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The Result of Auditory Presentation During Sleep of Meaningful Material

Donald J. Tyrell
Loyola University Chicago

THE RESULT OF AUDITORY PRESENTATION DURING SLEEP OF MEANINGFUL MATERIAL

by

Donald J. Tyrell

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Life

Donald J. Tyrell was born in Boston, Massachusetts, November 13, 1929.

He was graduated from Boston College High School, Boston, Massachusetts, June, 1946, and from Boston College, June, 1953, with the degree of Bachelor of Science. He began his graduate studies at Loyola University in September, 1953. At present the author is Director of the Victor C. Neumann School for Mentally Retarded Children at Association House of Chicago, Chicago, Illinois. The author is also associated with the University of Illinois Institute for Research on Exceptional Children as an interviewer of parents of mentally retarded children.

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Chapter I

Introduction

Scientific writings as well as literary exploits have from earliest times been concerned with the subject of sleep and its accompanying phenomena. Even today, in spite of scientific advances, the exact nature of sleep has yet to be determined. Various theories of sleep are presented in the literature and new theories of sleep are constantly being developed. The fact that so little evidence concerning sleep has been gathered presents fertile ground for the experimental psychologist and investigators in related disciplines to study this problem and its ramifications. The psychologist, by utilizing his knowledge of human behavior, and by the application of the scientific method to sleep problems, may find results that will help him to arrive at a more reasonable explanation of sleep phenomenon than has hitherto been offered.

The discovery of the electroencephalograph by Berger opened many new areas of investigation for learning theorists and experimenters concerned with sleep phenomenon. With the EEG, as it is called, it is possible to determine and precisely measure electrical brain activity during various types of cortical activity, a feat which hitherto was impossible.

EEG patterns during sleep show a decrease in cortical-electric activity. If the intensity of EEG record of an awake subject is

indicative of his learning, it would seem reasonable to assume that as long as there is some measurable electro-cortical change, there may be some learning taking place. It has been demonstrated by means of the EEG machine that, in fact, electro-cortical activity does take place during sleep (5, 11, 12, 13) but at a very reduced rate, and that as the sleeper awakens, this activity increases in intensity.

It seems possible that a subject might learn during sleep, but at a much slower rate than during the conscious state. The fact that the subject may not be aware of having learned during sleep, or even that he may not be aware that he was subjected to stimulation during sleep, cannot be offered as evidence against sleep learning, for it has been experimentally verified that people are constantly learning without awareness (30, 32, 52, 68).

Experience points to the possibility of sleep learning. Consider, for example, the urban parent who sleeps undisturbed by the many loud noises of the city, to which he is constantly subjected, but who seems to awake almost instantly upon receiving the stimulus of a crying baby, a stimulus less noisy than sounds which do not disturb him. Inhibition of response or selective forgetting may account for the parent's failure to respond to the city noises and therefore the example does not prove sleep learning. However, the fact that the baby's crying does awaken the parent does indicate that the parent has auditory contact with his external environment and that he has learned

a stimulus-response habit pattern to which he conforms during sleep.

We know that sleeping people often react to external stimuli without conscious awareness of their reactions (12, 13, 14, 29, 40, 42). The response producing stimuli may be auditory as in the case of the sleep-talker who coherently responds to questions, visual, as in the case of the sleep-walker who avoids objects, or, tactual, as has been demonstrated by physiological changes in sleeping subjects presented tactual stimulation during sleep (29). Evidence also indicates that dreams can be induced or modified by external stimulation (15).

Further evidence that sleep-learning is a possibility is offered by the fact that many people report retiring with a perplexing problem and awake with the problem solved or at least able to be solved. This phenomenon may be due to the rest factor, i. e. the organism may be incapable of solving the problem at night because of its physiological inability to function properly during a state of tiredness, but it may also be due to learning during sleep in the form of analyzing and problem solving on an unconscious level.

Experiments show that a greater amount of material is retained after an interim of sleep than after an interim of conscious activity (28, 35, 37, 58, 71, 72). While more retention after sleep does mean learning during sleep, the evidence indicates that sleep-learning may be a fact.

There seems to be nothing in the literature to indicate that

learning during sleep is impossible. On the contrary, experimentation indicates that sleep-learning is a possibility, and recent studies seem to indicate that sleep-learning is a fact (17, 21, 46).

The purpose of this study was to test the hypothesis that sleep-learning is possible, and that it can be demonstrated by testing subjects using the anticipation method of serial reproduction of lists of meaningful material, some of which are presented during sleep and others not. This study will also attempt to determine if the frequency of presentation of sleep material also affects the amount of retention. If learning itself during sleep cannot be demonstrated, of course the question of frequency of repetition and its relation to sleep learning becomes meaningless.

It may seem strange to the casual observer that so little scientific material has been published concerning sleep learning. Yet, in spite of this fact, there are many items on the market designed for people who wish to learn during sleep. One company reports that an entire new language may be learned while asleep. Perhaps one of the reasons for so little scientific investigation of sleep learning lies in the fact that so little is known about sleep itself. It is, therefore, difficult to know just what we are studying. It is more difficult to define this state.

The author of this paper is aware of no definition of sleep which will satisfy both the requirements of this study, and, at the

same time, agree essentially with definitions offered by previous investigators of sleep-learning. Therefore, for the purposes of this study, a subject was considered to be asleep if he failed to respond to auditory stimulation in the form of a question presented by the experimenter, "Are you awake," in a way that could be noticed by the experimenter. That is, if the subject, having been asked the question in a voice loud enough to be heard by others in the room, made no verbalization, and if there were no muscular changes or movements noticed by the experimenter, the subject was considered to be asleep.

Subjects of this experiment were probably, therefore, in what would be commonly thought of as a deep state of sleep. It was felt that if it could be demonstrated that subjects can learn while in this state, it would be even more probable that they could learn while in a lighter state of sleep. On the other hand, it was felt that a demonstration of learning in a light state of sleep would not necessarily prove learning in deep sleep, because light sleep is not necessarily a true sleep state but rather may be an interim between sleep and wakefulness. But still if learning cannot be demonstrated during a deep state of sleep, it should not be concluded that learning does not, or cannot, take place during a lighter state of sleep.

Chapter II

Review of the Literature

Perhaps the most comprehensive writings on sleep, its effects, and concomitant conditions, in present day literature, are those of Kleitman (40, 41, 42). In these works, the author discusses all the well known variables concerned with sleep, such as movement of the subject during sleep, depth of the sleep state, time factors, and their influences on sleep, effects of drugs on the sleeping subject, and on the sleep state, etc.

Kleitman defines sleep as, ". . . a periodic, temporary cessation or interruption of the waking state which is the prevalent mode of existence for the human adult" (40, p. 3). In spite of his analysis of sleep states, Kleitman's definition fails to note that in spite of the lack of consciousness of the subject during sleep, stimulation during sleep, of which the subject is later unaware, can both affect his sleeping state and influence his activities during sleep.

Kleitman offers a negative definition of sleep, that is, a non-waking state, but his writing gives us little indication of what sleep is in a positive sense.

In spite of the fact that the exact nature of sleep is not known, most authorities would agree that sleep is a gradual departure from wakefulness. Pavlov claims that sleep is identical with hypnosis

(60). Other investigators, however, disagree with this theory, and today sleep is considered by most authorities to be a cessation of wakefulness and a continuous departure from wakefulness according to what has been termed the depth of sleep.

The depth of sleep has been accurately demonstrated by observing changes in electroencephalographic recordings of sleeping subjects (10, 11, 12, 13). Blake (5) relates shifts in cerebral electropotentials to the presence of associational and symbolic activity during sleep and shows that subjective reports of sleep and dreams can be correlated with potential patterns (5). Blake shows that cerebral activity results from auditory stimulus material presented to a sleeping subject, and that such cerebral activity can continue without awakening the subject.

