Arts

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1953
Thomas G. Stampfl was born in Cleveland, Ohio, December 28, 1923. He was graduated from James Ford Rhodes High School, Cleveland, Ohio, February, 1942, and from John Carroll University, June, 1949, with the degree of Bachelor of Science in Social Science. He began his graduate studies at Loyola University in September, 1949. At present he is Director of the Victor C. Neumann School for Retarded Children, Chicago, Illinois.
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CHAPTER I

INTRODUCTION

Can you learn while you sleep? If "sleep learning" is possible, what effect does frequency of repetition of the material to be learned have on the retention of this material? These two questions are intimately related ones. If learning is not possible during sleep the effect of frequency of repetition on the retention of material presented during sleep is a meaningless one. On the other hand, if learning is possible during sleep, the question remains as to just what the relationship is between subsequent learning and varying amounts of repetition of the material presented. The present experimental study is an attempt to answer these questions.

Few experimental studies exist concerning the possibility of learning occurring during sleep. Kleitman in his comprehensive summary of the literature on sleep experimentation does not cite any studies which attempt to answer these questions.¹ No scientific published material so far as the writer is aware exists on the subject. An experimental program designed to affirm or refute this question would be of importance for some theoretical questions involved in various theories of learning. If affirmed it could well

¹ N. Kleitman, Sleep and Wakefulness, Chicago, 1939.
play an important role in the practical considerations of an educational psychology. Also, in view of the wide publicity accorded "sleep learning" in the past few years in many of our magazines and newspapers, an impression that learning is possible during sleep has been built up in the public. An impression such as this which is founded on the results of only one investigation bears reexamination and retesting.

It is difficult to assay the opinion of authorities in psychology on the possibility that learning could occur during sleep. Few of them refer to the subject. Those who do, mention it only casually, and implicitly intend that the sleeping state is a state of inactivity so far as learning is concerned. Thorndike states a critical test of the maturation hypothesis:

If by a miracle a child of ten could be kept alive and well, but in a dreamless sleep, for a year and then waked up to resume its ordinary life, it would not thereafter be a year behind in ability to learn.  

Thus Thorndike implies that learning does not occur during sleep since the maturation question is one of learning opposed to the growth of the organism from within. Harmon is more explicit: "... certain simple forms of learning may occur during hypnosis, whereas learning of any sort is impossible to a sleeping subject."  

Pavlov's generally discredited theory that sleep and hypnosis are identical states, seems to allow room for such a thing as sleep learning. He writes, that:

even when the inhibition is widespread there still remain certain

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isolated active points (so to speak on the alert) which are capable of being stimulated. We know this from daily life; a miller is awakened by the stopping of his mill, a mother is roused by a movement of her sick child.4

It is apparent that if such a view were accepted, that is, that certain points capable of receiving sensory stimulation were on the alert during sleep, then there would appear no theoretical obstacle to such a conception as the possibility of learning taking place during sleep. But Pavlov's theory of identity between hypnosis and sleep is thoroughly discredited today. On the other hand, it is Pavlov himself who implies that it is not possible for conditioning to occur during sleep.5 Presumably then, no learning would be possible either.

It would seem upon examination that a real difficulty confronting any investigator who attempts to answer this question lies in the fact that though a great deal of experimentation has been done on sleep, little is known concerning the nature of sleep.6 An additional difficulty lies in the fact that a satisfactory definition of sleep has not been formulated.7

Kleitman says that:

Sleep is commonly looked upon as a periodic temporary cessation, or interruption, of the waking state which is the prevalent mode of existence for the healthy human adult. . . . It is characterized by an almost complete absence of movement. Whatever reactivity is preserved is rather stereotyped and different from the individualized critical analysis of incoming impulses that lead to the elaboration of appropriate

6 Kleitman, Sleep and Wakefulness, 6-9.
7 Ibid., 3.
responses in the waking state. 3

The above definition is largely a descriptive one and implies lack of consciousness or awareness on the part of the sleeping subject, but does not take into consideration that differences in stimulation exist which can bring the sleeper back to consciousness or awareness. Of course, Kleitman is aware of this, but it is noteworthy that he does not include it in his definition.

That differences in stimulation exist which can bring the sleeper back to consciousness points directly to differences in the general level of unconsciousness or unawareness of the subject in the sleeping state. It is characteristic of workers in the field to ignore these differences in their definitions of sleep, but to include them in their descriptions of sleep phenomena as they do when they describe sleep as light or deep. Most investigators would probably agree that sleep is a continuous affair with gradations existing from the lightest sleep to the deepest sleep though as a convenience, most investigators call the sleeping state either light or deep. Under the conditions of the present study no facilities were available to determine adequately whether the subjects were in a state of light sleep or deep sleep so that "sleep" as used by the writer can be interpreted to mean at least a lack of awareness on the part of the sleeping subject with the implication that the state of sleep was at least light, but may have been deep.

