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Special Publication

ABSTRACTS OF PAPERS PRESENTED TO THE TENTH ANNUAL MEETING OF THE ASSOCIATION FOR THE PSYCHOPHYSIOLOGICAL STUDY OF SLEEP

ROSALIND CARTWRIGHT AND ALLAN RECHTSCHAFFEN, *Program Chairmen,* AND JOHN RHODES, *Arrangements Chairman*

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The tenth annual meeting of the Association for the Psychophysiological Study of Sleep (APSS) was held at the La Fonda Hotel, Santa Fe, New Mexico, on March 25–28, 1970.

APSS was founded in 1961 for the purpose of promoting both formal and informal exchange of information among workers from various disciplines with a common interest in the psychophysiology of sleep. Not wishing to sacrifice the advantages of informal presentation to the publication of its proceedings, APSS has allowed authors to decide whether abstracts of their presentations should be published at this time or whether the nature of their research is still too tentative or incomplete to warrant such treatment. Accordingly, several authors have elected not to include abstracts of their presentations among these published proceedings. The following abstracts, however, constitute the bulk of the program of the Santa Fe meeting.

The eleventh annual meeting will be held in Bruges, Belgium, in June 1971, with Olga Petre-Quadens and Michael Chase as Program Chairmen. Further information regarding this meeting or other matters pertaining to APSS may be obtained from the Executive Secretary, Dr. Vernon Pegram, 1309 Maple Drive, Alamogordo, New Mexico 88310.

The current elected officers of APSS are: Anthony Kales, Coordinating Secretary; Vernon Pegram, Executive Secretary; Dennis McGinty, Publication

Address requests for reprints to: Dr. Vernon Pegram, Executive Secretary, Department of Psychiatry, University of Alabama Medical School, 1919 7th Avenue South, Birmingham, Alabama 35233.

Chairman; Robert Brebbia, Membership Chairman; Olga Petre-Quadens and Michael Chase, Program Chairmen; and Rosalind Cartwright, Allan Rechtschaffen, Jack Rhodes, H. W. Agnew, Jr., I. Karacan, and R. Baust, Members at Large.

REM sleep is an abbreviation for Rapid Eye Movement sleep (ascending EEG sleep stage 1); NREM sleep for Non-Rapid Eye Movement sleep (EEG sleep stages 2, 3, and 4).

EXTRA SLEEP

Sleep Habits of College Students

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Introductory psychology students recorded times for retiring and awakening. One group of 180, tested on a Monday morning, gave information about the previous 3 nights; another group of 180, tested on a Friday morning, reported on the previous 4 nights. Thus there were 180 respondents, divided equally as to sex, for each day of the week.

From Sunday through Thursday night, students retired on the average around midnight. This is somewhat later than the routine in most sleep labs. On these nights they awakened around 8:00 a.m. the next morning. On Friday and Saturday they retired 1 to 2 hours later. There was no apparent sleep loss, however, since the *Ss* compensated by later awakenings on Saturday and Sunday mornings.

Analysis of variance showed significant overall results for Time Retiring, $F = 8.10$; Time Awakening, $F = 3.24$; and Total Hours of Sleep, $F = 6.32$ (all $p < .01$). This weekend pattern could have an effect on the sleep cycle of subsequent nights.

Two small but very consistent average sex differences were also highly significant, Time Awakening, $F = 7.80$, and Total Hours of Sleep, $F = 22.83$. On most weekdays women awaken 20–30 min earlier, thereby also getting less Total Hours of Sleep.

Napping Habits of a College Student Population

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Questionnaires were administered to 505 male and female introductory psychology students, aged 16–45 ($\bar{X} = 19.8$, S.D. = 3.7). Classifications ranged from freshman to graduate (freshman, 55.8%, and sophomore, 24.7%). The question, "Do you ever nap during the day when you aren't working?" was answered "yes" by 78.6%. The following napping frequencies were reported: 24.9% reported regularly napping 1 day/week; 15.6%, 2 days/weeks; 6.5%, 3 days/week; 4.5%, 4 or more days/week; and for 48.5%, the frequency of napping reported was variable. In regard to napping length, 13.3% checked the half hour category; 34.5%, 1 hour; 12.8%, 2 hours; 2.5%, 3 or more hours; 36.9%, no consistent length. Consistent afternoon napping was reported by 58.8%; early evening, 7.3%; morning, 3.5%; after meals, 1.5%; and at inconsistent times, 28.9%. Nappers and non-nappers reported sleeping an average of 7.46 hours/night on work or

school days; however, for days off, nappers reported night sleep of 8.97 hours (S.D. = 1.5), while non-nappers reported 8.57 hours (S.D. = 1.4) ($p < .01$). Subjectively estimated sleep onset latencies were shorter for nappers than non-nappers. Males were more willing than females to serve as volunteers for both a night and a nap EEG study.

Naps and Night Sleep

R. L. Williams, I. Karacan, and W. W. Finley

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Recent evidence has suggested that a constant "quota" of stage 1-REM and stage 4 sleep is required each night; yet, these stages occur in different amounts during daytime naps. This raises the question as to what effect naps might have on nocturnal sleep. Does daytime fulfillment of the need for stages 1-REM and 4 sleep result in a reduced need for these sleep stages at night, or are these needs only fulfilled by night sleep? EEG sleep patterns were monitored for 11 male *Ss*, aged 21–28, under three conditions: a two-hour morning nap, followed by a full night's sleep; then, a week later, a two-hour afternoon nap, followed by a night's sleep; then a week later, 2 one-hour naps on the same day, one in the morning and one in the afternoon, followed by a full night's sleep. Results indicated that morning naps, in which stage 1-REM predominated, had no effect on sleep at night, unless an afternoon nap, in which stage 4 predominated, was also taken. When only an afternoon nap was taken, a reduction in stage 4 sleep always occurred that night. Therefore, afternoon naps seem to serve a need-fulfilling role for stage 4 sleep.

Extended Sleep and Performance

John M. Taub, Gordon G. Globus, Eric Phoebus, and Robert Drury

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Twelve male students of college age who regularly slept 7 to 8 hours were tested on signal detection, complex motor performance, and self-paced calculation tasks following 2 nights of extended sleep and 2 nights of habitual sleep. On nights of extended sleep, the *Ss* averaged 9.1 hours of sleep and on nights of the control condition, their average sleep was 7.1 hours. The physiological pattern of extended sleep was generally similar to the regular sleep of the *Ss* on control nights. Performance on signal detection and complex motor tasks was significantly impaired following extended sleep compared to the control condition. This investigation indicates that deviating from a habitual duration of sleep in the direction of extending sleep is detrimental to subsequent waking behavior. We suggest that any general theory of sleep should attempt to explain this phenomenon. Although there may be other explanations, findings of sleep deprivation experiments and our own data on sleep extension imply that optimal sleep duration exists within a relatively narrow range with impairment in performance when habitual sleep duration is either decreased or increased.

Sleep Patterns of Long and Short Sleepers

*Frederick Baekeland, Patrick Hoy, **Ernest Hartmann, and George Zwilling

**State University of New York Downstate Medical Center, **Tufts University School of Medicine, and Boston State Hospital*

Studied for 8 nights were 10 long sleepers (habitual sleep $\geq$ 9 hours) aged 20–34, 10 short sleepers (habitual sleep $\leq$ 6 hours) aged 20–34, and 8 short sleepers aged 35–49. Nights 1 and 2 were for adaptation. Nights 3–5 were baseline. On nights 1–5 *Ss* slept their mean home sleep times. On night 6 they slept lib. On nights 7 and 8 they were awakened from REM periods for dream reports. Ten minutes after awakening in the a.m. *Ss* performed the Wilkinson vigilance test for a half hour. Compared with young short sleepers, young long sleepers accumulated more wakefulness, REM, and stage 2 sleep, and had longer inter-REM-period intervals. On awakening nights their inter-REM-period intervals were shorter than on baseline nights. There was no difference in vigilance test performance. Among short sleepers, the older *Ss* accumulated more wakefulness, tended to have less stage 3 and slow wave sleep, had shorter first REM period latencies, and on the vigilance test had higher detection rates and a higher proportion of false reports. Among short sleepers values of sleep parameters on night 6 did not differ significantly from those on nights 3–5 or night 5.