Harmon claims that, ". . . learning of any sort is impossible to a sleeping subject" (31, p. 285) but he offers no experimental evidence for this statement. White would seem to agree with this view. In a paper in which he distinguishes sleep from hypnotism, he says that a hypnotized subject, ". . . remains capable of fairly active mental operations" (74) and thus it seems that White would claim that a sleeping subject is not capable of this same mental activity.

Franz and Lashley (22, pp. 152-176) investigated the function of the frontal lobes in the retention of associations formed in learning with cats and monkeys. They concluded that newly formed associations

are primarily dependent on activity of the frontal lobe. We cannot, of course, conclude from their experiments that the same situation is true in man, nor can we conclude that frontal lobe activity per se is enough to cause learning. But it is agreed that the presence of brain activity is necessary for learning in all species, including man, and there does seem to be a significant correlation between the amount of brain activity and the amount of learning of a subject.

White distinguishes sleep from wakefulness when he says, ". . . there is a continuum from the wide-awake state through drowsiness to sound sleep" (74, p. 499). He also distinguishes sleep from hypnotism when he claims that, ". . . the hypnotized person is in no true sense asleep (and) he remains capable of fairly active mental operations" (74, p. 500).

Few experimental studies have been performed to determine the possibility of learning during sleep. Perhaps the most recent study concerned directly with the possibility of sleep learning is that by Thomas Stampfl (67). Stampfl used six subjects and presented them with lists of nonsense syllables during sleep in a varying number of repetitions and in varying order. The subjects acted as their own controls and on half of the nights received sleep material, and on half of the nights did not receive sleep material. "No significant advantage for learning occurred for material which had been presented during sleep" (67, p. 36). Stampfl concludes that ". . . the hypothesis that learning can take place during sleep is uncertain and improbable" (67, p. 36).

The major criticism of this work is that although nonsense sylla-

bles were used in an attempt to limit the interference of previous associations in the learning experiment, this very fact of limitation of associations may have resulted in such a small amount of learning that learning during sleep could not be demonstrated. It may be that if sleep learning is to take place, the subject needs all the advantages of a normal learning situation, that he needs any associative "hooks" that can be utilized.

Charles Elliott (17) utilized forty subjects, twenty of whom were control subjects in an experiment directly concerned with sleep learning. To each of these subjects he presented, during sleep, fifteen three letter words, not meaningfully connected, by means of an under the pillow speaker. Elliott found a twenty per cent savings by subjects who had been presented the sleep learning material. He used an electroencephalograph to determine the depth of sleep. The twenty experimental subjects were equated in learning ability and intelligence.

The major criticism of this experiment is that Elliott did not condition his subjects to the experiment. Subjects slept in a strange environment and this introduced a variable that was not controlled. Although Elliott did use an EEG machine to determine the depth of sleep and to determine if subjects were asleep, he did not use this machine during the entire presentation of sleep material for each subject. Elliott does not report the depth of sleep of the subjects, and, more important, he does not tell us if his results are statistically significant.

Le Shan (46) used suggestion presented during sleep to twenty subjects who were nail biters. He also used twenty control subjects. He

reports that eight out of twenty stopped biting their nails. His experimental procedure consisted of playing a record through the loud speaker to twenty boys, six times a night, for fifty-four successive nights. It was played two and a half hours after the subjects were asleep. His criterion of sleep was failure to respond to the question, "Is anyone awake," The volume of his apparatus was lowered and turned off if any subject seemed to be showing signs of waking. The subjects did not know the experiment was in progress.

The major criticism of this experiment is against the method of presenting the sleep material. It seems doubtful that twenty subjects in one room, being presented material loud enough for all to hear, could sleep through the material to the number of repetitions used by Le Shan. Although Le Shan claims that the subjects did not wake up, it seems probable that because of the method of presentation of material, and because of the age of the subjects, some of them because of curiousity might have failed to report waking and yet actually have been awake during at least part of the experimental procedure.

Schmidhofer (65) used suggestion presented during sleep to patients in a veteran's hospital. The same recorded suggestions were presented to the same patients while they were awake. The results of the experiment were not studied statistically and a control group was not used. Results of the study do seem to indicate that in some instances suggestions presented to sleeping subjects did facilitate improvement of the patients. However, because of the nature of Schmidhofer's experimental de-

sign, it was not possible to determine if sleep learning took place. Schmidhofer presented his material both during sleep and waking hours, and therefore it was impossible to determine if any, or to what degree, sleep learning took place.

Fox and Robbin (21) used three groups of ten subjects per group and presented them with given material by means of a Telex under the pillow speaker, presented automatically by means of an electric clock timing device. Group one was presented twenty-five Chinese words with true English equivalents. This was the facilitation group. Group two, which was called the interference group, was presented twenty-five Chinese words with mismatched English equivalents. Group three was called the control group and was presented music. All groups received material during sleep for about a half hour. The results of this study showed differences favoring the group presented with material during sleep, which were significant at better than the one per cent level. From these results Fox and Robbins concluded that learning can occur during sleep and can be detected by the savings method (21, p. 78) which was the method they used the following morning as a criterion of learning.

The major criticisms of this study are that Fox and Robbins gave no definition of sleep and that the experimenters were not present during the experiment. Ten of thirty subjects reported hearing the machine during sleep, and it is quite possible that they also heard the sleep material during the time when they were not actually asleep. Fox and Robbins also used no adaption period for their subjects and this variable may account

in part for the significant results.

Chapter III

Methods and Procedure

The Subjects. Four male college students were selected on the basis of adaptability to the conditions of the experiment from among twenty volunteers living at a medical fraternity house in Chicago, Illinois. All subjects lived at the fraternity house during the course of the experiment. The ages of the subjects were twenty, twenty-one, twenty-one, and twenty-two. It was required of the subjects that they be heavy sleepers, as determined by their ability to sleep throughout the conditioning process described below; that they be willing to serve as subjects until conclusion of the experiment; and, that their ability to learn experimental material be nearly equal to that of the other subjects of the experiment.

The proposed design of this experiment included eight subjects and was modified to include four subjects, because pilot studies indicated that conditions could not be adequately controlled with more than four subjects.

The twenty volunteers for the experiment were required to learn lists of nonsense syllables until a leveling of acceleration in their learning curves was obtained. From this group of twenty volunteers twelve subjects whose learning curves were similar were selected for further screening. The experimenter entered the rooms of these twelve subjects on three successive nights and attempted to determine whether they were heavy or light sleepers by the following method: Approximately three hours after each subject retired, the experimenter entered his room and said to him,

"Are you awake?" (The subjects had previously been apprised of the importance of answering the experimenter if they heard his voice at any time during the night.) If the subject failed to reply to the examiner's question, or, if no unusual behavior was noticed immediately following this question, "Are you awake?" the experimenter waited five minutes and again asked the same question. This procedure was continued at five minute intervals until the subject was finally awakened, or, until four degrees of loudness of the question had been employed with the subject. This procedure was repeated with all twelve subjects for three consecutive nights. Four subjects who were awakened on one of the first three trials during one of the three conditioning nights were dropped from the experiment.