It is agreed by a number of investigators that conditioning is not

8 Ibid.
possible during sleep. Since these same writers equate learning with conditioning it is presumed that they would intend by this statement that learning is not possible either. It has been a source of perplexity to the present writer for some time that though learning is considered to be detectable by a number of methods including the method of relearning or saving some investigators ignore this possibility and use the method of recall as the sole criterion of efficiency of learning or even that learning has taken place. Regardless of the theoretical position one takes on the issues of latent learning, it is obvious that responses may not exceed the reaction threshold and hence may not be evident so far as recall or overt responses is concerned, though considerable learning as determined by the saving or relearning method may have taken place. Thus the failure to obtain conditioning during sleep in no way demonstrates that learning has not occurred unless it can also be demonstrated that saving does not occur when the conditioned stimulus is presented in a subsequent waking state. This would appear to be the pivotal point upon which investigators content themselves in either ignoring the possibility of sleep learning, or feeling a priori that such a possibility is slight or impossible. It is apparent that if any advantage in memorizing material which is presented during sleep occurs, such a phenomenon will be strikingly similar to latent learning.


CHAPTER II

REVIEW OF THE LITERATURE

The number of studies undertaken to determine whether learning is possible during sleep is very limited. Kleitman's\(^1\) comprehensive work on sleep phenomena treated a great number of variables such as motility during sleep, effect of time or season on depth of sleep, effect of various drugs on sleep, the criteria of sleep, and the effect of many other variables on sleep. However, he does not refer to the possibility that learning could occur during sleep.

Jenkins and Dallenbach\(^2\) and Van Ormer\(^3\) demonstrated that sleep following learning favors retention. Jenkins and Dallenbach used two subjects who learned ten nonsense syllables to the point of one correct repetition before going to sleep. Recall was used as the criterion of retention, and was much higher after sleep than after equal intervals of activity. Van Ormer used two subjects who learned nonsense syllables either

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3 E. B. Van Ormer, "Retention After Intervals of Sleep and of Waking," *Archives of Psychol.*, 1932, 21, no. 137.
just before bedtime or in the morning. Saving in learning the lists was used as the criterion of retention. Saving was greater after sleep with the difference being statistically reliable after an eight hour interval. Van Ormer made the necessary corrections for learning efficiency at different hours of the day. Both writers concluded that forgetting was due more to the interference of old impressions with new rather than simply the decay of old impressions. A possible alternative is that sleep favors rehearsal of the material on an unconscious or dream level; whereas when the subjects learned lists followed by waking activity they were explicitly told not to rehearse the material.

More pertinent to the possibility of learning during sleep was the study of LeShan. He attempted to stop nail biting by a suggestion that the fingernails tasted bitter. LeShan selected twenty boys at a summer camp who bit their nails, and used twenty other boys who bit their nails as controls. The suggestion was presented with an electrical phonograph. It contained 50 repetitions of the sentence: "My fingernails taste terribly bitter." The record was played six times a night for 54 successive nights. It was played two and one half hours after the children fell asleep. Before the record was played the children were asked, "Is anyone awake?" Volume was lowered and turned off if a child seemed restless. The children did not know that an experiment was in progress. Both the control and experimental children were checked for nail biting approximately every two weeks.

change was observed in nail biting for one month and two days when one of the experimental subjects stopped biting his nails. Seven more of the experimental subjects stopped biting their nails. No questions were asked the boys concerning their dream experiences during the experiment.

The major weakness of LeShan's experiment lies in the great number of repetitions he presented his subjects—a total of 16,200 repetitions! Such a procedure favors the chance waking of subjects on various nights as well as a wide range in the depth of the sleeping state. Presenting the material by means of a loud speaker to twenty subjects at the same time is also hazardous, since volume from a single source must be loud enough to reach all subjects and thus facilitate wakefulness. Finally, a procedure such as LeShan's of presenting a suggestion repetitively is analogous to hypnotic technique and it is interesting to note that the type of behavior he selected to change by sleep suggesting is the type of behavior peculiarly amenable to change through hypnosis. As will be shown later in this paper the hypnotic state is not a natural sleep state, and some authorities specifically write that it is possible to transform an individual from a natural sleep state to an hypnotic one by the use of suggestion.

Schmidhofer⁵ used a sleep presentation technique as a therapeutic symptom alleviating method. Patients at a veteran's hospital received suggestions while they were asleep as well as while they were awake by a broadcast from a tape recording through a loudspeaker. Examples of some of

The suggestions used are: "I can rid myself of any symptoms, completely, and in less than a minute." or "I'm not overly dependent on medicines or doctors."
The patients received the waking portions of the treatment three times each day. The last period was a "live" period, i.e., the suggestions were given by a therapist and followed by a one half hour discussion as to the purpose of the treatment and answering of questions pertaining to it. Statistical techniques were not applied to the results and a control group was not used. Subjective and objective results indicated general improvement in the patients.

The same objection of similarity to hypnotic technique as applied to LeShan's study is applicable to the study by Schmidhofer. In addition, the inclusion of waking suggestion makes it impossible to evaluate the effectiveness of the sleep portion of this study.