Characteristics of Natural Long and Short Sleepers

Wilse B. Webb, Janette Friel, and James C. Dixon

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Entering first year students at the University of Florida (1968–1969) completed a questionnaire to determine the length of their typical sleep period during the previous year. From those reporting less than 5½ hours or more than 9½ hours, three samples were obtained from follow-up interviews: 12 short sleepers (less than 6 hours per night), 10 continuing long sleepers (more than 9 hours per night), and 9 long-average sleepers (originally long sleepers now sleeping 7–8 hours per night). The *Ss* were administered the MMPI, the California Personality Inventory, the Cornell Medical Index, and the Zung Measurement of Depression Scale. Additional data collected were high school placement test results, scholastic aptitude scores, and entering physical examination statistics (height, weight, blood pressure, pulse rate, and physician-detected and self-reported abnormalities). Analyses of variance performed separately for men and women comparing the three sleep length groups on each of these measures revealed no statistical differences. The conclusion drawn was that in an achieving young adult population self-selected extremes in sleep length do not result in obvious adverse mental, psychological, or physical consequences.

Characteristics of Multiple Naps

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EEG studies of daytime naps have shown that 1-REM occurs predominantly in the morning and stage 4 occurs predominantly in the afternoon. It has also been shown that the potential for 1-REM (and presumably for stage 4 as well) is time-locked to a recurrent 90–120 min cycle which remains relatively constant throughout the circadian

cycle. The purpose of the present study was to determine whether or not the potential (inferred from duration and latency measures) for sleep stages 1,1-REM, 2, 3, and 4 would change significantly when 3 two-hour portions (morning, afternoon, and evening) of the normal circadian cycle were sampled. Sleep EEGs were obtained for 11 adult males for 3 two-hour sleep periods, 2 of which were interjected during the waking portion of the normal sleep-waking circadian cycle. Stage 1-REM, most prevalent during the morning nap, decreased progressively through the afternoon and evening sleep periods, while stage 4 sleep, minimal during the morning nap, increased progressively through the afternoon and evening sleep periods. These results were found to be statistically significant, particularly with regard to latency to onset of each sleep stage. The 90–120 min cycle time-lock hypothesis was not supported.

Chronic Schizophrenic Sleep Patterns Under Napping and Non-Napping Conditions

ARTHUR C. TRAUB

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Daytime napping is a characteristic feature of institutionalized schizophrenic patients. In order to investigate the effects of daytime napping on nocturnal sleep patterns, 8 chronic schizophrenic males ranging in age from 24–61 were monitored for 12 consecutive nights. All *S*s were on low to moderate maintenance dosages of phenothiazines. Nights 1 and 2 were baseline days and nights. Nights 3–8 followed days in which napping was permitted and observed to occur. Nights 9–12 followed days in which napping was prevented. Separate repeated measures analyses of variance were performed on all important sleep variables with sleep nights nested within napping and no-napping treatments. Results were: the no-napping condition produced a significant effect upon only one sleep measure—sleep latency was reduced from approximately 34 min to 25 min ($p < .05$).

The Accumulation of REM Sleep Need During Sleep and Waking

WILLIAM E. WHITEHEAD, THOMAS M. ROBINSON, MICHAEL Z. WINCOR, AND ALLEN RECHTSCHAFFEN

University of Chicago

The issue of whether the need for REM sleep accumulates at a faster rate during NREM sleep than during wakefulness was investigated. Each of 7 young adults served both in a Day Sleep and a Control condition in a counterbalanced design. In the Day Sleep condition *S*s spent the day in bed in the laboratory where they were allowed as much NREM sleep as possible but were deprived of REM sleep (mean total sleep = 300.5 min). In the Control condition they also spent the day in bed in the laboratory, but all stages of sleep were minimized (mean total sleep = 48.9 min). On a test night immediately following the daytime laboratory procedures, stage REM per cent was similar following both conditions (Day Sleep, 28.7%; Control, 28.4%), as was latency to first REM period (Day Sleep, 53.1 min; Control, 56.9 min), duration of first REM period (Day Sleep, 25.6 min; Control, 28.1 min), and distribution of stage REM. Mean total min of stage

REM were similar if calculated for equivalent amounts of total sleep (Day Sleep, 109.5 min; Control, 102.1 min). These results suggest that the need for REM sleep accumulates at a similar rate during sleep and wakefulness.

INFORMATION PROCESSING

Distorted Visual Feedback and Augmented REM Sleep

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Eighteen young normal male *Ss* wore distorting spectacles for a varying number of days. Each of the 14 *Ss* who were exposed to *extreme distortion* (upside-down or 90 degree tilt) of their visual fields showed increased REM sleep (mean = 27% increase in per cent REM relative to both pre and post-experimental baseline nights; range = 6%–59%). The 4 *Ss* who experienced only a *moderate distortion* of the visual field (horizontal left-right displacement) failed to show increased REM sleep (mean = 7% *decrease* in per cent REM sleep; range = −24%–+15%). Of the 14 extreme distortion *Ss*, 13 showed decreased mean latencies to the first REM period on experimental nights. The moderate distortion *Ss* also showed this effect—each of these 4 *Ss* showed decreased mean latencies to the first REM period on experimental nights. These results are consistent with the hypothesis that a major function of REM sleep is the processing of sensory experience, and are clearly in accord with the very specific predictions generated by Dewan's (1968) model. It seems quite possible that REM sleep may be strongly involved in perceptual learning, in adaptation to novel sensory input.

The Effects of REM Sleep Deprivation During the Retention Interval on Long-Term Memory of a Discrimination Task

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Previous evidence suggests that REM sleep influences processes involved in the storage of long-term memory. In the present study, Swiss Webster mice were REM deprived (REMD) (water tank technique) during the interval between a discrimination training experience in a black-white T-maze and the subsequent retention test. The animals were trained to avoid or escape shock by choosing the non-preferred white limb to the criterion of 4 out of 5 consecutive correct responses. The mice were REMD for 3, 5, or 7 days and then allowed 30 min rest before the administration of a single retention test trial. On the subsequent retention trial, 67% of the control mice (i.e., animals not REMD) ran to the safe-white limb, while only 38% of the REMD mice chose the safe-white limb ($\chi^2 = 10.53$, $df = 1$, $p < .01$). In order to check on the permanence of the amnesia, mice REMD but allowed 24 hours rest before the subsequent retention test were also found to perform poorly when compared to the control groups ($\chi^2 = 3.43$, $df = 1$, $p < .10$). This most telling evidence argues against interpretations based on possible nonspecific effects of changes in per-

formance or activity level which were proposed as an alternative interpretation of previous findings obtained in a passive avoidance task.

The Effects of Electroconvulsive Shock During Recovery from REM Sleep Deprivation on Long-Term Memory

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Electroconvulsive shock (ECS) produces amnesia of an event if it is administered immediately after training. Generally, no amnesia occurs if ECS is given several hours or longer after training. In the present experiment, Swiss Webster mice were REM deprived (REMD) (water tank technique) for 48 continuous hours following training in a one trial passive avoidance task. At varying intervals following termination of REMD the animals were lightly etherized and administered an ECS (800 msec, 8 ma). The control groups were not REMD but were etherized and given ECS at the same time intervals as the experimental animals. Other control groups were only etherized and given a sham ECS. Twenty-four hours following termination of REMD, when the animals had recovered from the ECS, they were tested for retention. Mice administered ECS 5, 30, or 60 min after termination of REMD displayed marked retention deficits when compared with non-REMD groups of animals administered ECS ($p < .05$, $p < .05$, and $p < .10$, respectively). Mice administered ECS 3, 6, or 12 hours after termination of REMD displayed normal memory. The etherized controls also showed normal retention. This experiment suggests that the memory trace of a remote experience can be made susceptible to disruption several days after the trace has been consolidated. As the animals recover from REMD the susceptibility attenuates.