For the next three nights the experimenter entered the rooms of the remaining eight subjects and played music[1] on a portable electric phonograph through a Telex under-the-pillow speaker. A Telex speaker is a plastic disc shaped speaker three inches in diameter and about one-fourth of an inch thick, which can be attached to a radio or phonograph by means of a standard phonograph jack and plug. During these three facilitation nights of music the Telex speaker was connected to a phonograph which was playing a long play record. The experimenter kept the volume of the speaker turned off until he entered the subject's room, closed the door, and stood beside the subject's bed. He then said to the subject, "Are you awake?" If the subject did not manifest any signs of waking, the experi-

[1] The music used during the entire experiment was from the first movement of Brahms First Symphony.

menter turned on the volume of the speaker and placed it under the pillow of the subject. The volume was raised to a point at which the experimenter could hear music five feet away from the bed and at which anyone in the room could hear sound from the speaker. During these nights one roommate of each subject was awakened and asked if he could hear sounds from near the bed of the subject. If the roommate answered that he could, and if he was able to recognize the sounds as music, the volume was considered to be sufficient. A mean volume was arrived at by utilizing this method with all subjects and cooperating roommates. The music was played for ten minutes unless the subject manifested signs of waking. In this case, the volume was immediately turned off and remained off for three minutes after cessation of noticeable movement of the subject. At the end of this three minute waiting period, the subject was again asked the question, "Are you awake?" If the subject gave no reply, and had no change of position in bed for three minutes, the volume was gradually increased to the previous level and the procedure was continued until the ten minutes of music had been played.

The subjects were required to report to the experimenter in the mornings following the three nights of facilitation. They were asked if anything unusual had taken place during the night, if they had slept well, or had had any dreams, if they had heard the material, or thought they might have heard it. They were also asked if they thought the experimenter had been in the room, even if they did not recall hearing sleep material. One of the eight subjects reported definitely hearing the music on

one occasion, and one subject reported that he did not hear anything but that he had dreamt that he had heard music two of the three nights. Since none of the subjects had been informed that music was to be presented to them, these subjects were both dropped from the experiment. Two more subjects were dropped because each of them was sleeping in a room in which there was another subject present. It was necessary to drop these two latter subjects in order to avoid the possibility of practice effect while material was being presented to another subject in the same room.

Four subjects remained after the initial conditioning period. These subjects had on no occasion shown any signs of waking while the experimenter was in their rooms. They had reported no unusual dreams or experiences during the facilitation period. Their learning ability for experimental material was approximately equal as determined by scores obtained in learning lists of words.

These four students were selected as subjects for the experiment proper. They were all undergraduates in a pre-medical course in a Chicago university. Each subject was within two years of age of the other three subjects. All the subjects had the same class schedule and all retired between 11:00 P.M. and 12:00 M. Each subject arose between 6:45 A.M. and 7:30 A.M. The four subjects lived at the fraternity house five nights per week (Monday-Friday) and all went home week-ends. These subjects all lived within fifty miles of Chicago and had lived in Illinois all of their lives and they were B students or better, and each reported that he spent about the same amount of study time as the other subjects.

Experimental Design. The four subjects selected for the experiment were further conditioned. For the next five nights, these subjects were presented during sleep with ten minutes of music followed by twenty repetitions of a list of material. For the first of these five nights nonsense syllables[1] were used. However, during the morning testing it was discovered that all subjects had some difficulty in understanding the nonsense syllables which were presented through headphones attached to a wire recorder. Therefore, one syllable words were used on the following four nights of this facilitation period. The lists of words[2] were devised in the following way: One hundred undergraduate college students who had no previous knowledge of the experiment, and who were not informed of the purpose of their task, were instructed in the following way:

> I would like you to take a pencil, and on the piece of paper provided, write down the first fifteen one syllable words that you think of. The only requirement is that these words be nouns. It is important that you work as fast as you can and that you write down the first one syllable nouns that come into your head.

From the three hundred most frequently used words the experimenter devised the lists of words to be used in the experiment.

The material was presented to the subjects during sleep by means of a Telex speaker which was attached to a wire recorder. The experimenter entered the room of the subject, set up his equipment, and asked the

[1]Nonsense syllables were selected from Glaze's list of nonsense syllables (27). Lists of nonsense syllables were equated in association value.

[2]These words are listed on page 42 of this paper.

subject if he was awake. If the subject was asleep according to the definition of sleep used in this paper, he was presented with ten minutes of music played through the under-the-pillow speaker. If the subject did not wake up during the presentation of music, the nonsense syllables or meaningful words which had previously been recorded on wire to the desired frequency were played through the speaker which had been placed on top of the subject's pillow, close to his ear. On these five facilitation nights, each list of material was presented to every subject twenty times during sleep.

The material was considered to have been presented to a sleeping subject if the subject failed to manifest signs of awakening for a period of from three minutes before the beginning of presentation until three minutes after the twentieth presentation of the list of words or nonsense syllables.

The morning following the presentation of sleep material, the subjects were required to learn lists of material different from but similar in association value to the sleep presented material. The anticipation method of learning was utilized and a subject was required to correctly anticipate the entire list once without error to be scored as having learned the list.

After the five morning learning sessions each subject had reached a plateau in learning and the experiment proper was begun on the following night.

During the experiment proper there were four experimental

Table 1

Procedure of Experimental Presentation of Material

Night of experiment.....	1	2	3	4	5	6	7	8
Sleep presented material								
List.....	A	B	C	D	E	F	G	H
Frequency of presentation...	10	10	30	30	20	20	40	40
Subject.....	III	I	III	I	III	I	III	I
Subject.....	IV	II	IV	II	IV	II	IV	II
Control situation								
Subject.....	I	III	I	III	I	III	I	III
Subject.....	II	IV	II	IV	II	IV	II	IV
Morning testing								
List.....	A	B	C	D	E	F	G	H

nights and four control nights for each subject. The experiment lasted for eight nights. On a given night half of the subjects were presented material while asleep, that is, material to be learned the following morning, and half of the subjects were not presented any material during sleep.

Table 1 on this page shows the procedure throughout the experiment. During the experimental nights the lists of meaningful words were presented to sleeping subjects ten, twenty, thirty, or forty times.

Night one was a control night for subjects I and II and on this night these subjects received no sleep presentations of any sort. Night one was an experimental night for subjects III and IV and these subjects were presented list A (ten one-syllable words) ten times during sleep. The next morning all subjects were required to learn list A to the criterion of one errorless anticipation. The second night of the experiment was a control night for subjects III and IV and these subjects received no sleep presentations on this night. Night two was an experimental night for subjects I and II and these subjects were presented list B ten times during sleep. The following morning all subjects were required to learn list B. The procedure continued in this way until all subjects had received sleep material four times (each time at a different frequency of presentation of the material), and until each subject had had four control nights during which he had received no sleep presentation of material. With this type of experimental procedure, each subject's performance after sleep presentation of material could be compared with his own performance after no sleep presentation.

The directions to the subjects for the morning testing were as follows:

> I am going to play some material on this recorder and I am going to keep playing it over until you learn it. The recorded material is one-syllable words. When you hear the material for the first time I want you to repeat out loud each word after it is spoken on the recorder. The next time I play the material and every other time after the first time that it is played, you must say the word before it is played on the recorder. There are ten words to a list and before each list of ten words there is recorded

the word, "start." You don't say this word "start" out loud. It is just a signal that the list of words is going to begin playing in three seconds. There are three seconds of time between each word and there is a six second break between one playing of the list and the next.

Now, suppose that instead of words I had recorded the numbers 5, 12, 7, 16 and 4. It would sound like this, "Start ....5....12....7....16....4. Now, if I took the place of the recorder and you were hearing these numbers for the first time, tell me what you would do as you hear "_____." Now, when the recorder played the list for the second time, what would you do? Let's try it. (Examiner did not proceed until the subject did this correctly.)