The problem of whether learning is possible during sleep was investigated by Charles Elliot at the University of North Carolina. His results were used as the basis of a large number of magazine and newspaper articles. Elliot's thesis was titled, "An Experimental Study of the Retention of Auditory Material Presented During Sleep," but was not published. Since Elliot's dissertation was not available to me, the following account of his study is based on a number of magazine articles6 and personal communications with Elliot and Max Sherover, President of the Lingualphone

6  Look, March 14, 1950.
Science Illustrated, July 1948.
Time, February 2, 1948.
Institute of New York, who supplied the automatic phonograph and recorder for Elliot's study. This procedure is, of course, hazardous; however, this writer feels that by restricting himself to the more factual aspects of Elliot's study as reported in the magazines, and by refraining from filling in details, however reasonable and plausible they may seem, some clarification of the thesis problem might be obtained, and the status of research as it exists today clarified.

Elliot used two groups of twenty subjects each. The two groups were equated for learning ability and intelligence. Volunteer students were used and these students did not know that the experiment was concerned with "sleep learning." The students thought that they were being used to test an electroencephalograph which Elliot used to determine whether his subjects were in the sleeping state. The students slept in a laboratory cubicle alongside another laboratory where all of the necessary apparatus for the experiment was installed. The students were tested one at a time. When the students were asleep as determined by the electroencephalograph, a phonograph was turned on sending through a concealed pillow speaker, a list of fifteen three-letter words: boy, egg, say, art, run, not, sir, leg, bag, row, ice, out, age, box, eat, these words were repeated thirty times. One group of twenty subjects slept while these three-letter words were presented through the pillow speaker; the other twenty subjects slept in identical surroundings with the sole difference that the words were not presented through the pillow speaker. All subjects learned the three-letter word list in the morning. The criteria for learning were time and errors. The subjects who had the list presented to them while asleep made fewer errors
in learning the list, and had a saving in time of approximately 20% over the subjects who did not receive presentations of the list. The magazine articles do not state whether these differences were statistically significant and it is especially important to note that Sherover in his letter said: "As yet, I am not ready to claim that a language can be learned during deep sleep." Since it is impossible to determine from the magazine articles whether there were differences in the depth of the sleeping state, and the number of the subjects who might be involved, little can be said regarding this aspect of Elliot's study. It is known that differences in the depth of the sleeping state are indicated by characteristic patterns in the frequency and wave length of the electroencephalogram.7 As stated above, no information regarding this aspect of Elliot's study was available. The conclusion was drawn, however, that some learning took place while the subject was asleep.

Fox and Robbin8 attempted to test the sleep learning hypothesis by equating three groups of ten subjects each. The material was tape recorded and presented through a Telex miniature pillow speaker. The subjects retired to bed at 11:30 P.M., and the material was presented at 2:30 A.M. by means of an electric clock timing device. One group was presented with


twenty-five Chinese words and their true English equivalents. This was termed the Facilitation Group. The second group received the same twenty-five Chinese words with randomly mismatched English equivalents. This was termed the Interference Group. The third group was used as a control group, and received music instead of verbal stimuli. All groups were presented approximately twenty-nine minutes of the material that had been recorded for them. The experimenter was not present when the material was presented; thus actual verification that their subjects were not awake was not possible. All subjects were questioned and those who reported hearing the machine or waking up were replaced by other subjects. These numbered ten. Saving in learning the lists the following morning was used as the criterion of learning. The subjects were questioned about their dreams in the morning. Some of the subjects reported dreams related to the stimulus material which was presented. The groups differed from each other in the expected direction at better than the 1% level of confidence whether the differences were taken as correlated or uncorrelated. Fox and Robbin conclude: "that learning can occur during sleep and can be detected by the saving method."9

Fox and Robbin make no attempt to define the term "sleep." No distinction is made between possible differences in the depth of the sleeping state. Since some of their subjects reported dreams related to the stimulus material the evidence is unambiguous that at least some of their subjects were in a state of light sleep or one of borderline partial awareness more

9 Ibid., 78.
akin to drowsiness than sleep.\textsuperscript{10}

It is significant that of thirty subjects ten reported hearing the machine or waking up. If one third of their subjects had to be dropped for those reasons, it is legitimate to ask whether a greater percentage of subjects or all of them approached a state of partial awareness. Since the subjects were not observed while asleep one might expect Fox and Robbin to take every possible precaution in order to control the crucial variable of sleep in their subjects. It is known that auditory stimuli; especially auditory stimuli customarily not present to a sleeping subject tend to awaken or produce a change in the sleep level of the sleeper. However, it is also known that a subject quickly adapts to prolonged auditory stimulation.\textsuperscript{11} Fox and Robbin failed to provide a period of adaptation for their subjects with neutral stimuli which might have allowed their subjects to return to a deeper sleep state. Instead their subjects received the to be learned material immediately and abruptly without any chance for adaptation to take place. Chinese verbal stimuli because of their relative strangeness would still further emphasize this need.