Effect of Stage REM Deprivation Upon Latent Learning

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Our adaptive hypothesis about the function of stage REM sleep involves integration of past and present experience leading to effective coping. An experimental approach was provided by Blodgett's classical latent learning paradigm. This experiment was replicated with interpolation of stage REM deprivation between the first rewarded trial and the following trial. Rats deprived of food for 23 hours were given one trial per day in a 6-unit multiple-T maze. On the fourth day, food was placed in the goal box. Fifteen animals were then REM deprived (REMD) by the pot technique. Fifteen controls were immersed in water for about an hour at various times before the next trial. Spontaneous activity of all animals prior to testing was at baseline levels. Most of the controls showed greatly improved performance on the fifth day. REMD animals performed only slightly better than before. The *U*-test showed REMD and control groups to differ significantly in reduction of cul entries ($p < .01$) and running time ($p < .002$). Within the limitations of the pot technique, the results suggest that REM deprivation prevents integration of the unrewarded maze exploration with the reinforcement experience, resulting in less effective coping with the situation.

THE NEED FOR REM SLEEP

Effects of REM Sleep Deprivation on Waking Perception

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The effects of REM sleep deprivation on auditory thresholds, space localization, and Embedded Figures Tests (EFT) performance were studied in 8 human *S*s, each of whom spent 17 consecutive nights in the laboratory. Four subjects received the following order of experimental conditions: 1) 5 baseline nights, 2) 2 REM deprivation nights, 3) 5 recovery nights, 4) 2 nights of NREM control awakenings, and 5) 3 recovery nights. Four other subjects experienced the "deprivation" nights in the reverse order. *Auditory threshold data* (for 6 *S*s), as measured by a clinical audiometer, indicated that compared to the respective preceding baseline: 1) 3 *S*s exhibited no change, 2 showed a higher and 1 a lower threshold after REM deprivation; and 2) 1 subject exhibited no change, 4 showed a lower and 1 a higher threshold after NREM control awakenings. *Space* localization data, as measured by the Apparent Eye Level (AEL) task, indicated that: 1) increasing temporal experience resulted in a significant lowering of the AEL; and 2) REM deprivation was associated with smaller decrements in the lowering of AEL with increasing experience. *EFT* data indicated that: 1) performance after REM deprivation and NREM control awakenings was inferior to baseline; and 2) greater decrements in performance were obtained after NREM control awakenings.

Treatment of Intractable Narcolepsy with a Monoamine Oxidase Inhibitor (MAOI)

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Six narcoleptic patients who had had extensive but unsuccessful therapeutic trials with stimulants were placed on 60–90 mg/24 hours of the monoamine oxidase inhibitor (MAOI) phenelzine following a placebo period of 1–2 weeks. On a dosage of phenelzine which completely suppressed REM sleep all 6 patients felt they had fewer narcoleptic attacks than on placebo. This was confirmed by 24-hour EEG monitoring. For 5 patients the attacks were fewer than on previously used stimulants. The 1 patient for whom the attacks did not improve from amphetamine preferred the MAOI because it made him less anxious. The first patient has now taken MAOI for one year. She was without REM sleep the first 10 months of this period but in the last few months has had a few minutes per night. Transient side effects include: orthostatic hypotension, blurring of vision, ankle edema, insomnia, and inability to get and sustain an erection. Discontinuation of MAOI for as little as one day produced frightening hypnagogic hallucinations, extreme anxiety, and suicidal thoughts.

Exercise as a Substitute for REM Sleep

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This study tested the hypothesis that exercise can substitute for REM

sleep if the *S*s exercise lightly during expected periods of REM sleep. Six *S*s were awakened at the onset of each REM period for 2 consecutive nights and exercised by merely strolling for the expected duration of each REM period (9, 19, 24, 28, and 34 min for each successive REM period). Two nights of uninterrupted sleep followed. In the control, *S*s were REM deprived by awakenings for 2 nights but had no exercise. Two recovery nights followed. Total sleep times were similar on comparable nights in exercise and control conditions. The hypothesis predicted less REM per cent on recovery nights following REM deprivation with exercise than following REM deprivation without exercise. Records were scored "blind." On the first recovery night the mean REM per cent was 5.8% less in the exercise condition than the control ($p < .005$). Over both recovery nights the mean REM per cent was 4.4% less in exercise than control condition ($p < .005$). Results are consistent with the hypothesis that exercise during expected periods of REM sleep can substitute for REM sleep.

Visual Evoked Response Following REM Deprivation

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Averaged visual evoked responses (AVER) with and without attention to a flash were averaged in 9 normal college age *S*s following two experimental manipulations: a) 2 nights of selective deprivation of REM sleep, and b) 2 nights of NREM sleep awakenings with comparable sleep loss. Two *S*s did not tolerate the experimental procedure well and experienced marked sleep loss. They did not show a post-REM deprivation rebound in REM time on the first 2 recovery nights. The remaining 7 *S*s had REM time increases over baseline averages during 2 recovery nights following the REM deprivation but not the NREM awakenings. The vertical peak to peak voltage from the first major negative deflection (latency 180 msec) and the following maximum positive deflection of the AVER is larger when the *S* attends to the visual stimulus and has to press a button to indicate he has seen it than when he does not. The amplitude difference, the attention differential, was calculated for each *S* in the two conditions. Five out of 7 had larger attention differentials following REM deprivation. One showed no change and 1 had a smaller attention differential ($p < .05$, one tailed t). There were no other differences in overall amplitudes or latencies of the AVER.

The Effects of REM Deprivation on GSR during Sleep

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Ten males, aged 20–28, were studied during 12 consecutive nights of sleep to determine whether or not REM deprivation would induce increases of GSR activity, and to observe differences between GSR on the palm (PGSR) and on the back of the hand (BGSR). After 5 baseline nights (B), all *S*s were deprived of REM sleep by forcible awakenings during 2 nights (D), which were followed by 5 nights of recovery sleep (R). Average total REM time in R compared with B increased from 16 min to 42 min in 9 *S*s. Four *S*s showed decreases in total number of BGSRs per night within the first 3 nights of R, and returned to their

respective B average levels during subsequent R nights. Five *S*s did not show apparent decreases, but 4 of them had sparse BGSRs during all R nights. Only 1 *S* showed an increase. Two control studies, one employing NREM deprivation and the other short total sleep time without awakenings, showed an increase in number of BGSRs. Although BGSR changed, PGSR had fewer changes and both frequency and amplitude were less through B, D, and R. These data suggest the possibility that sympathetic autonomic function may be suppressed after REM deprivation.

EYE MOVEMENTS

Does a Paralysis of Upward Gaze During Waking Persist During Sleep?

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Eye movements were studied in 5 patients with paralysis of upward gaze resulting from pretectal lesions. Eye position and movements were recorded by DC oculogram during wakefulness and multiple nights of sleep. With eyelid closure the globes moved upward above the level of paralysis. During the NREM stages of sleep the eyes drifted 30° above the central position 60–85% of the time. This was well above the level of paralysis when awake. Also, intermittent rapid saccadic vertical movements which crossed the level of paralysis occurred during NREM stages. Abrupt upward movements of 40° occurred in patients who, during waking, were able to move the eyes upward only 5°. Thus, the paralysis of upward gaze which appeared to be a fixed neurologic deficit during waking was no longer present during sleep. During REM periods the eyes abruptly moved downward. Rapid eye movements took place at or below the central position and the eyes tended not to move above the level of waking paralysis. The results suggest that during NREM sleep stages the eye movement system is similar to the awake eyelid closed state. Eye movements during REM periods were similar to those of the awake eyelid open state.