Now, don't become discouraged. Keep on trying as hard as you can. I am interested in how many successes or correct anticipations you make on each trial, as well as how many trials it takes 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 don't stop trying for the rest of the list, but try as hard as you can all the time. Are there any questions before we begin?

Control of Conditions. While one cannot say that unmeasured variables did not affect the results of this experiment, conditions were controlled as much as possible, in an attempt to eliminate the influence of undesired variables. Subjects were selected whose economic background, sex, learning ability, interest and cooperation was similar. The ability of subjects to learn lists of meaningful one-syllable words was similar as determined by pre-experimental study. Each subject acted as his own control and thus the experimental results of each subject were able to be compared with that same subject's control results. Besides this, total experimental results of all subjects were able to be compared with total control results of all subjects.

The subjects of the experiment underwent a period of adaptation

and facilitation during which they became used to the presence of the examiner in the room and became used to the presentation of material while they were asleep. During the facilitation period, subjects gained experience in learning lists of words and also became used to the experimental procedure which, although it did not interfere with their regular routine, did require some modification in their daily activity.

The presentation of sleep material took place after each subject had been in bed for at least two hours but not more than three and one-half hours. All subjects were tested within thirty minutes of arising and morning testing of all subjects never required less than ninety minutes nor more than one-hundred-twenty minutes.

The use of meaningful words instead of nonsense syllables opens the possibility of the criticism that the association value of lists of words differed to the extent that this factor could account for any differences in results between sleep-presented lists of words and non-sleep-presented lists of words. Lists of nonsense syllables can be grouped in association value according to an objective criterion (27) but no such criterion was available for lists of one-syllable words.

In an attempt to equate one-syllable words in association value the experimenter had non-experimental subjects learn various lists of words and judge the association value of these words. When one considers that each subject acted as his own control and that each list of material was used both in sleep presentations and as a control list, doubt is cast on the hypothesis that the differences in association value of the lists of

material could account for differences in results between learning of sleep-presented and non-sleep-presented lists of material.

Another control factor in this experiment was the equipment used. The material was first recorded on wax discs and from these discs material was recorded on wire to the desired number of frequencies. Each time a list of words was repeated on wire it was repeated exactly as the time previous.

Care was exercised in selecting a person to transcribe the material. The person who made the recordings had a well modulated voice and his diction and enunciation were precise. He had for many years lived in the same area as the subjects, and, therefore, his pronunciation of words was similar to that of the subjects.

Each recording of material was submitted to a board of judges whose task was to judge the clarity and precision of the transcription. After each recording passed inspection by the judges, extra-experimental subjects learned the material in order that the relative difficulty of the lists of material could be ascertained.

The method of morning presentation of material through headphones tended to eliminate outside noises and this fact plus the fact that the same recordings of material were used for both sleep presentation and morning testing made sleep and morning presentation of material similar except for the sleep variable.

As mentioned before, heat and lighting factors were kept constant and the physical appearance of the testing room was not changed dur-

ing the experiment. The furniture of the room consisted of a few wooden chairs and one table. All factors as far as possible remained constant except the sleep variable.

Finally, perhaps the most important control in the experimental design is the adherence to the definition of sleep. While no objective criterion was available for accurately measuring the depth of sleep of the subjects, if subjects conformed to the criterion of sleep as it is defined in this paper, they were most certainly in a true state of sleep when material was presented to them at night. Therefore, the results of this experiment can be interpreted accordingly.

Chapter IV

Results and Interpretations

Explanation of tables. The following tables represent the results for morning learning of the meaningful material presented during sleep and for the material used as control material. Each list of material was used as a sleep presented list for two subjects and as a control list for two subjects.

Table 2 shows the results of morning testing for Subject I. The second horizontal column indicates the frequencies of sleep presentation for the four experimental nights, that is, ten, twenty, thirty, and forty presentations during sleep of lists of ten words. The third horizontal column indicates the number of trials needed by Subject I to anticipate all ten words of the list during morning testing to the criterion of one errorless repetition of the list. The fourth horizontal column indicates the total number of errors that Subject I made during the morning testing situation while learning the list. For instance, on a given night Subject I was presented a list of ten words during sleep. This list of words was repeated to the sleeping subject ten times. The next morning, this subject required five trials to learn the list which had been presented to him during sleep the previous evening. While the subject was learning this list of words in the morning, he made fifteen errors, that is, he incorrectly anticipated, or failed to anticipate fifteen words during the five trials. Fifteen errors is an average of three errors per trial (i.e. fifteen words divided by five trials). The average number of

Table 2

Results of Morning Testing

Subject I

Sleep-presented material					Average
Frequency of sleep presentation...	10	20	30	40	
Trials to learn.....	5	11	6	9	7.75
Total no. of errors.....	15	33	15	35	24.50
Average no. of errors per trial...	3.00	3.00	2.50	3.89	3.10
Non-sleep-presented material					
Trials to learn.....	5	8	5	5	5.75
Total no. of errors.....	14	35	13	17	19.75
Average no. of errors per trial...	2.80	4.38	2.60	3.40	3.29

errors is indicated in horizontal column five.

Horizontal columns seven, eight and nine can be interpreted the same as horizontal columns three, four and five respectively, except that columns seven, eight and nine contain figures which indicate the results of morning testing for non-sleep presented material or for control material, while columns three, four and five represent results of morning testing for experimental or sleep presented material.

The extreme right vertical column in Table 2 represents the averages per lists of words of the items in the horizontal columns. For example, Subject I averaged 7.75 trials per list to learn in the morning all

Table 3

Results of Morning Testing

Subject II

Sleep-presented material					Average
Frequency of sleep presentation...	10	20	30	40	
Trials to learn.....	5	8	9	6	7.00
Total no. of errors.....	19	27	35	23	26.00
Average no. of errors per trial...	3.80	3.38	3.89	3.83	3.72
Non-sleep-presented material					
Trials to learn.....	7	10	6	5	7.00
Total no. of errors.....	34	40	26	21	30.25
Average no. of errors per trial...	4.86	4.00	4.33	4.20	4.35

the material presented to him during sleep. The figures in the right vertical column were obtained by adding each horizontal column and dividing by four, the number of experimental nights, or the number of control nights in the case of columns seven, eight and nine.

Table 3 through Table 5 are the same as Table 2 except that the figures in Table 3 through Table 5 indicate results of Subjects II, III, and IV, while Table 2 indicates results of Subject I. Table 6 is similar to Table 2 through Table 5 except that Table 6 represents the results of all subjects averaged together.

Table 4

Results of Morning Testing

Subject III

Sleep-presented material					Average
Frequency of sleep presentation...	10	20	30	40	
Trials to learn.....	26	11	12	12	14.50
Total no. of errors.....	120	46	60	53	69.75
Average no. of errors per trial...	5.27	4.18	5.00	4.41	4.72
Non-sleep-presented material					
Trials to learn.....	6	8	7	19	10.00
Total no. of errors.....	30	30	29	58	36.75
Average no. of errors per trial...	5.00	3.75	4.14	3.05	3.99

Table 7 indicates the differences in trials required to learn sleep-presented and non-sleep-presented lists of material to the criterion of one errorless repetition for all frequencies of sleep presentation. The first horizontal column lists the subject whose results appear below this column. The subsequent vertical columns indicate the lists that were compared to each other at a given frequency. For example, Subject II had either List A or List B presented to him during sleep ten times. From Table 1 on page 19 we can determine that List B was the sleep-presented list for this subject and that List A was the control list at ten frequen-

Table 5

Results of Morning Testing

Subject IV

Sleep-presented material					Average
Frequency of sleep presentation...	10	20	30	40	
Trials to learn.....	9	6	5	4	6.00
Total no. of errors.....	29	21	9	9	17.00
Average no. of errors per trial...	3.22	3.50	1.80	2.25	2.69
Non-sleep-presented material					
Trials to learn.....	7	6	6	5	6.40
Total no. of errors.....	21	26	14	16	19.25
Average no. of errors per trial...	3.00	3.25	2.33	3.20	2.95

cies of sleep presentation. The number of trials necessary to learn the two lists of material was compared by subtracting the number of trials necessary for learning the non-sleep-presented list from the number of trials necessary to learn the sleep-presented list (see Table 3) and the difference was -2. The other vertical columns on Table 7 represent the same differences between sleep and non-sleep-presented material for the other frequencies of sleep presentation of material for this subject as well as for the total subject population.