Fox and Robbin completely ignore the possibility of a generalized tendency on the part of their subjects toward lighter sleep or partial wakefulness when they defend the possibility that though a few of the subjects might have awakened this is not borne out by the consistency of the


results. In this connection it would have been interesting to examine the data on the ten subjects who were dropped. It is not known whether these subjects were even tested, but if they had been then it would have been possible to compare their scores with those subjects who were not dropped. This would have allowed further examination of the "consistency of results" explanation.
CHAPTER III

METHOD AND PROCEDURE

Subjects: Six male subjects were used. All of the subjects were males and medical students in the Loyola University Medical School. All were sophomores at the time the study was made. The subjects lived at the same house as members of the medical fraternity; it was the second year the subjects had lived together while school was in progress.

Memory Material: Nonsense syllables, selected from Hull's table were used as the memory material and constructed into ten syllable lists. Two lists were used for each frequency of presentation so that in all, eight lists were prepared excluding the lists for the practice sessions. The two lists for each frequency of presentation were approximately equal in strength as determined by Hull's computation. In addition, the nonsense syllables of each list started with the same letter though they were not in the same respective position but were varied systematically. Care was taken to approximate the strength of each syllable at each position in the two lists. Where this was not possible, a nonsense syllable was inserted in another

position in the list so as to offset the associational strength or weakness of the syllable in the other list.

The syllables were recorded in intervals of three seconds between syllables and five seconds between successive presentations of the list. The cue for each ten syllable list was the word "Ready."

Apparatus: An RCA portable wire recorder was used in conjunction with a Telex miniature radio pillow speaker. Few models of this type are on the market. From the standpoint of the experimental procedure, the unusual feature of this recorder is that the wire is contained in a cartridge on two spools of wire. The cartridge slides into a groove in the machine, and has a small slot which is calibrated in minutes. While one spool is playing the recorded material, the other spool is rewinding which, by a turn of a switch, makes it possible to reverse the direction of the two spools. What happens, then, is that by turning the switch the spool which was rewinding plays the recorded material, and the other spool which previous to the turn of the switch was playing the recorded material, now rewinds. The two spool arrangement of the wire enables the operator to record any number of minutes to thirty and play whatever length is recorded back again continuously. Thus it was possible to present as many repetitions of a list as desired without increasing the length of the recorded material.

The Telex miniature radio pillow speaker is a small, flat, light speaker of 128 Ohms made especially for the purpose of enabling the individual to listen to the radio without disturbing others. The speaker slips under the pillow without any noticeable bulge. The recorded material tends to have a
slightly more metallic sound than a larger speaker, but otherwise reproduces faithfully the recorded material.

Method of Learning: The subjects learned the lists by the anticipation method using the wire recorder as a verbal memory drum. Each subject received three practice sessions. At each session he learned one list of nonsense syllables. The subjects, based on the practice sessions, were divided into two groups somewhat similar in ability to memorize (designated as group A and group B).

Group A received four presentations of nonsense syllable list 1 while asleep; group B received no presentations of nonsense syllable list 1 while asleep. The following morning groups A and B learned nonsense syllable list 1 by the anticipation method to the criterion of one complete repetition of list 1 without error. The following night group A received no presentation of nonsense syllable list 2 while asleep; group B received four presentations of nonsense syllable list 2 while asleep. The following morning groups A and B learned nonsense syllable list 2 by the anticipation method to the criterion of one complete repetition of the list without error.

This procedure was followed for the other frequencies of presentation for the remainder of the experimentation. The frequencies of presentation for the entire experimentation were respectively four, thirty-two, sixteen, and eight. Thus, two lists of nonsense syllables were used for the frequencies of thirty-two, sixteen, and eight as described for four so that group A had one list presented to them while asleep and group B did not and both were tested in the morning. The following night group B had the other of the two lists
presented to them and group A did not and both were tested in the morning.

The wire recorder was employed as a verbal memory drum in the following manner—the cue stimulus word "Ready" was used for each nonsense syllable list. The subjects while asleep were presented the nonsense syllable list with the cue stimulus word "Ready" included. In the morning each subject heard the nonsense syllable list and the experimenter repeated each syllable as it played on the recorder; then upon hearing the cue stimulus word "Ready" the subject attempted to anticipate the next syllable and on hearing that syllable the next one and so on to the end of the list. The experimenter recorded all successes and failures. If the subject could not anticipate any syllable he could repeat it aloud when the recorder played it if he chose. Each subject received as many trials as necessary until he reached the criterion of one complete successful repetition of the list.

Each syllable was recorded three seconds apart with five seconds elapsing from the last syllable in a list to the beginning of the same list.