Content Analysis and Visual Scanning in Dreams

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Maimonides Medical Center

A content analysis approach to the theory that there is a direct relationship between REM density and dream content was attempted using the Hall-Van de Castle "Activities" content category. During 20 all-night sessions with a subject, 97 dream reports were collected. Since the mean number of activities per dream was 4.73, all dream reports containing 5 activities or more were referred to as "high activity dream reports," while all reports containing 4 activities or less were referred to as "low activity dream reports." The EEG machine was run at 15 mm/sec; REM density was measured by inspecting each 20-sec interval of each REM period following the first observation of REM activity. If there were REMs during the 20-sec interval, the designation of "REM Unit" was made. A figure of 80% "REM Units" was selected as the cut-off point separating high REM density REM periods from low REM density REM periods. When the data were entered in a chi square table (high activity, low activity, high density, low density), significant results were obtained. After

noting that the night's first report was usually a low activity, low density dream, all 20 initial reports were eliminated. The statistics were recomputed, yielding non-significant results.

Increased Accuracy of Binocular Depth Perception at the End of REM Periods

RALPH J. BERGER AND THOMAS D. SCOTT

University of California, Santa Cruz

One of us has proposed that REM sleep might maintain facilitation of coordinated eye movements necessary for accurate binocular depth perception (Berger, 1969). This experiment confirmed the prediction that binocular depth perception would be more accurate at the ends of REM periods than at their onsets. Eight male *S*s were studied during 4 non-consecutive nights of sleep. Accuracies of binocular and monocular depth perception were measured with different apparatuses in the evening prior to first-falling asleep, throughout the night after awakenings made alternately at the onsets or ends of REM periods, and 15 min after awakening in the morning. Accuracy of binocular depth perception was significantly better at the ends of REM periods than at their onsets ($p < .001$, one-tailed t), whereas accuracy of monocular depth perception did not significantly differ. That the monocular task was sensitive to variables of sleep was indicated by a significantly greater mean error 15 min after morning awakening than the previous evening before falling asleep ($p < .05$, two-tailed t). In contrast, accuracy of binocular depth perception was significantly better in the morning than the previous evening ($p < .05$, two-tailed t).

Characteristics of Sleep in the Burrowing Owl and the Tree Shrew

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One of us has proposed that the evolution of REM sleep might be linked with that of binocular coordinated eye movements (Berger, 1969). The eyes of the owl are immobile and the tree shrew exhibits few conjugate eye movements. Two owls and 4 tree shrews were implanted with cortical, subcortical, eye muscle, neck EMG, and EOG electrodes. The tree shrews slept a mean of 65.8% of the total time, of which 16.2% was REM sleep, 42.6% light slow wave sleep, and 41.2% deep slow wave sleep. The mean periodicity of the sleep cycle was 12.0 min. Unlike other mammals both *tonic* and phasic activity in the EMG *increased* during REM sleep, and REMs were few in number and usually non-conjugate. The owls slept a mean of 58.0% of the total time, of which 7% consisted of brief periods of EEG desynchronized sleep, and 93% of high voltage slow wave sleep. The mean periodicity of the sleep cycle was 1.7 min. Unlike the hen or pigeon the desynchronized sleep phases were unaccompanied by any consistent changes in neck EMG activity; eye movements were absent at all times; and phasic eye muscle activity unassociated with eyelid movement was never observed.

Evolution of Eye Movement Frequency Through REM Periods of the Same Night

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This study bears on 42 records concerning 23 normal *S*s. The frequency

(number per minute) of eye movements during REM sleep in the course of 1 night was studied according to the time of appearance of REM sleep from the beginning of sleep (stage 2). The frequency of eye movements increased with each successive REM period. Statistical relationships were found between eye movement frequency and: 1) the order of REM period ($p < .01$, Spearman correlation coefficient); and 2) the time of appearance of the REM period. The relationship is a bilogarithmic one. The first night effect has an influence on the eye movement frequency, although a less statistically significant one. These results agree with those of Aserinsky (1967, 1969) and show an increase in phasic phenomena with the length of sleep.

ECOLOGY AND PHYLOGENY

Sleep in the Phalanger (Trichosurus vulpecula): An Australian Marsupial

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We hoped to determine whether or not the high percentage of active sleep found in the American opossum is characteristic of marsupials in general. One female and 2 male phalangers were implanted with electrodes in the hippocampus, cortex, neck muscle, and around the eyes. Environmental conditions were varied in order to record sleep patterns under a wide range of testing conditions, including presence of mate, noise, and temperature stress (18°–37°C). Quiet sleep was accompanied by high voltage slow waves and spindle bursts. The EMG was either reduced or abolished. During active sleep the cortex was desynchronized with occasional spindles; the hippocampus displayed theta; and the EMG was abolished. EOG bursts accompanied all active sleep episodes. Short awakenings (about 1 min) followed most active sleep epochs. Total sleep time averaged 57% (range 47.9%–64.3%) of total recording time; active sleep averaged 7% (range 6.0%–9.3%) of total recording time or 13% (range 10.0%–16.5%) of total sleep time. The temperature stress condition slightly increased the percentage of active sleep, but, in general, these sleep patterns were consistent throughout a wide range of other environmental conditions. All marsupials do not enjoy the high active sleep percentages (33%) seen in the American opossum.

Free Choice of Lighting and Sleep-Waking Behavior in the Laboratory Rat

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We hypothesized that under free choice conditions rats would prefer predominantly dark environments over equivalent amounts of light and dark and consequently would obtain more REM sleep, as do rats subjected to continuous darkness. Three male albino rats maintained under 12-12 light-dark conditions were shifted to a free choice (FC) situation for 9 days. Continuous polygraphic recordings were obtained. Two baseline days, the first 2 FC days, and the last 2 FC days were examined. During FC, because each half of the cage was wired to trigger light or dark (red light), the *S*s could select the lighting condition. Cage position preference was accounted for. *S*s averaged 95% (88%–99.8%) of total time in the dark and obtained virtually no

sleep when the lights were on. The small intrasubject variability correlated with cage position preference. While NREM initially fell below and then recovered to baseline levels, REM time and per cent showed sustained average increases of 30% and 25%, respectively. That rats prefer the dark in which more REM sleep is obtained indicates that under 12-12 light-dark conditions chronic REM deprivation may result. It is questionable, therefore, whether such "baseline" data can be considered "normative."

The Ecology of Sleep

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Tentative conclusions can be reached concerning the ecological factors determining whether a species is a "good" or "poor" sleeper. By a good sleeper we mean an animal that sleeps readily in the laboratory and appears to "need" considerable sleep. Such species typically sleep a sizable portion of the day and have large percentages of REM sleep. The opposite is typical of poor sleepers. Poor sleepers are ecologically rather homogeneous. They are primarily or wholly surface dwellers whose defense against predation is extreme wariness and flight. Good sleepers are more diverse. Several groupings can be discerned: 1) carnivores; not commonly preyed upon, they usually sleep in a safe place; 2) hibernators; this group necessarily sleeps in a well-protected nest; 3) large primates; for various reasons they are rarely bothered during sleep; and 4) a diverse group which sleeps in various (but clearly safe) environments, e.g., moles (underground) and bats (cave ceilings). The generalization that emerges is that security of sleep is the most important determinant of the "goodness" of sleep. Mammals whose habitat allows them to sleep soundly do so. Species which live dangerously have evolved the ability to get by with little sleep.

Sleep of the Red Kangaroo (*Megaleia rufa*)

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The present experiment was designed to observe the sleep processes of a group of 5 red kangaroos (*Megaleia rufa*). Two observers continuously recorded the behavior of all animals throughout the inactive period of the diurnal cycle for 4 days. It was concluded from these observations that the kangaroo does engage in REM sleep. The proportion of the observation time spent sleeping and the ratio of REM sleep to total sleep were inversely related to age. In addition, the behavioral correlates of REM sleep in the younger *Ss* were more intense than they were in the older *Ss*. The younger *Ss* also tended to have a shorter sleep cycle. The oldest *S*, who was 10 years old, spent 19.8% of the observation time sleeping, 2.5% of her sleep time in REM, and had a median sleep cycle length of 18.5 min. The youngest *S*, who had been out of his mother's pouch for 3 months, spent 37.9% of the observation time sleeping, 23.0% of his sleep time in REM, and had a median sleep cycle length of 10.0 min.