Table 8 represents the results of mathematical computation of

Table 6

Results of Morning Testing

Averages of All Subjects

Sleep-presented material					Average
Frequency of sleep presentation...	10	20	30	40	
Trials to learn.....	10.50	9.00	8.00	7.75	8.81
Total no. of errors.....	45.75	31.75	29.75	30.00	34.31
Average no. of errors per trial...	3.82	3.51	3.30	3.60	3.56
Non-sleep-presented material					
Trials to learn.....	6.25	8.50	6.00	8.50	7.31
Total no. of errors.....	24.75	32.75	20.50	28.0	26.50
Average no. of errors per trial...	3.91	3.84	3.35	3.46	3.64

the data in Table 7, and Table 10 gives the computation for Table 9. The standard deviation, standard error of the mean, and t scores were found for these data and were obtained by using the formulas for obtaining a t score or critical ratio for a test of significance for small samples (66, p. 67). The t scores were compared to those in Fisher's table of t (66, p. 69) to determine the probability of the value of t occurring on the basis of chance.

Table 9 can be read in the same way as Table 7 except that calculations are based on average number of errors per trial while learning

Table 7

Differences in Trials Necessary to Learn to Selected Criterion Between Experimental and Control Lists of Material for Various Frequencies of Sleep Presentation for All Subjects

Subject.....	I	II	III	IV
Lists A-B				
10 Frequencies of sleep presentation...	0	-2	17	2
Lists E-F				
20 Frequencies of sleep presentation...	3	-2	3	-2
Lists C-D				
30 Frequencies of sleep presentation...	1	3	5	-1
Lists G-H				
40 Frequencies of sleep presentation...	4	1	-7	-1

material to the selected criterion instead of on the number of trials necessary to reach the selected criterion of successful learning of material. Table 10 differs from Table 8 in the same way that Table 9 differs from Table 7.

Interpretation. None of the critical ratios obtained from statistical manipulation of the data appearing in Tables 2 to 10 were statistically significant at the five per cent level. The results were very slightly positive favoring the sleep learning hypothesis on the basis of the number of trials needed to learn a list of material, but the differences were so

Table 8

Differences Between Means, Standard Errors of Means, Standard Deviations, and t scores for Experimental and Control Situations for All Subjects for Number of Trials Necessary to Learn to Selected Criterion

Statistic	MD*	SD*	SEM*	ts*
Lists A–B				
10 Frequencies of sleep presentation..	4.25	8.66	4.33	.98
Lists E–F				
20 Frequencies of sleep presentation..	.50	2.88	1.44	.35
Lists C–D				
30 Frequencies of sleep presentation..	2.00	2.58	1.29	1.55
Lists G–H				
40 Frequencies of sleep presentation..	-.75	4.66	2.33	.32

*MD - Mean Difference

*SD - Standard Deviation

*SEM- Standard Error of the Mean

*ts - t score

slight that they can be attributed to chance factors, and therefore the conclusion that sleep presentation of material results in a decrease of the number of trials needed to learn the material cannot be drawn.

The results were very slightly negative favoring the non-sleep-presented material on the basis of the average number of errors per trial

Table 9

Differences in Average Number of Errors per Trial While Learning Material to Selected Criterion Between Experimental and Control Lists of Material for Various Frequencies of Sleep Presentation for All Subjects

Subject.....	I	II	III	IV
Lists A-B				
10 Frequencies of sleep presentation..	.20	-1.06	.27	.22
Lists E-F				
20 Frequencies of sleep presentation..	-1.38	- .62	.43	.25
Lists C-D				
30 Frequencies of sleep presentation..	- .10	- .44	.86	-.53
Lists G-H				
40 Frequencies of sleep presentation..	.49	- .37	1.36	-.95

while learning the material, but the results are so insignificant that it cannot be concluded that sleep presentation of material hinders learning.

Therefore, the results of this experiment indicate that under the circumstances of this experiment, the sleep learning hypothesis cannot be demonstrated.

The results of this study tend to confirm the results of the study performed by Stampfl (67) and add experimental evidence to Stampfl's conclusion that the sleep learning hypothesis is a doubtful one (67, p. 31). The experimental design of the present experiment was very similar to that

Table 10

Differences Between Means, Standard Errors of Means, Standard Deviations, and t scores for Experimental and Control Situations for All Subjects for Average Errors per Trial While Learning Material to Selected Criterion

Statistic	MD*	SD*	SEM*	ts*
Lists A-B				
10 Frequencies of sleep presentation..	.09	.63	.32	.28
Lists E-F				
20 Frequencies of sleep presentation..	-.33	.86	.43	.38
Lists C-D				
30 Frequencies of sleep presentation..	-.06	.64	.32	.17
Lists G-H				
40 Frequencies of sleep presentation..	.13	.98	.49	.28

*MD - Mean Difference

*SD - Standard Deviation

*SEM - Standard Error of the Mean

*ts - t score

of Stampfl except that Stampfl used nonsense syllables as sleep and test material and in this experiment one syllable meaningful words were used as sleep and testing material.

As it seems likely that meaningful material would be more apt to elicit positive results if sleep learning were a fact, the similarity of

these results to Stampfl's offers substantial evidence as to the accuracy of Stampfl's results. However, in spite of the close agreement between this and Stampfl's results, the highly positive results of Charles Elliott (17) which favored the sleep learning hypothesis must be explained in some way.

One difference between Elliott's study and Stampfl's study is the choice of material used. Elliott used three letter, meaningful words, not meaningfully connected. Stampfl used nonsense syllables. However, the present experimental design utilized meaningful words of one syllable, not meaningfully connected, and, therefore, the material used in this present experiment is more similar to Elliott's material than it is to Stampfl's material, and, subsequently, one would expect on this basis that the results would be closer to those obtained by Elliott than to the results obtained by Stampfl. This was not the case, and, therefore, it is concluded that the difference in material used during the experiment does not account for the difference in results among the studies.

Another difference between Elliott's study and the present one is the conditioning period to which the subjects were required to submit before the experiment proper. Elliott used two groups of twenty subjects per group. There were twenty experimental subjects and twenty subjects served as controls. Thus, the subjects did not act as their own controls, and this factor may be responsible for the difference in the results between the two studies.

Elliott used an EEG machine to determine the depth of sleep of

his subjects. The present study did not control the depth of sleep. It may be that subjects in the present study were in a deeper state of sleep than Elliott's subjects, and, therefore, it may be that subjects can learn while in a lighter state of sleep than subjects of this present experiment were experiencing while being presented sleep material. Elliott's subjects may have actually learned material while asleep but they may have been in a light state of sleep.

Although Elliott used an EEG machine to determine the depth of sleep, he did not have the machine turned on during the entire period of presentation of sleep material to his subjects. In view of the fact that the subjects received only one night of conditioning to sleeping in strange surroundings with electrical apparatus attached to their heads, it does seem possible that some of the subjects may have been awake during part of the presentation of sleep material. If this was true, some of the experimental subjects received a premature presentation of the material while awake. This fact alone could account for the differences in results between Elliott's study and the present study, and between Elliott's study and Stampfl's study.