Control Of Conditions: Probably the most important single variable to be controlled was the determination of whether the subjects were actually asleep at the time the recorded nonsense syllable lists were presented to them. The experimenter attempted to control this variable in the following manner: The subjects slept in their own rooms; the experimenter assumed that the subjects would sleep more soundly with familiar environmental conditions rather than with unfamiliar ones. Since it was necessary for the experimenter to enter the subjects' rooms while they were sleeping, he sought to accustom the subjects to the moderate amount of noise he made as well as to the hum of
his apparatus. To accomplish this the experimenter entered the subjects' rooms on three different nights before the main experiment began and played a ten minute recording of music for the subjects. This served a threefold purpose:

1) The experimenter learned to move about in semidarkness in an unfamiliar environment thus enabling him to keep noise at a minimum. He also learned an efficient mode of procedure for setting up his apparatus.

2) The experimenter hoped that the subjects would become accustomed to the moderate amount of noise that he made as well as to the low hum of the recorder, while the music served to adapt the subjects to the characteristic stimuli coming from the pillow-speaker.²

3) Finally, through these initial practice entrances, the experimenter had a chance to observe the subjects while they were asleep and note their respiration, breathing, and movement.

In the actual presentation of the experimental material for the various frequencies, the experimenter entered the subjects' rooms approximately one to three hours after the subjects had gone to bed. The experimenter noted the respiration, movement, and general resemblance to the sleeping state of the subject. The experimenter then played the same ten minute recording of music through the under-the-pillow speaker, and then

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asked the subject if he were awake. If the subject did not respond to this question the experimenter played the recorded nonsense syllable list the previously determined number of repetitions. At the conclusion of the list the experimenter again asked the subject if he were awake. This procedure is considered a valid one for determining sleep. In addition the time of year in which the experiment was conducted (from the beginning of April to the middle of June) is optimal for ease of going to sleep and soundness of sleep in comparison to the other periods of the year.

The subjects learned the lists the following morning under these conditions: The room used for learning the lists was an isolated one in the basement where noise and distractions were at a minimum. Light conditions were the same from morning to morning. The subjects learned the lists after waking at their usual time in the morning. When the subjects learned the lists they were not aware whether the experimenter had presented them the lists while they were asleep or not. The subjects were questioned in the morning before testing, and at no time could any of the subjects tell with certainty whether the experimenter had or had not presented the list to them while they were asleep. In all cases the subjects reported they had slept well or reasonably well the previous night. All of the testing was done within a period of thirty days. All six subjects were tested for each


frequency of repetition on the same morning, i.e., three of the six subjects received sleep presentations of the material and all six of the subjects were tested in the morning. This served to keep conditions when the subjects were learning the lists more constant than they might have been if the subjects had been individually tested over a period of days. Also, it was likely that whatever effect school requirements have on the mood and temperament of subjects which might conceivably affect learning to some extent on a particular day would be more nearly constant if testing were carried out in a single day, because the subjects being sophomores in a medical school were required to take the same courses, and were at the same stage in each course.

Practice Sessions: It has been considered imperative in any study involving learning to give subjects initial practice sessions at learning similar material before the main experimentation begins.

Reasons for administering: Some of the reasons for this practice consists in:

1) Practice enables the subject to make a general adjustment to the conditions of the total learning situation, and eliminates excessive emotional reactions to it.

2) The subject develops characteristic modes of attack in order to learn the material more rapidly.

3) Since a general adjustment is made to the situation, and more efficient modes of attack are developed, the subject invariably improves rapidly at a learning task after practice. Improvement is usually very rapid with small amounts of practice, but after
larger amounts of practice improvement is gradual and tends to
die out.

Each subject received three practice sessions; at each session he learned one
list of nonsense syllables ten syllables in length.

The group was divided into two sections. Group A had a total of
58 trials and Group B had a total of 60 trials on the third practice list.

Instructions for the practice sessions: "The syllables you are
going to hear on this recorder are nonsense syllables. These syllables will
have little meaning to you, and may be a little difficult to pronounce at
first. When I start the recorder I want you to say the syllables as they are
spoken on the recorder. After you have pronounced each syllable, the same
syllables will be played on the recorder again—-it is your task, your job, to
anticipate, to say out loud, the syllable which is going to come. For example
if there were numbers recorded instead of syllables—-say 6, 12, 9, 15, and 4,
on hearing the word "Ready" on the recorder you would say 6, when the recorder
played 6, you would say 12, when the recorder played 12, you would say 9,
when the recorder played 9, you would say 15, when the recorder played 15,
you would say 4, and you would do the same for the rest of the numbers in the
list. Suppose that instead of syllables I had recorded the numbers 6, 12, 9,
15, and 4 in that order. Now if I took the place of the recorder and said
"Ready" What would you say?" (At this point the experimenter took the place
of the recorder and said "Ready." When the subject responded "6" the
experimenter repeated "6" and when the subject said "12" the experimenter
repeated "12." Only when the subject anticipated all of the numbers correct
did the experimenter continue): "Of course, nonsense syllables are more difficult than numbers so don't become discouraged if it seems difficult to do at first, but keep on trying as hard as you can. I'm interested in how many successes or correct anticipations you make on each trial as well as how many trials it takes you to learn the complete list. So even though you get off to a bad start on a particular trial or list, don't become discouraged and quit trying for the rest of the list, but try as hard as you can all the time."