Sleep of the Jaguar and the Tapir: A Prey-Predator Contrast

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Two adult jaguars and 2 adult tapirs with both sexes represented were

observed continuously for 48 hours in a zoo, with the animals' pens illuminated at night. A reclining position with eyes closed for 1 min defined sleep in the tapir; eyes closed for 2 min was the criterion for the jaguar. Drowsiness was scored for more frequent eye openings. Sleep periods were relatively unambiguous in the jaguar, but REM sleep could not be judged confidently. Time asleep averaged 10.8 hours per day (including 50 min of drowsiness). Sleep epochs of 50–113 min were common. The normal nocturnal activity pattern was clearly reversed, with sleep occurring primarily at night. Sleep criteria seemed less reliable for the tapirs, but their REM periods, which were marked by twitching of the snout, were striking. Based on the 24-hour period which was scored most confidently, time asleep averaged 6.2 hours per day (including 1.8 hours of drowsiness) with REM sleep amounting to 16%. Sleep cycle length was 54 min (including 6 min of drowsiness but excluding wakefulness). Sleep was fragmented, with epochs rarely exceeding 10 min. Unlike the jaguars, the tapirs frequently awoke to sounds made by other animals.

Mammalian Sleep and Longevity

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Relationships between maximum life spans and sleep parameters were analyzed. Studies of sleep in 42 mammals were reviewed, including studies based solely on behavioral observations. In 25 species for whom data were available, no relationship was found between life span and daily REM time or REM per cent. For 31 species, an inverse correlation between life span and daily sleep time (rho = $-.61$, $p < .01$) was found, but this relationship was not present within orders analyzed separately. This result shows that greater sleep time is not life-prolonging on the species level. However, life span and metabolic rate are inversely correlated, while daily sleep time and metabolic rate are positively correlated. (In 10 species, the correlation between sleep time and oxygen consumption was $+.80$; $p < .01$.) Thus, metabolic rate may be the crucial determinant of sleep time. The role of body weight and brain weight, which are positively correlated with life span and negatively correlated with metabolic rate and sleep time, also requires consideration. For 19 species a positive correlation (rho = $+.74$, $p < .01$) was found between life span and sleep-cycle length. Cycle length is also positively correlated with brain weight and inversely correlated with cortical acetylcholine content and neuron density.

RHYTHMS

Effect of Adrenalectomy on Circadian Distribution of Paradoxical Sleep (PS) in Rats

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Studying rats on a continuous schedule of alternating half hours of light and darkness, we noticed the persistence of circadian (24-hour) periodicity in the occurrence of PS even in the absence of circadian light-dark cues. The influence of adrenal secretion on the retention of this circadian rhythm was investigated in 4 male and 3 ovariectomized female rats. They were studied before adrenalectomy, after adrenalectomy, and after cortisol administration (1 mg/100 g/day), with

at least 8 days on 14 hour light–10 hour dark between pre- and post-adrenalectomy recordings. The total amounts of PS were determined from EEGs recorded continuously, and the ratio of total amount of PS during the former circadian dark period (1900–0500)/total amount of PS during the former light period (0500–1900) was used to measure shifts in the circadian rhythm of PS occurrence. Adrenalectomy increased this ratio from 0.29 to 0.61 ($p < .05$), i.e., the PS was now distributed more randomly throughout the 24 hours. Treatment with cortisol resulted not in a return to the original circadian pattern, but rather in a further increase in the ratio to 0.95 ($p < .05$), reflecting a further shift of PS into the former circadian dark period.

The Effect of a Prolonged Non-Geographic 180° Sleep-Wake Cycle Shift on Body Temperature, Plasma Growth Hormone, Cortisol, and Urinary 17-OCHS

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The effect of an acute 180° shift of the sleep-wake cycle on rectal temperature was determined in 2 independent experiments of 3 and 9 weeks respectively. A consistent progressive change in the circadian temperature curve following reversal was found across *Ss* and in both studies. The temperature decreased (~.5°F) during the first week after inversion but reached comparable values to baseline during the third inverted week. A second fall in temperature occurred 180° out of phase with the sleep period while the *Ss* were awake. This drop decreased until the third week when it was no longer apparent. Thus, an apparent 180° phase shift of the circadian body temperature cycle took place during the third week of the inverted sleep-wake cycle. Upon re-inversion the temperature cycle was re-established within a few days. Re-establishment of both the plasma cortisol and urinary 17-OHCS circadian and sleep pattern did not occur in the 2 week period. The rise of plasma growth hormone during the first few hours of sleep also occurred during the day sleep, the timing being similar to night sleep. Therefore, growth hormone release appeared to shift immediately, whereas the cortisol pattern was not readily inverted.

Ultradian Rhythms in Rhesus Monkeys

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We hypothesize an ultradian oscillatory modulation of function in various physiological systems occurring throughout the 24 hours. Biorhythm analyses were performed on selected data from a study of male 2.5–4.6 kg *Macaca mulatta*. For 10 monkeys, least-squares frequency spectra were computed separately for a 12-hour light span and a 12-hour dark span. The animals slept almost all of the dark spans and were awake most of the light spans. There was almost no stage REM during lights-on. Computations have been completed for three variables: stage REM, EEG theta frequency band amplitude, and EMG.

During lights-out, significant ($p \leq .05$) ultradian rhythms were found in stage REM and theta for 10 animals and in EMG for 9 animals. During lights-on, significant rhythms were found in EMG for 10 animals and in theta for 9 animals, but not in stage REM. Amplitudes of the EMG rhythm increased markedly during lights-on while amplitudes decreased for stage REM and theta.

The REM State: Evidence For Its Continued Manifestation as a Basic Physiological Rhythm During Wakefulness in the Cat

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Kleitman has suggested that the recurrent REM phase of sleep is the manifestation of a fundamental physiological rhythm which also influences the functions of the brain during wakefulness. This concept of a "basic rest-activity cycle" was evaluated here in experiments on cats trained to receive food instrumentally by generating a specific EEG slow wave pattern (the so-called sensorimotor rhythm). Twelve trained animals were allowed to work and sleep during 24-hour observations in which both performance and sleep physiology were monitored. It was found that during wakefulness the onset of performance or periods of peak performance occurred cyclically every 23.4 ±8.9 min. During interspersed sleep the REM phase occurred cyclically every 22.8 ±8.6 min. With sleep onset, REM epochs often occurred 20–30 min after a period of peak performance. Statistical comparisons have indicated in this and other experimental paradigms that these two periodicities are comparable. Although preliminary, these findings provide reliable evidence for a modulation of waking behavior similar to and continuous with the REM sleep cycle. This cycle may reflect a metabolic periodicity, influencing both higher and more fundamental nervous activities, which occurs continuously, like the cardiac cycle, throughout life.

REM "Sleep" Manifestations During Waking

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This study was designed to test the hypothesis that the cycle manifested in sleep as an alternation between REM and NREM sleep has a counterpart in waking behavior (cf. Klietman's "basic rest-activity cycle"). Individual *S*s' characteristic REM-NREM cycles were first studied over a series of baseline nights. On experimental nights, *S*s were awakened at varying times after their first REM period and immediately placed on a continuous performance task. Improvement in task behavior was predicted at those times that REM periods would be anticipated had the *S* remained asleep. Tasks utilized were the Wilkinson Vigilance Task, a complex reaction time task, and a motor performance task (pinball machine). The statistical approach was to construct a sinusoidal time series based on the cycles present in the baseline sleep data (mid-REM periods equal the cosine of zero degrees), and cross correlate this with the time series of waking performance data. Initial data analysis suggested that signal detection on the vigilance task improved at the clock time of predicted REM sleep had the *S* remained asleep. The data on reaction time was equivocal, and the motor task showed no relationship to the REM-NREM sleep cycle.

