Electroencephalographic Studies of Sleep

Final Report Covering The Period January 1, 1974 - December 31, 1974

NASA-Ames Grant NGR 10-005-057, Supplement 6 and 7

by

W. B. Webb, Principal Investigator
H. W. Agnew, Jr., Co-Investigator

Department of Psychology
College of Arts and Sciences
University of Florida
Gainesville, Florida 32611

The NASA Technical officer for this Grant is:
Dr. James Anliker, Ames Research Center, Biotechnology Division

January 10, 1975

Progress to Date

This description of our progress covers the period from January 1, 1974 through December 31, 1974.

1. An experimental series which studied the effects on sleep of altered "day" lengths is complete. The "days" studied were: a 36 hour day (24 hours wakefulness and 12 hours sleep), a 30 hour day (20 hours wakefulness and 10 hours sleep), an 18 hour day (12 hours wakefulness and 6 hours sleep), a 12 hour day (8 hours wakefulness and 4 hours sleep), and a 9 hour day (6 hours wakefulness and 3 hours sleep). Four subjects were studied on the 36 and the 12 hour day and two subjects were studied on each of the other modified days. The electroencephalogram and body temperature were recorded continuously during the experimental runs which lasted from seven to fourteen 24 hour periods.

Sleep during a normal day of 16 hours wakefulness and eight hours sleep was compared with the sleep during each of the modified days. A preliminary analysis of the data reveals that all the modified day schedules resulted in reduced total sleep time, increased stage 0 time from increased sleep latencies, brief arousals, and early awakenings, increased stage 1 without REM and a reduction in stage 2 sleep time. Stages REM and 4 were differentially affected by the schedules. The 36 hour day produced an increase in the absolute amount of REM sleep while the shorter days produced a reduction in the absolute

minutes of REM sleep. The amount of stage 4 found in sleep during the modified days lawfully followed increases in prior wakefulness found in each day with the longest period of prior wakefulness (in the 36 hour day) producing the greatest absolute amount of stage 4. These data indicate that day schedules shorter than 24 hours are limited by an insufficient amount of prior wakefulness to produce a normal sleep pattern while the 36 hour day is limited by the inability of the subject to sleep 12 continuous hours.

A rough draft of a paper describing this study has been written. It is anticipated that the final draft will be ready for submission to Psychophysiology by February, 1975.

2. A paper has been accepted by Psychophysiology describing the effects of a partial loss of sleep on one night on subsequent nocturnal sleep. Eight male subjects aged 18-25 years old were studied in this series. After baseline recordings were made, sleep was restricted to either a period between 4-8 AM or to a period between 6-8 AM. On the following night the subjects retired at 11 PM and were permitted to sleep ad lib. in the morning.

The first eight hours of ad lib. sleep following the two restricted sleep periods did not differ in any significant way from the eight hours of baseline sleep. When sleep was permitted to continue until the subjects awakened spontaneously, the sleep after the restriction of sleep to two hours was significantly longer and displayed significantly more of stages REM and 2 when compared with the baseline ad lib. sleep condition. The ad

lib. sleep period following the four hour condition showed similar changes but these were not statistically significant.

The significant reductions in stages REM and 2 during the restricted sleep periods can be attributed to the effects of reduced sleep length per se. The increases in sleep length and specifically the increases in stages REM and 2 during the ad lib. sleep periods can be attributed to a differential sleep "debt" accruing from restricted sleep length.

3. A graduate student working on his Masters of Science degree has utilized our library of FM tape recordings of normal sleep to collect data for his thesis. Tape recordings of three nights of sleep on each of eight subjects were played through a spindle detector designed and supplied by Dr. Jack Smith of the University of Florida Electrical Engineering Department. A count of the number of spindles in each minute of sleep was obtained. There was available also the minute by minute visual analysis of the record for stages of sleep.

With these data the student has described for the first time the distribution of spindles during a full night of sleep, he has shown the relationship between the amount of spindling and the stage of sleep, and he has described individual differences and consistencies in spindle rate from one night to the next.

The thesis describing these results is nearly complete and should be ready for distribution by the end of the year.

4. The paper entitled "Sleep and Waking in a Time Free Environment" appeared in the June issue of Aerospace Medicine. Copies of this paper have been sent to the proper NASA agencies.

An abstract of this work reads as follows:

> The sleep and waking of 14 subjects in time-free environments for 14 d were studied. Half of the subjects had a heavy exercise regime. All subjects exhibited a longer-than-24 h rhythm but the groups did not differ from each other in this extension of the rhythm. There were large individual differences between subjects and large variations from the projected sleep and waking times. The overall amount of sleep increased in the environment, and there were marked increases in both shorter and longer sleep and waking period lengths. Exercise did not increase the overall amount of sleep but did increase the variability in the distribution of sleep. The overall distribution of sleep stages during sleep did not differ from baseline measures or between groups.

5. The paper entitled "Regularity in the Control of the Free-Running Sleep-Wakefulness Rhythm" appeared in the July issue of Aerospace Medicine. Copies of this paper have been sent to the proper NASA agencies. The abstract of this work reads as follows:

> The natural tendency of humans to lengthen their sleepwakefulness cycle in environments which minimize natural cues to time of day poses problems for designing efficient work schedules. In the present experiment, rigid control over the sleep and wake-up times was employed in an attempt to contain the natural rhythm to a 24-h cycle. Eight subjects were placed on a rigid schedule of sleep between 11 p.m. and 7 a.m. The results indicate that, for practical purposes, the free-running sleep-wakefulness rhythm can be contained to a 24-h cycle by rigid control of the sleep portion of the cycle. When part of the control was released by allowing the subjects to sleep beyond 7 a.m., they slept an average of 67 min longer and showed sleep latencies which averaged 73 min. From these data it is concluded that control of the sleep portion of the sleep-wakefulness cycle, particularly control of the wake-up time, is sufficient to contain the free-running sleep-wakefulness rhythm to 24-h cycle.

Work in Progress

We have selected the subjects to begin a new series of studies

on the effects on sleep and performance of swiftly changing shifts of work. Four subjects have been studied while they were on a schedule of shift work that changes shifts frequently. We are using the "Continental Rota" which is a shift with the following pattern of work:

6 AM - 2 PM Monday, Tuesday

2 PM - 10 PM Wednesday, Thursday

10 PM - 6 AM Friday, Saturday, Sunday

Rest Monday, Tuesday

The sleep of these subjects is restricted only in regard to wake-up time. The subjects are awakened one hour before the beginning of their shift. The subjects have a clock in their rooms and a copy of the entire shift schedule which lasts for 23 days.

By specifying only the wake-up time we will be able to observe the time the subject naturally tends to sleep and the type of sleep he obtains when he is free to select his own sleep onset time. The subjects will be free to acquire their sleep in naps or place it all in one long sleep period. This procedure will provide us with a baseline on what subjects do naturally when placed on a swiftly changing work shift. With this knowledge of the natural baseline in hand we can then work toward improving the sleep schedules of individuals.

We expect to study four more subjects in this series before completing it.

REFERENCES ISSUED DURING THE COURSE OF THE GRANT

1. Webb, W.B., and Agnew, Jr., H.W. Sleep and Waking in a time free environment. Aerospace Medicine, 1974, June, 617-622

2. Webb, W.B., and Agnew, Jr., H.W. Regularity in the control of the free-running sleep-wakefulness rhythm. Aerospace Medicine 1974, July, 701-704.

3. Webb, W.B., and Agnew, Jr., H.W. The effects of a chronic limitation of sleep length. Psychophysiology, 1974, 11, 265-274.