There seems to be some question of the validity of Elliott's results based on the questions of procedure and experimental design, and the present writer agrees with Stampfl who says, ". . . there appears to be rational grounds for questioning Elliott's results" (67, p. 34), and the results of the present study offer further evidence that the sleep learning hypothesis is a doubtful one, at least under conditions such

as were posited for this experiment.

Chapter V

Summary and Conclusions

Sleep has been discussed and written about as long as man has reported on paper the results of his thinking and observation. Nevertheless, at this time relatively little is known about the nature of sleep and about the effect of the biological and psychical processes present during sleep on conscious and unconscious behavior. However, within recent years it has been determined that there is cortical activity going on during the entire life processes of man. It is assumed by many, held as a fact by some, and questioned by few, that this is the same type of cortical activity during sleep as is present during waking activities. It is a fact that many biological processes continue during sleep but at a lower rate than during the waking hours and that they produce their effects, however slightly, at all times.

Learning theorists agree that some neural activity is necessary for learning to occur. There is a dispute as to whether this neural activity must be cortical and if it is a cause of, a result of, or merely concomitant with learning. However, it is reasonable to assume that if electrochemical neural activity within the brain cells is present during sleep, that the concomitant processes should be present in some degree. Therefore, it is a possibility that some learning does take place during sleep.

Introspection would lead us to consider the possibility of sleep learning. The experiences of people indicate that there is sleep learning.

It must, of course, be realized that these people are attributing to sleep learning something that may be explainable by other causes.

However, in spite of the vagueness and the difficulty of studying this problem, reputable scientists have acclaimed sleep learning as fact. Mechanical devices are being marketed as aids to sleep learning. It is, therefore, of serious importance to determine if sleep learning is a fact. If this fact can be determined, we can then attempt to devise some uses for this phenomena and explore it for the benefit of society. The implications for academic learning are obvious. More subtle, perhaps, is the possible use of sleep learning in a therapeutic situation. It may be possible to gain access to unconscious material by working directly with a subject in a non-conscious state. Therapeutic results might be startling and revolutionary if scientists could devise some way of gaining access, or of gaining contact with a subject who is not utilizing conscious defenses of the waking state. But before these things can be studied, it must first be determined if sleep learning can take place. Because of the difficulty of studying such a phenomena, it is necessary to isolate a small segment of the problem and determine if under given circumstances sleep learning can be demonstrated.

The literature on sleep learning offers no conclusive evidence either for or against the sleep learning hypothesis. Of four studies performed on sleep learning, the results of two are positive and the results of two are slightly negative. In only one of the studies were the results highly positive (17). In the other study that was positive, the results

were only slightly thus (21). The purpose of this study was to test the hypothesis that sleep learning is possible and that it can be demonstrated by testing subjects using the anticipation method of serial reproduction of lists of meaningful material. It was a further purpose of this study to determine if the frequency of repetition of presentation of sleep material affected retention. If sleep learning cannot be demonstrated, discussion of frequency of repetition becomes meaningless becaus of its dependence on sleep learning. Four subjects were used in this experiment. These subjects were presented lists of ten one syllable words while they were sleeping. The lists were presented to them in a varying number of repetitions and in a varying order. Each subject received four different frequencies of repetition of sleep material and each subject participated in the experiment on four control nights during which he was presented no material during sleep. On any given night half of the subjects were presented sleep material and half were not. The morning following each experimental evening, all subjects were required to learn a list of meaningful one syllable words which half of the subjects had been presented the previous evening. No significant results were obtained from statistical manipulation of the data of this experiment. The results computed on the basis of a comparison of number of trials to learn the material, slightly favored the sleep learning hypothesis. However, the differences were so slight that chance alone could account for them. On the basis of average number of errors per trial while learning the material, slightly negative results in favor of the hypothesis that presentation of sleep material

interferes with learning were obtained, but, again the results could have been to chance factors.

As a result of this study, the hypothesis that under a given set of circumstances retention can be facilitated by presentation of material to be learned during sleep, has not been demonstrated by the anticipation method of serial reproduction. Therefore, discussion of the effect of frequency of repetition on the retention of auditory material presented during sleep becomes meaningless in terms of the results of this study.

If our method of testing failed to indicate sleep learning, it cannot be concluded that sleep learning is not possible. It may be that other methods of presenting sleep material, or other methods of testing for retention, or the utilization of other types of material during the experiment may indicate sleep learning to the degree that statistically significant positive results can be obtained. It is, therefore, important that this problem be studied further by different methods and with different material. Because of the implications of the sleep learning question, it is important to study the problem under as many different aspects and conditions and by as many methods as possible, before it is concluded that sleep learning is not a fact.

Appendix

A

Lists of Meaningful Words Used During Experiment

List A	List B	List C	List D
food	cat	town	dog
ball	sound	chalk	class
dish	park	boat	home
tooth	moon	fan	eye
friend	bird	stone	plane
light	grass	rat	dance
man	bed	pen	noun
belt	foot	girl	ring
sum	sky	mask	cake
drink	face	job	barn

List E	List F	List G	List H
floor	cup	crank	nose
coat	head	stove	cab
wheat	pal	gun	boy
cap	flea	mat	fit
noise	shoe	pen	path
pot	queen	love	trunk
cow	beard	goal	wall
desk	rag	horse	crown
toy	tie	plan	hat
race	car	door	cause

B

Pilot Studies to Determine the Advisability of a Method to be Used in Further Study of the Sleep Learning Problem

Because of the possible effect of the method of learning and of the type of material used for experimentation on the results obtained from experimentation, it was decided to run pilot studies utilizing different types of material and different methods of morning testing than used in the experiment proper in order to indicate the advisability of an experimental design to be used in further research on the sleep learning problem.

Pilot Study One. Four subjects were used for this pilot study. They were the same subjects who had been presented the experimental procedure described in the previous pages of this paper and therefore they were, at this time, aware of the nature of the experiment. The subjects were given a list of ten words in sleep to a frequency of thirty repetitions. The next morning the list of sleep words was presented to the subjects after a different list of words and before another different list by means of the headphones to which they had become accustomed. That is, there were ten words which had not been sleep presented followed by the ten sleep presented words, and these sleep presented words were followed by ten more non-sleep presented words. The subject was unaware that all ten sleep presented words appeared in order. The task of the subjects was to identify the sleep presented words by guessing "yes" or "no" after they heard each word presented by means of the headphones. Three subjects guessed no sleep words correctly, one subject guessed one sleep word correctly, and one sub-

ject guessed two sleep presented words correctly. These results were not statistically significant and it is concluded that this type of experimental design would probably not facilitate the demonstration of sleep learning, even if sleep learning were a fact.

Pilot Study Two. Eight subjects were used for this pilot study. Each of the eight subjects was presented a list of eight nonsense syllables together with a meaningful word. The order of sleep presentation was varied ten different ways. Each set of ten variations of the list was presented three times, so the subjects received a total sleep presentation of the list of nonsense syllables together with the associative words thirty times. Each time the same word appeared with the same nonsense syllable, but in a different list placement from the previous placement. The subjects were required in the morning to learn by the anticipation method which meaningful word went with which nonsense syllable. Subjects were not required to learn the lists. Success was measured by the correct association of the meaningful word after the nonsense syllable had been presented. The headphones method of presentation used in the experiment described in the previous pages of this paper was used for the morning testing situation. In the morning the nonsense syllable was pronounced through the headphones, from the wire recorder. The subject was allowed six seconds to correctly anticipate the meaningful word. If he did not correctly anticipate the meaningful word that went with the nonsense syllable, the recorder provided the answer and the subject was scored an error.