NEUROPHYSIOLOGY

EEG Coherence During Sleep

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Pair-wise coherence, a quantity expressing the strength of the linear relationship between activity at various frequencies which can be interpreted as squared correlations, was obtained for 6 stages (awake [W], 1, 2, 3, 4, REM) in 8 *Ss*. The coherence values were obtained from cross-spectral analyses, .49 Hz resolution interval, using 3 (1 min) periods of the 6 stages for the F3, C3, and 01 leads referenced to the mastoids. The frequencies studied were .49–20 Hz. Coherences were obtained for F3 with C3, F3 with 01, and C3 with 01. F3-C3 coherence values, average .60, were highest of the three pairs. The F3-01 pair had the lowest average coherence, .12. The C3-01 pair gave an intermediate average coherence, .36, but provided the clearest differentiation among stages. REM was lower than all other stages in its coherence for delta, theta, alpha, and sigma. All *Ss* had higher sigma coherences during states 2, 3, and 4 than during W, 1, or REM, suggesting a single source for sigma unique to stages 2, 3, and 4. Delta activity did not become more coherent during sleep. Based on coherence values, two separate patterns emerged: that for stages 2, 3 and 4; and that for W, REM and 1.

Activity and Atonia in the Decerebrate Cat

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We have assessed sleep-related behavior with long-term observations following brain transection above the pons, midbrain, or thalamus, and in hemithalamic animals. As reported previously, pontile cats exhibit periodic episodes of the atonic phase with REM and pontile slow wave activity. An approximately 30–50 min cyclicity in atonia is observed at body temperatures of 37.5°C, as in the intact cat. Elevation of body temperature increases the frequency and reduces the cycle duration while lower temperatures have the opposite effect. Other behavioral activity is seldom observed. The amount of behavioral activity ("running," head movements) is greatly increased in midbrain, compared with pontile cats, and is further increased in thalamic cats, activity occurring every few minutes. The occurrence of the atonic phase was reduced in midbrain and was usually absent in thalamic cats. Thus, thalamic cats may be sleepless. Hemithalamic cats exhibit nearly normal locomotor behavior and electrographic patterns, but exhibit reduced sleep: 25% sleep instead of the normal 70%. The mechanisms for atonia reside in the lower brainstem and are controlled by metabolic processes. However, the manifestation of both slow wave sleep and the atonic phase in the normal cat appears to depend upon the balance of rostral brainstem excitatory and forebrain suppressive processes.

Brainstem Polysynaptic Reflex Activity in the Kitten During Sleep and Wakefulness

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The digastric (jaw opening) reflex was induced and recorded in unanes-

thetized freely-moving kittens. Its amplitude was smaller during wakefulness than during quiet sleep. This pattern is similar to that observed in the adult cat. In the kitten (less than 3 weeks of age) reflex responses during active sleep state were *larger* than those recorded during quiet sleep. In contrast, in the adult this reflex is tonically depressed during active sleep. By 4 weeks of age an adult pattern of reflex modulation was observed. In both the kitten and adult cat this *brainstem polysynaptic somatic reflex* reacts differently during active sleep from homologous spinal cord reflexes. In the kitten increased reflex amplitude during active sleep may reflect a lack of forebrain inhibition of the reticular activating system. In the adult, forebrain systems may tonically depress the reticular activating system and the level of arousal during wakefulness, as well as during active sleep.

Brainstem Signs, Sleep Attacks, and REM Sleep Enhancement

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At a time when neurologic signs were localizable to the vestibular region of the brainstem and cerebellum, a 54-year old man developed awakenings from non-refreshing nocturnal sleep and sleep attacks with hallucinosis by day. Sleep attacks were characterized by lid fluttering and closure, upward turning of the eyes, rapid eye movements and myoclonic twitching of all extremities, and loss of consciousness. They lasted 1 or 2 min or could be aborted by stimulation. At their termination, reports of hallucinoid imagery were given. There was no loss of postural muscle tone, and speech and hand movements appropriate to the imagery later reported were occasionally observed. In a sleep record of 6.5 hours, there were 2.2 hours awake (33%) and 4.3 hours of stage 1-REM (67%). The 53 stage 1-REM periods had a mean duration of 4.9 min. Submental EMG had no consistent relationship to EEG stages; fine arm, hand, and finger movements, and vocalization often accompanied stage 1-REM. Reports of hallucinoid imagery were given after stage 1-REM awakenings. Except for 2.8 min of stage 1 without REM, no NREM sleep was observed. Subsequently the disease progressed and was fatal. Neuronal loss, astrocytosis, and demyelination were seen throughout the nervous system with particularly severe involvement of the pontine tegmental nuclei.

UNIT ACTIVITY

Spontaneous Repetitive Discharge of Thalamic Units During Sleep in Cats

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Spontaneous activity of single units in the somesthetic thalamic nucleus was recorded in unrestrained cats. A typical pattern was recorded during slow wave sleep (SWS) with high frequency rhythmical bursts of 2–7 spikes separated by silent periods lasting more than 100 msec. Rhythmical bursts of the same type were observed in REM periods but never in wakefulness. The organization of bursts was analyzed: the average interspike interval depended upon the number of spikes in the burst and on its order. The greater was the number of spikes in the burst, the shorter was the first interval. The duration of successive intervals increased progressively. Joint interval histograms revealed a strong statistical dependency between suc-

cessive intervals. There was no correlation between the number of spikes in a burst and the duration of the preceding or following silent periods. The same repetitive discharges in thalamic units during SWS and REM sleep suggested an hyperpolarizing-depolarizing mechanism during the two phases of sleep, which predominates in SWS and is also present, although not always obvious, in REM sleep.

Spontaneous Unit Activity of Cat Cerebellar Purkinje Cells in Sleep and Waking

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Using chronic microelectrode recording techniques and computer data analysis, we have studied 39 Purkinje cells identified by presence of complex and simple spikes and located in lobules VI and VII of cat cerebellar vermis. For simple spikes most units decreased firing rates in transition from waking (W) to synchronized sleep (S) (67%), and increased firing in transition from S to desynchronized sleep (D) (72%), while D firing rates were higher than W in 64%. Mean firing rates in simple spikes/sec were: W, 47.91; S, 43.88; and D, 53.67 ($p < .03$ for all differences). The rate increase in D was partly tonic and partly phasic with increased firing coming during rapid eye movements (REMs): mean rate for D without REMs was 50.51, and for D with REMs was 64.61. In 22 cells where differentiation of complex spikes was sufficient for counting, the same relationship of firing rate to state was observed. Mean rates in complex spikes/sec were: W, 1.16; S, 1.02; and D, 1.44. Unlike the simple spike, however, the complex spike rate increase in D was predominantly phasic, occurring during REMs: mean rate for D with REMs was 1.57, D without REMs 1.04, virtually the same as S.

Cell Discharge Rate as a Manifestation of Motivational Level During Sleep

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In order to investigate whether or not the nervous system codes information indicative of arousal or motivational level during sleep, we recorded extracellular unit activity from various subcortical sites in 5 cats during sleep both before and after a change in level of motivation. Rate of cell discharge was first recorded during sleep in a 48-hour food-deprived cat. Upon awakening, the cat was allowed to feed to satiation. Discharge rate during the next sleep session was then recorded. Comparisons were made of the discharge rates while food deprived with rates while satiated, during both NREM and REM sleep. Control data consisted of making the above comparisons during 2 contiguous sleep sessions without any intervening feeding. Results: 1) In the sleep session following satiation discharge rates of 24 of 43 cells analyzed were changed significantly. The changes in the various sites were generally as follows: medial hypothalamus—increase; lateral hypothalamus—increase and decrease; midbrain reticular formation—decrease; red nucleus (assumed to be less involved in motivation)—no change. 2) The rate changes were larger during REM than NREM. 3) None of the 11 control cells changed significantly. Our conclusion is that some type of coding of arousal or motivational level appears to be maintained during sleep.

Activity of Single Neurons During Sleep and Alterated States of Consciousness

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This study compared neuronal activity in rabbits during sleep and during two sleep related states: atropine dissociation and cataplexy (animal hypnosis) induced by inversion and restraint. Administration of large doses (3 mg/kg) of atropine induces a sleep-like synchronized EEG while an animal is still alert. During the early stages of induced cataplexy the EEG resembles that of an alert animal. Activity of single neurons was recorded from the hippocampus, septum, medial and anterior thalamus, and reticular formation of 25 rabbits during these two dissociated states and during sleep sessions. Fourteen of 18 cells had similar firing rates or patterns during atropine dissociation and during slow wave sleep. In the cataplexy experiments, 39 of 46 cells had similar firing rates or patterns during the induced trance and during periods when the animal was alert but not moving. These results are interpreted as indicating that a majority of cells examined were seen to fire in a pattern that was related to the EEG pattern, rather than to the behavioral state of the animal.