Experimental Design: As will be noted in the previous section under "Method of Learning" the experiment was one of a simple counterbalanced order with the subjects acting as their own controls. This design appeared best to the writer for the purposes of the study. It is a difficult problem at best to equate two groups adequately, but the difficulty is accentuated when small numbers are used and the sample available to select from is limited. The subjects, based on the practice sessions, were divided into two groups roughly similar in ability to learn nonsense syllables by the anticipation method utilized in this study. It was thought that this would facilitate the statistical computations involved in the experiment. It will be noted that the six subjects were relatively homogeneous by reason of the selectivity contained in those students who qualify for medical school. In addition, all were sophomores at the time the study was made. In dividing the two groups on the basis of the practice sessions it was thought that the most valid indication of a subject's ability to learn this material was his score on the last practice list learned rather than on the mean of the three lists or some other composite measure. It seemed likely that a number of
extraneous variables such as initial emotional reaction might affect a subject's performance on the first practice list and possibly the second list which would radically distort his true ability for learning these lists. However, if an extraneous variable as this were eliminated at all, it would be eliminated or tend to be less effective by the time the subject learned the third practice list. The results of the third practice list are given below:

**TABLE I**

RESULTS OF THE THIRD PRACTICE LIST

<table>
<thead>
<tr>
<th>Subjects of Group A</th>
<th>Score on third practice list</th>
<th>Subjects of Group B</th>
<th>Score on third practice list</th>
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<tr>
<td>1</td>
<td>30</td>
<td>4</td>
<td>13</td>
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<td>2</td>
<td>14</td>
<td>5</td>
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</tr>
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<td>3</td>
<td>14</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>58</td>
<td>Total</td>
<td>60</td>
</tr>
</tbody>
</table>

In view of the finding of Van Ormer\(^5\) that even extensive practice does not completely obliterate slow, but gradual improvement in learning, it was thought advisable to stagger the frequencies of presentation. Thus, instead of presenting material at four, eight, sixteen, and thirty-two repetitions, the material was presented at four, sixteen, eight, and thirty-

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\(^5\) E. B. Van Ormer, "Retention After Intervals of Sleep and Waking," *Archives of Psychol.*, 1932, 21, 137.
two repetitions. This procedure, it was thought, would offset any spurious increase the greater number of repetitions might receive as a result of improvement through practice.
Learning of First and Second Lists: The following tables represent the results for learning the nonsense syllables for all four stages of the experimentation. The designation "After sleep presentations" in the tables indicates the learning of a list after the stated number of repetitions which were presented during sleep. "Without sleep presentations" in the tables indicates that the list was learned in the morning without previous sleep repetitions.

Percentages Saved: Saving in learning the lists after sleep repetitions was evident at only one frequency of the various frequencies of repetition, that for four repetitions of the material where one hundred and eleven trials were required after sleep repetitions and one hundred and twenty trials when the material was not presented during sleep. The difference of nine trials in favor of material learned after sleep repetitions resulted in a t score* of .54 which would occur approximately sixty times out of a

\[
D_0 = \sqrt{\frac{E D^2}{N} - \frac{(E D)}{N}^2}
\]

*computed by the formula for correlated small samples:

hundred by chance alone and consequently, is not significant. All other frequencies revealed a saving for material learned without sleep repetitions. At eight repetitions there was a saving of eighteen trials, at sixteen repetitions a saving of 20 trials, and at thirty-two repetitions a saving of eight trials. On the hypothesis that sleep repetitions interfere with learning statistical measures of confidence were calculated. The saving of eighteen trials for material learned which was not presented during sleep resulted in a t score of 1.677 and would occur by chance alone between fifteen and twenty times out of a hundred. The saving of twenty trials at sixteen repetitions yielded a t score of 1.522 and would also occur between fifteen and twenty times out of a hundred by chance alone. The saving of eight trials at thirty-two repetitions yielded a t score of .347 and would occur between 60 and 80 times out of a hundred by chance alone. None of these measures are statistically significant so the hypothesis that sleep repetitions interfere with learning is not verified.

The data contained in Tables III, IV V and VI refer to the cumulative successes or the cumulative number of syllables learned on the first five trials. It was thought that the advantage which would accrue in learning after sleep repetitions might be manifested in the first trials of learning and disappear as a result of obscure masking factors on later trials. Thus, the results of subject 2 in Table III would be read as follows: Subject 2 on the first trial learned three syllables, he then succeeded to anticipate five syllables on the second trial which gave him a cumulative score of eight successes or correct anticipations. He only succeeded on one syllable on
TABLE II

TRIALS NECESSARY TO REACH CRITERION OF ONE REPETITION OF LIST WITHOUT ERROR

<table>
<thead>
<tr>
<th>Number of trials</th>
<th>Group A Subjects</th>
<th>Group B Subjects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>After 4 sleep presentations</td>
<td>17</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Without sleep presentations</td>
<td>26</td>
<td>22</td>
<td>18</td>
</tr>
<tr>
<td>After 8 sleep presentations</td>
<td>21</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Without sleep presentations</td>
<td>20</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>After 16 sleep presentations</td>
<td>30</td>
<td>7</td>
<td>29</td>
</tr>
<tr>
<td>Without sleep presentations</td>
<td>20</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>After 32 sleep presentations</td>
<td>23</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Without sleep presentations</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
### TABLE III