The eight subjects used for this pilot study had not been con-

ditioned for the experiment and had never taken part in a learning experiment of this type. This fact alone makes the accuracy of the results questionable and the results must be interpreted only speculatively.

The critical ratio was obtained from a comparison of the number of trials needed to correctly learn the list of material that had been sleep presented with the number of trials necessary to correctly learn the list of material that had not been sleep presented. The lists on pages 46 and 47 show the sleep list and the non-sleep list and the order of recording and presentation to the subject. List 1 was sleep presented to four subjects and not sleep presented to four subjects. List 2 was sleep presented to the four subjects to whom List 1 had been sleep presented, and for these subjects, List 1 acted as the control, or, non-sleep presented list. For the first four subjects, List 2 served as the control list. Both lists contained nonsense syllables that were equal in association value according to Glaze's list from which they were obtained (27).

Thus, four subjects received thirty sleep presentations of List 1 during sleep and four subjects received thirty sleep presentations of List 2 during sleep. All subjects were tested on both lists the following morning. One half of the subjects were tested on the sleep presented list first and one half of the subjects were tested on the non-sleep presented list first. The t scores were obtained for a comparison of the number of trials required to learn the lists. The t score was 1.48 and was statistically non significant at five degrees of freedom according to Fisher's table of t scores (66, p. 69).

Nonsense Syllables and Associated Words in Order of Sleep and Morning Testing Presentation

List 1

First Presentation	Second Presentation	Third Presentation	Fourth Presentation	Fifth Presentation
gex - dog	byj - nose	yuz - head	wug - cake	mec - barn
zoy - wall	saj - ring	heg - queen	heg - queen	saj - ring
byj - nose	mec - barn	wug - cake	yuz - head	yuz - head
heg - queen	wug - cake	gex - dog	byj - nose	zoy - wall
saj - ring	gex - dog	byj - nose	mec - barn	gex - dog
wug - cake	yuz - head	saj - ring	gex - dog	byj - nose
mec - barn	zoy - wall	zoy - wall	saj - ring	wug - cake
yuz - head	heg - queen	mec - barn	zoy - wall	heg - queen

Sixth Presentation	Seventh Presentation	Eighth Presentation	Ninth Presentation	Tenth Presentation
yuz - head	saj - ring	heg - queen	wug - cake	yuz - head
wug - cake	byj - nose	mec - barn	yuz - head	zoy - wall
saj - ring	gex - dog	zoy - wall	heg - queen	saj - ring
heg - queen	heg - queen	yuz - head	zoy - wall	heg - queen
mec - barn	zoy - wall	wug - cake	mec - barn	mec - barn
gex - dog	mec - barn	byj - nose	saj - ring	wug - cake
byj - nose	wug - cake	saj - ring	gex - dog	byj - nose
zoy - wall	yuz - head	gex - dog	byj - nose	gex - dog

Nonsense Syllables and Associated Words in Order of Sleep and Morning Testing Presentation

List 2

First Presentation	Second Presentation	Third Presentation	Fourth Presentation	Fifth Presentation
yab - tie	jiv - dance	zyg - play	yop - word	yab - tie
koj - hand	yab - tie	zur - wheat	ged - bug	jiv - dance
yop - word	zyg - play	koj - hand	dax - school	yop - word
zyg - play	zur - wheat	yab - tie	zyg - play	zyg - play
zur - wheat	koj - hand	jiv - dance	koj - hand	zur - wheat
jiv - dance	yop - word	ged - bug	zur - wheat	dax - school
ged - bug	dax - school	yop - word	jiv - dance	ged - bug
dax - school	ged - bug	dax - school	yab - tie	koj - hand

Sixth Presentation	Seventh Presentation	Eighth Presentation	Ninth Presentation	Tenth Presentation
zur - wheat	yab - tie	ged - bug	jiv - dance	dax - school
yop - word	zyg - play	yop - word	zyg - play	koj - hand
yab - tie	jiv - dance	zur - wheat	yab - tie	ged - bug
koj - hand	dax - school	jiv - dance	ged - bug	zyg - play
dax - school	ged - bug	dax - school	zur - wheat	yop - word
ged - bug	yop - word	yab - tie	dax - school	jiv - dance
jiv - dance	koj - hand	koj - hand	yop - word	zur - wheat
zyg - play	zur - wheat	zyg - play	koj - hand	yab - tie

The results of this pilot study indicate that sleep learning probably cannot be demonstrated utilizing this method of procedure and the results offer further evidence that the sleep learning hypothesis is a doubtful one. However, these results are not experimentally accurate because of the lack of conditioning, and can, therefore, be questioned regarding their reliability and validity.

Bibliography

1. Adrian, W.D., & Matthews, B.H.C. The Berger Rhythm: potential changes from the occipital lobes of man. Brain, 1942, 57, 355-385.

2. Arnold, Magda B. On the mechanism of suggestion and hypnosis. J. abnorm. soc. Psychol., 1946, 41, 107-128.

3. Bartlett, M.R. Minimal auditory stimuli during the onset of sleep. Amer. J. Psychol., 1930, 25, 110-114.

4. Bass, M.J. Differentiation of suggestion and hypnosis. J. exp. Psychol., 1931, 14, 382-399.

5. Blake, H. & Gerard, R.W. Brain potentials during sleep. Amer. J. Physiol., 1937, 119, 692-703.

6. Bousfield, W.A. Certain subjective correlates of sleep and their relation to the euphoric attitude. J. appl. Psychol., 1942, 26, 487-498.

7. Bousfield, W.A. The relation of the euphoric attitude to the quality of sleep. J. Psychol., 1940, 9, 393-401.

8. Cook, T.W. A case of abnormal reproduction during sleep. J. abnorm. soc. Psychol., 1935, 29, 465-470.

9. Corn-Becker, F., Welch, L. & Fisichelli, V. Conditioning factors underlying hypnosis. J. abnorm. soc. Psychol., 1949, 44, 212-222.

10. Davis, H., Davis, P.A., Loomis, A.L., Harvey, E.N., & Hobart, G. A search for changes in direct current potentials of the head during sleep, J. Neurophysiol., 1937, 2, 129-135.

11. Davis, H., Davis, P.A., Loomis, A.L., Harvey, E.N. & Hobart, G. Changes in human brain potentials during the onset of sleep. Science, 1937, 86, 448-450.

12. Davis, H., Davis, P.A., Loomis, A.L., Harvey, E.N., & Hobart, G. Analysis of the electrical response of the human brain to auditory stimulation during sleep. Amer. J. Physiol., 1939, 126, 474-475.

13. Davis, H., Davis, P.A., Loomis, A.L., Harvey, E.N., & Hobart, G. Electrical reactions of the human brain to auditory stimulation during sleep. J. Neurophysiol., 1939, 2, 500-514.

14. Davis, P.A. The electrical response of the human brain to auditory stimuli. Amer. J. Physiol., 1939, 126, 455-476.

15. Dunlap, K. Sleep and dreams. J. abnorm. and soc. Psychol., 1931, 16, 197-209.

16. Dynes, J.B. Objective method of distinguishing sleep from the hypnotic trance. Arch. Neurol. Psychol., 1947, 57, 84-93.

17. Elliott, C.R. An experimental study of the retention of auditory material presented during sleep. Unpubl. Master's Thesis, Univer. of N. Carolina, 1947.