NEUROCHEMISTRY

The Effects of Alcohol on NREM Sleep and REM Sleep in the Rat

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Sleep records were monitored for 24 hours after a single intraperitoneal injection of a placebo, 0.5 gm/kg, and 1.5 gm/kg of ethyl alcohol in 12 chronically implanted rats. A sedative effect of alcohol, evidenced by an increase in NREM sleep, was observed with the two doses of alcohol. REM sleep, on the other hand, was decreased by the high dose but was not greatly modified by the low dose.

Altered ^{14}C-Leucine Incorporation into Brain Protein of Sleeping Rats

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Two sets of 4 rats were sleep deprived by hand for 18 hours before they were injected i.p. with ^{14}C-labeled leucine. After the injections, one set of rats was allowed to sleep for 2 hours and the other set was sleep deprived for an additional 2 hours before sacrifice. Each rat was killed, his brain removed and dissected into five parts: the cerebral cortex and basal ganglia, midbrain, hypothalamus, cerebellum, and brain stem. Protein in the various parts was purified from free amino acids, lipids, etc., by the extraction method of Lajtha. Radioactivity associated with the protein was determined by scintillation counting. Incorporation of ^{14}C into protein in the sleeping rats' brains was 35% to 50% higher than in those awake. ^{14}C incorporation into liver protein likewise increased 25%. In a similar experiment, rats were sleep deprived for only 9 hours before injection of ^{14}C-leucine. It was noted after this shorter period of sleep deprivation that the "sleeping" rats were not as uniformly asleep as had been the case with the group deprived for 18 hours. In these animals, only the hypothalami exhibited significant

differences in ^{14}C incorporation into brain protein between the "sleeping" and "awake" sets. ^{14}C incorporation into liver protein increased 30% in the "sleeping" group.

Effects of AMPT, L-Dopa, and L-Tryptophane on Sleep in in the Rat

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AMPT, given orally, significantly increased D-time at all three doses (50, 75, and 100 mg/kg) in all rats tested. The greatest effect was at 75 mg/kg. However, AMPT 75 mg/kg, given i.p., produced disturbed sleep and decreased D-time! Total sleep was slightly but not significantly increased by oral AMPT. L-Dopa alone (100, 300 mg/kg) produced a slight decrease in total sleep and a decrease in D-time at the higher dose. Dopa at the lower dose (100 mg/kg), given in addition to AMPT, reversed the AMPT effect so that sleep and D-time were approximately as in placebo conditions. L-tryptophane alone (150, 300 mg/kg) produced slightly increased total sleep and decreased D-time. Tryptophane, given in addition to AMPT, did not reverse the AMPT effect; if anything, at the lower dose, tryptophane further increased D-time. The results are consistent with our hypothesis that there is a reciprocal relationship between brain NE and D-time. AMPT—which blocks the synthesis step between tyrosine and dopa—clearly reduces brain NE and increases D-time (*when given orally*). Adding dopa, which bypasses the block and presumably prevents the decrease of NE, restores normal D-time.

Temporal Relationship of Increased D-Time and Decreased Brain NE After AMPT in the Rat

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Alpha methyl para tyrosine (AMPT), a specific inhibitor of tyrosine hydroxylase, produces a fall of at least 50% in brain norepinephrine (NE). We believe that aside from dosage and possible species differences, route of administration may be very important for adequate assessment of drug effect on sleep. We have found, in studies described elsewhere, that 50, 75, or 100 mg/kg of AMPT given orally produces a significantly increased D-time over an 8-hour period, while 75 mg given intraperitoneally appears to disturb sleep and produces decreased D-time. In the present study, we examined the temporal relationship between the rise in D-time and the fall in brain NE over 24-hour periods. Results showed a clear increase of D-time in AMPT animals starting at about 3 hours after drug, reaching a maximum at 6–9 hours, falling somewhat by 10–12 hours, and returning to baseline or slightly below by 16–24 hours. Brain NE started to fall at 1–2 hours, reached a nadir (about 60% of control values) at 8 and 9½ hours, rose somewhat by 12 hours, but was still below placebo values at 24 hours. There appears to be a close temporal relationship between fall in brain NE and rise in D-time after AMPT. This is consistent with our hypothesis that there is a reciprocal relationship between NE in some crucial brain loci and D-time; and that the D-state may function to restore NE or increase receptor sensitivity to NE.

Hallucinatory-like Behavior Elicited in Cats by Elevation of Catecholamines

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The role of catecholamines (CA) in waking and paradoxical sleep (PS) was investigated in 3 chronically implanted cats by the administration of tropolone, an effective inhibitor of catechol-o-methyl transferase (COMT), by itself and in combination with L-DOPA, a direct percursor of the CA. The unique injections of DOPA (50 mg/kg, i.p.) and tropolone (100 mg/kg, i.p.) produced similar peripheral and central effects. Both drugs elicited vomiting, defecation, hyperventilation, piloerection, mydriasis, and panting. The central effects were manifested as quiet waking behavior and approximately 5 hours of continuous EEG activation. Paradoxical sleep was absent for a period of 6–9 hours and showed a rebound in the following 24 hours. The simultaneous administration of DOPA (25 mg/kg) and tropolone (50 mg/kg) produced extreme peripheral reactions and very dramatic hallucinatory-like behavior. One hour following the injection, the cat showed orienting movements of eyes, ears, and head, and later began reacting violently to that to which he had been orienting by escape and defense reactions. The EEG was characterized by activation which lasted for a mean period of 8 hours. Paradoxical sleep was absent for 10 hours; however, phasic PGO spikes appeared during cortical activation at approximately 5 hours following injection and persisted continuously for a period of 5 hours at a mean frequency of 14 spikes/min. A rebound of PS occurred in the following 24 hours.

L-Dopa, Parkinsonism, and Sleep

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This is a study of sleep patterns in Parkinsonian patients and the effect of L-Dopa on their sleep and REM. Because L-Dopa is a precursor of norepinephrine, its possible effect on REM sleep is important. Damage to the locus caeruleus in Parkinsonism also makes the baseline sleep patterns of interest. Nine patients were studied in the sleep lab before and during the institution of L-Dopa treatment of up to 6 g/day. Patients were interviewed to determine their psychological status and adaptation to their illness. No obvious abnormalities in sleep patterns emerged. Despite probable locus caeruleus damage, the EMG showed a clear fall in potential during REM periods. L-Dopa showed no clear effect on any sleep parameter. Of interest were the differences in REM times from patient to patient. High REM times were found in the relatively undepressed patients who were adapting to their illness and low REM times in the poorly adapting patients. L-Dopa did not affect sleep stages in this group of patients, perhaps because of the locus caeruleus damage. Of importance in this and other drug studies is the observation that REM time may relate to the subject's psychological state.

The Effect of L-D Hydroxyphenylalanine (L-Dopa) on the Sleep of Two Depressed Patients

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Oral doses of up to 4 g/24 hours of L-Dopa were given in divided doses q.i.d. to 2 depressed male patients. Ex-

cept for slight irritability, there were no behavioral changes noted on drug days. Subject one, aged 41, was psychotically depressed and had severe psychomotor retardation. Imipramine 200 mg/q.i.d. was discontinued 2 weeks prior to the sleep study and baseline nights were recorded prior to L-Dopa nights. Subject two, aged 48, was chronically depressed and alcoholic. He had not ingested ethanol or any other drug for 3 weeks prior to the sleep study. He did not receive any medication during the study except for 3000 mg/day of tybamate for 3 weeks following the last dose of L-Dopa. The tybamate was discontinued 2 days before post-drug recordings. The data indicated that L-Dopa increased REM time. While on the drug, there was an average 6% increase in total sleep time and a 40% increase in total REM time (average for 2 *S*s).