**CUMULATIVE SUCCESSES THROUGH FIRST FIVE TRIALS AFTER 4 SLEEP PRESENTATIONS**

<table>
<thead>
<tr>
<th>Group</th>
<th>Subject</th>
<th>Trials after 4 sleep presentations</th>
<th>Trials without sleep presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>0 0 3 3 3</td>
<td>1 4 7 10 11</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3 8 9 12 20</td>
<td>0 2 6 10 15</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0 0 0 0 0</td>
<td>1 2 2 2 3</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>2 2 4 9 13</td>
<td>0 2 4 8 12</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>1 5 9 14 21</td>
<td>2 5 6 11 15</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2 5 9 11 11</td>
<td>1 3 5 6 9</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8 20 34 49 68</td>
<td>5 18 30 47 65</td>
</tr>
</tbody>
</table>

### TABLE IV

**CUMULATIVE SUCCESSES THROUGH FIRST FIVE TRIALS AFTER 8 SLEEP PRESENTATIONS**

<table>
<thead>
<tr>
<th>Group</th>
<th>Subject</th>
<th>Trials after 8 sleep presentations</th>
<th>Trials without sleep presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 2 3 4 5</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>3 8 14 20 26</td>
<td>0 1 1 2 3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2 6 9 13 20</td>
<td>1 5 10 19 21</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4 7 15 19</td>
<td>1 4 6 12 19</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>0 1 2 4 7</td>
<td>1 4 8 14 25</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>2 4 6 10 13</td>
<td>0 2 6 10 17</td>
</tr>
</tbody>
</table>
### TABLE IV (Continued)

**CUMULATIVE SUCCESS THROUGH FIRST FIVE TRIALS**
**AFTER 8 SLEEP PRESENTATIONS**

<table>
<thead>
<tr>
<th>Group</th>
<th>Subject</th>
<th>Trial after 8 sleep presentations</th>
<th>Trials without sleep presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>12</td>
<td>30</td>
</tr>
</tbody>
</table>

### TABLE V

**CUMULATIVE SUCCESSES THROUGH FIRST TRIALS**
**AFTER 16 SLEEP PRESENTATIONS**

<table>
<thead>
<tr>
<th>Group</th>
<th>Subject</th>
<th>Trial after 16 sleep presentations</th>
<th>Trials without sleep presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7</td>
<td>29</td>
</tr>
</tbody>
</table>
*TABLE VI*

CUMULATIVE SUCCESSES THROUGH FIRST FIVE TRIALS
AFTER 32 SLEEP PRESENTATIONS

<table>
<thead>
<tr>
<th>Group</th>
<th>Subject</th>
<th>Trials after 32 sleep presentations</th>
<th>Trials without sleep presentations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>8</td>
<td>25</td>
</tr>
</tbody>
</table>

The fourth trial giving a cumulative score of twelve, and then anticipated eight syllables on the fifth trial giving him a total cumulative score for the first five trials of twenty. All of the cumulative scores of the other subjects are calculated in the same matter for learning after sleep presentations, and for learning with no sleep presentations. At no frequency was learning after sleep repetitions more rapid as measured by cumulative successes on the first five trials. Thus this hypothesis was not borne out.

A saving of 9 trials was evident at 4 frequencies of repetition for material presented during sleep over material which was not presented during...
sleep. At 8, 16, and 32 repetitions a saving in learning was evident for material which was not presented during sleep. Saving in trials for these frequencies was respectively 18, 20, and 8 trials. None of the saving scores for either sleep or non-sleep presentations was statistically significant for the various frequencies. Cumulative successes on the first 5 trials did not result in statistically significant differences for material learned after sleep presentations on any of the various frequencies. When cumulative successes favored the learning of material which had not been presented during sleep no statistically significant difference was evident.

A comparison of the learning curves for material learned after sleep presentations and for material learned without sleep presentations disclosed no unusual difference in these curves. The sleep and non-sleep curves were quite similar and showed positive acceleration followed by negative acceleration.

Interpretation: It is difficult to properly evaluate the significance of this study. The negative results obtained seem to indicate that the "sleep learning" hypothesis is a doubtful one. However, it must be remembered that Elliot obtained results which were apparently positive. It is important, then, to sift out the similarities and dissimilarities between the present study and Elliot's study with a view toward isolating the variables which might be responsible for the difference in results.

One difference existing between the present study and Elliot's study was the choice of material to be learned. Elliot used three letter words though they were not meaningfully connected. The present writer used
nonsense syllables.