18. Fisher, V.E. Hypnotic suggestion and the conditioned reflex. J. exp. Psychol., 1932, 15, 212-217.

19. Foley, D.P. An experimental analysis of the relationship between inhibition and learning set for logically related materials. Unpubl. Master's Thesis, Loyola Univer., 1951.

20. Ford, W.L., & Yeager, C.L. Changes in the electroencephalogram in subjects under hypnosis. Dis. of nerv. system., 1948, 9, 190-192.

21. Fox, B.H., & Robbin, J.S. The retention of material presented sleep, J. exp. Psychol., 1952, 43, 75-79.

22. Garrett, H.E. Great experiments in psychology. (rev. ed.) New York: Appleton-Century-Crofts. 1941, Ch. 6, 7, 8, 10.

23. Garrett, H.E. Statistics in psychology and education. New York: Longmans, Green, 1950.

24. Gibb, J.R. The relative effects of sleeping and waking periods upon retention of nonsense syllables. Psychol. Bull., 1941, 38, 743.

25. Gibbs, F.A., & Gibbs, E.L. Atlas of electroencephalography. Cambridge: Addison-Wesley, 1941.

26. Gibbs, F.A., Davis, H., & Lennox, W.G. The electroencephalogram in epilepsy and in conditions of impaired consciousness. Arch. Neurol. Psychiat., 1935, 34, 1133-1148.

27. Glaze, J.A. The association value of nonsense syllables, J. Genet. Psychol., 1928, 35, 255-267.

28. Graves, E.A. The effect of sleep on retention. J. exp. Psychol., 1936, 316-322.

29. Grossman, C. Sensory stimulation during sleep. EEG clin. Neurophysiol., 1949, 1, 487-490.

30. Guthrie, E.R. The psychology of learning. New York: Harpers & Brothers, 1935.

31. Harmon, F.L. Principles of psychology. Milwaukee: Bruce, 1938.

32. Hilgarde, E.R. & Marquis, D.G. Conditioning and learning. New York: Appleton-Century-Crofts, 1940.

33. Hull, C.L. The meaningfulness of 320 selected nonsense syllables. Amer. J. Psychol., 1933, 45, 730-734.

34. Huxley, A.L. Brave new world. New York: Doubleday, 1932.

35. Jenkins, J.G., & Dallenbach, K.M., Oblivescence during sleep and waking. Amer. J. Psychol., 1924, 35, 605-612.

36. Johnson, H.M. An essay towards an adequate explanation of sleep. Psychol.,Bull., 1926, 23, 141-142.

37. Johnson, H.M. Improvement of memory by sleep. Science, Suppl. No. 82, Dec. 15, 1935.

38. Johnson, H.M. & Swan, T.H. Sleep. Psychol. Bull., 1930, 27, 1-39.

39. Johnson, H.M., & Weigand, G.E. Some recent experiments bearing on the problems of sleep. Psychol. Bull., 1927, 24, 165-166.

40. Kleitman, N. Sleep and Wakefulness. Chicago: Univer. of Chicago, 1939.

41. Kleitman, N. The effect of continued stimulation and of sleep upon conditioned salivation. Amer. J. Physiol., 1930, 94, 215-219.

42. Kleitman, N., Mullin, F.J., Cooperman, W.R., & Titlebaum, Sleep Characteristics. Chicago: Univer. of Chicago, 1937.

43. Laird, D.A. Types of sleepers: normal and abnormal. N.Y.M.J. & M. Rec., 1935, 142, 13-15.

44. Langfeld, H.S., & Allport, F.H. An elementary course in psychology. (rev. ed.) Boston: Houghton-Mifflin. 1916.

45. Lee, M.W.M., & Kleitman, N. Effects of experimental insomnia on the nervous system. Amer. J. Psychol., 1923, 67, 141.

46. Le Shan, L. The breaking of a habit by suggestion during sleep. J. abnorm. soc. Psychol., 1942, 37, 406-408.

47. Lindsley, D.B. Electroencephalography. Personality and the behavior disorders. ed. by Hunt, J. McV. New York: 1944, 2, 1033-1103.

48. Lindquist, E.F. A first course in statistics. Boston: Houghton-Mifflin, 1942.

49. Loomis, A.L., Harvey, E.H., & Hobart, G. Brain potentials during hypnosis, Science, 1936, 83, 239-241.

50. Loomis, A.L., Harvey, E.H., & Hobart, G. Electrical potentials of the human brain. J. exp. Psychol., 1936, 19, 249-279.

51. Lundholm, H., & Lowenbach, H. Hypnosis and the alpha activity of the electroencephalogram, Charac. Person., 1942, 11, No. 2.

52. McGeoch, J. Psychology of human learning. New York: Longmans, Green, 1942.

53. Meehl, P.E. On the circularity of the law of effect. Psychol. Bull., 1950, 47, 52-75.

54. Mischenko, M.N. The relation between hypnosis and experimental sleep in man. Psychol. Abstr., 1936, 10, No. 1999.

55. Mischenko, M.N. Conditions of the development of experimental sleep in man. Psychol. Abstr., 1937, 11, No. 1744.

56. Mode, E.B. Elements of statistics. New York: Prentice-Hall, 1951.

57. Mullin, F.J., & Kleitman, N. Variations in threshold of auditory stimuli necessary to awaken the sleeper. Amer. J. Physiol., 1938, 123, 477-481.

58. Newman, E.B. Forgetting of meaningful material during sleep and waking. Amer. J. Psychol., 1939, 52, 65-71.

59. Pavlov, I.P. Conditioned reflexes. (Trans. by G.V. Anrep) London: Oxford Univ. Press, 1927.

60. Pavlov, I.P. The identity of inhibition with sleep and hypnosis. Scientific monthly, 1923, 17, 603-608.

61. Postman, L., & Eagan, J.P. Experimental psychology. New York: Harper and Bros., 1949.

62. Reed, G.I., & Kleitman, N. The effect of sleep on respiration. Amer. J. Physiol., 1926, 75, 600.

63. Sarma, R.N.R. The scientific study of sleep. Current Science, 1941, 10, 7-97.

64. Schiele, B.C. A clinical study of sleep disturbances. Amer. J. Psychiat., 1941, 98, 119-123.

65. Schmidhofer, E. Mechanical group therapy. Science, 1952, 115, 120-123.

66. Smith, G.M. A simplified guide to statistics. New York: Rinehart, 1946.

67. Stampfl, T.G. The effect of frequency of repetition on the retention of auditory material presented during sleep. Unpubl. Master's Thesis, Loyola Univer., 1953.

68. Thistlewaite, D. A critical review of latent learning and related experiments. Psychol. Bull., 1951, 48, 97-129.

69. Thomson, M.M., Forbes, T.W., & Bolles, M.M. Brain potential rhythms in a case showing self-induced apparent trance states. Amer. J. Psychiat., 1937, II, 93, 1313-1314.

70. Tuttle, W.W. Effect of sleep on the patellar reflex. Amer. J. Physiol., 1924, 86, 345.

71. Van Ormer, E.B. Retention after intervals of sleep and waking. Arch. Psychol., 1932, 21, No. 137.

72. Van Ormer, E.B. Sleep and retention. Psychol. Bull., 1933, 30, 415-439.

73. Von Ebers, P.J. A study of the influence of rhythm and grouping upon learning. Unpubl. Master's Thesis, Loyola Univer., 1951.

74. White, R.W. Preface to the theory of hypnotism. J. of abnorm. soc. Psychol., 1941.

75. Williams, O. A study of the phenomenon of reminiscence. J. exp. Psychol., 1926, 9, 368-387.

APPROVAL SHEET

The thesis submitted by Donald J. Tyrell has been read and approved by 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.

June 4, 1956
Date

Frank J. Kobler
Signature of Adviser