A far more important consideration appears to be the determination of the depth of the sleeping state at the time the subjects received presentations of the learning material. As stated previously, the present study did not control the factor of "depth" of the sleeping state. In view of the negative results obtained it may be argued that the subjects were in a state of relatively deep sleep where learning might not be possible. It is interesting to note relative to Elliot's study that no claim for learning during deep sleep was made in the magazine articles, or in Elliot's letter. In addition, Sherover explicitly stated that he could not claim learning could occur during deep sleep. Furthermore, it is considered rather difficult to insure deep sleep in subjects. In this connection Kleitman says that sleep deprivation seems to be the best method to obtain deep sleep records from most subjects.1 It must be emphasized that Elliot's subjects slept in a laboratory which was probably conducive to less favorable sleeping conditions even if some adjustment to the strange sleeping environment was attained through preliminary practice sessions.

Since Elliot used the electroencephalograph to determine whether his subjects were asleep it is pertinent to consider some characteristic electroencephalographic patterns indicative of sleep. During the waking state alpha waves predominate when the eyes are closed, but as an individual becomes drowsy the alpha waves become less frequent until at the beginning.

1 Kleitman, Sleep and Wakefulness.
of light sleep the alpha waves disappear entirely. Large "random" potentials are characteristic of deep sleep. While an individual is asleep, auditory stimuli may cause alpha waves to reappear temporarily though the individual does not appear to awaken. The point to be made here, however, is that a subject might be in a state in which though light sleep might be indicated by the electroencephalographic pattern, the state might be one in which learning is definitely possible since the state is not actually one of light sleep. In other words, two distinct states might be represented by electroencephalographic patterns which are similar or identical. Evidence for this view comes from the finding that the electroencephalographic pattern in a trance state may be the characteristic one of light sleep. Learning is known to be possible for an individual in a trance state though some investigators have found that the characteristic alpha rhythm more closely approaches that of the waking state rather than light sleep. The two findings are not necessarily contradictory since the conditions under which the

3 Lindsley, "Electroencephalography," Personality, 2, 1068.
6 Lindsley, "Electroencephalography," Personality, 2, 1061.

investigations were made varied. This is extremely important since the electroencephalographic pattern characteristic of light sleep was presumably used by Elliot in his study. It follows that if some of his subjects were in a trance state then they might have yielded an electroencephalographic pattern characteristic of light sleep, of course, at the same time been capable of learning. That this is not an unreasonable view of what might occur when auditory stimuli are presented to a sleeping subject is reflected in the known facts of hypnotic phenomena where it has been considered possible to transform a sleeping individual into a hypnotic trance by purely verbal stimuli. 8

Thus there appears to be rational grounds for questioning Elliot's results. In view of the consistently negative results yielded in this study and in view of the questionable aspects relating to the positive results obtained in Elliot's study, it would seem that an appraisal of these results leads to the conclusion that learning during sleep as sleep is defined in this paper, has not as yet, been demonstrated.


CHAPTER V

SUMMARY AND CONCLUSIONS

Authorities in the field of psychology imply that sleep is a state in which learning cannot occur. The experimental determination of such a possibility is important for the practical and theoretical considerations of psychology and education.

The evidence from relatively recent experimental studies indicates that such a possibility as learning during sleep exists. The possibility follows as a direction of study from the work of Jenkins and Dallenbach and Van Ormer who demonstrated that sleep following learning favors retention. LeShan and Schmidhofer used sleep suggestion as a therapeutic technique, and reported results which favored the hypothesis that learning could occur during sleep. Elliot and Fox and Robbin more directly tested the sleep learning hypothesis. No highly positive results were obtained in Elliot's study; whereas the results of the Fox and Robbin study were highly positive.

The purpose of the study was to determine the effect frequency of repetition had on the retention of material presented during sleep. A test of whether sleep presentations aided subsequent learning in any way was also possible and served as a secondary purpose of the study. In order to test these hypotheses, six subjects were presented nonsense syllable lists while...
they were sleeping in a varying number of repetitions, and in a varying order. Three of the six subjects actually received sleep presentations of the material and all six learned the list the following morning by the anticipation method. The subjects alternated in groups of three in having the learning material presented to them while they slept. Thus, a counterbalanced order was used with the subjects acting as their own controls. No significant advantage for learning occurred for material which had been presented during sleep. In fact, there was a fairly consistent advantage in learning for material which had not been presented during sleep, but this difference was not statistically significant.

The results of this study indicate that the hypothesis that learning can take place during sleep is uncertain and improbable, and makes the question as to what effect frequency of repetition has on retention a meaningless one. However, there are so many uncertain aspects to the phenomenon of sleep that further careful studies should be undertaken to corroborate the present conclusion or reject it as the evidence warrants. Inherent in the problem is a fairly adequate operational definition of sleep that would be sound logically. The possibility of learning taking place during sleep is an important one to those who are interested in the problems of education. There are many possible applications of such an approach, and all aspects of the problem should be thoroughly investigated before a result is accepted as final.
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Kleitman, N., Sleep and Wakefulness, Chicago, 1939.

B. ARTICLES


The thesis submitted by Thomas G. Stampfl has been read and approved by a board of three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Arts.

January 30, 1953
Date

Signature of Adviser