Effects of L-Dopa Administration on Sleep in Parkinson and Control Patients

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Eight *S*s were monitored in the laboratory for 3 consecutive nights without placebo or drug. This allowed for adaptation and obtaining baseline measurements. Administration of L-Dopa was then started and 6 of the 8 *S*s were studied in the laboratory on the first 2 drug nights. After being at home a month during which dosage was increased to a range of 4–6 g, all of the *S*s returned to the laboratory and were each studied for several consecutive, long-term drug nights. *Results:* With initial drug administration, the control *S*s (spouses of the patients) had an increase in REM. One patient had a REM increase and 2 had marked decreases. After one month of drug administration, all of the *S*s tended to have REM levels similar to baseline. We studied another Parkinson patient more intensively. After 4 initial laboratory nights with placebo administration during the day, he was started on L-Dopa. Starting with the second drug night, there was a marked and consistent increase in the absolute amount and percent of REM sleep through the first 2 weeks of drug administration. On returning to the lab, one month after original drug administration, REM time was similar to baseline.

Effects of the Cholinergic Antisynthesis Agent HC-3 on the Awake-Sleep Cycle of the Cat

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When given intraventricularly, hemicholinium (HC-3) dramatically reduces subcortical but not neocortical acetylcholine (Dren and Domino J.P.E.T. 161: 141–154, 1968). Many of these subcortical areas are involved in sleep. Therefore, the actions of HC-3 were determined on the awake-sleep cycle of 5 cats with chronic indwelling brain electrodes and intraventricular cannulae. Continuous EEG and polygraphic activity was monitored 24 or 48 hours after a 0.1 ml injection of 50 μg (base) of HC-3 Br or an equimolar dose of NaBr in solution with a similar osmotic tension and pH as cerebrospinal fluid. HC-3 reduced the occurrence of hippocampal *theta* waves and neocortical desynchronization of REM sleep for 6–12 hours after injection. The reduction of the EMG of neck muscles and the eye movements of REM sleep were not blocked. Furthermore, NREM sleep increased and EEG

wakefulness decreased. NaBr produced a slight but definite alteration of the sleep cycle especially during the first 6 hours after injection. However, the effects were much more dramatic following HC-3. Gross behavioral arousal after HC-3 was accompanied by neocortical EEG slow waves which resembled the effects of the muscarinic cholinergic antagonist atropine. A rebound increase in REM sleep occurred in HC-3 treated animals 24–48 hours after intraventricular injection. The decrease in REM, increase in NREM, and decreased alertness following HC-3 suggests an important role of the cholinergic system in both wakefulness and REM sleep.

The Effects of Diphenylhydantoin (DPH) on Sleep in Man

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I. Each of 6 normal human *S*s was given a single dose of DPH, of 200, 300, or 400 mg at bedtime. Sleep was relatively normal, but with a small increase in D-time and decrease in stage 4 ($p < .05$). There was little difference between the dosages used. II. Three normal *S*s each took DPH 100 mg 3 times a day for 5 days. Sleep recordings were performed on the fifth night of DPH and on 3 subsequent nights (just after withdrawal of DPH). There was a trend toward increased D-time and D-percent both on the fifth night of DPH and after withdrawal. However, D-latency was also increased. Stage 4, which was consistently decreased after a single night of DPH and after 5 nights of DPH, showed an increase which might be considered a rebound, on the first night of discontinuation. III. Four patients were studied who had been taking DPH daily for at least 2 years. All were epileptic, but none had had any recent seizures. Patients continued on medication throughout and thus no nights on placebo were available. Each patient was studied for approximately 3 study nights, after laboratory adaptation nights. Sleep patterns in these patients were not remarkable. Sleep latency ranged from 10 to 20 min and sleep time from 6 to 7½ hours. D-time and D-percent were also within normal range for 3 patients; the fourth slept poorly and had almost no identifiable D-time. Stage 4 time was normal in 2 *S*s but distinctly low—less than 10 min—in the other 2 *S*s.

L-Dopa and Sleep in Depressed Patients

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National Institute of Mental Health

All-night, longitudinal EEG sleep recordings were made on 8 depressed inpatients who were receiving a therapeutic trial of L-Dopa in divided doses up to 12.6 g/day. Sleep recordings were made nightly throughout the course of treatment, which extended up to 7 weeks, as well as during placebo periods of at least 1 week before and after L-Dopa administration. Marked changes in sleep patterns occurred in 5 of the 8 patients. These 5 patients showed marked decreases in total sleep and REM sleep while on L-Dopa, while the others had no discernible changes in their sleep. Four of the 5 patients who had marked insomnia while on L-Dopa became clinically hypomanic or manic during the insomnia period; the other had a worsening of her depression. The patient who received 12.6 g of L-Dopa had, in addition to insomnia and reduced REM sleep, frequent episodes of rapid eye movements associated with stage 2 sleep

occurring during the first hours of sleep while on the high dose of L-Dopa. This patient exhibited a mixed clinical picture of mania and agitation during this period.

Longitudinal Sleep Patterns in Depressed Patients Treated with Amitriptyline

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National Institute of Mental Health

All-night longitudinal EEG sleep recordings were made on 3 depressed patients throughout the course of a 6 week therapeutic trial of 150 mg of amitriptyline (Elavil), and during a 1 week placebo period prior to and a 3 week period following drug administration. Each of the patients showed a suppression of REM sleep of up to 50% of baseline levels for the first 3 weeks of drug administration. During the second 3 weeks of drug administration 2 of the patients showed a return of REM sleep to baseline levels, while the other continued to have reduced amounts of REM sleep. The latter patient and 1 of the patients who showed a return of REM sleep to baseline levels both had clinical remissions during the course of drug treatment. The other patient showed no observable change in her clinical state. All 3 patients had a marked rebound of REM sleep when amitriptyline was discontinued. The rebound commenced on the first drug-withdrawal day and lasted up to 18 days. REM sleep increased up to 200% of baseline levels during this rebound period. Both of the improved patients had a return of their depressive symptoms during the rebound period, while the unimproved patient continued to show no change.

SEROTONIN

Degeneration Studies of the Rostral Projections of the Raphe Nuclei in the Cat

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The raphe nuclei have been implicated in sleep mechanisms and histochemical studies of their rostrally projecting serotonergic fibers have traced these elements into the basal forebrain via the medial forebrain bundle (MFB). Following lesions in the anterior nuclei of the raphe, degeneration extends through lateral and medial components of the MFB. Much of this degeneration terminates along the trajectory of this bundle in the lateral hypothalamic and lateral preoptic areas, while the remainder can be traced into the septal area, the amygdaloid complex, and the Diagonal Band of Broca. These raphe lesions decrease serotonin in the entire basal forebrain area and are also associated with significant reductions in slow wave sleep (SWS) and an enhancement of wakefulness over a period of several weeks. However, it is significant that lateral hypothalamic lesions, presumably interrupting most of the ascending fibers of this rostrally projecting system, and also associated with marked decreases in basal forebrain serotonin levels, do not significantly diminish SWS or affect waking time percentages when sleep profiles are examined quantitatively. These findings shed doubt on the apparent relevance to sleep of the reduction of basal forebrain serotonin following raphe lesions. Thus, descending neural systems from the raphe may be more critical in determining the effects of raphe lesions on sleep.

The Nocturnal Variations of Serotonin Levels in the Peripheral Blood

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Four patients were used to study the levels of nocturnal plasma serotonin. The patients were placed in a room that was acoustically insulated from the monitoring equipment. An indwelling, polyethylene catheter was placed in the antecubital vein and then connected to a 6 ft length of polyethylene tubing which allowed for the taking of blood samples without entering the room. The patients were allowed to sleep for 3 nights with a sham catheter in place and on the fourth night the catheter was placed in the vein. Every 20 min 15 cc of blood was sampled. The platelet-rich plasma was used for the determination of serotonin by zinc sulfide precipitation and butanol extraction. The labeling of the various stages of sleep was done according to the NINDB manual for staging sleep. In all 4 *S*s it was found that serotonin varied from .03 to .6 mcg per milliliter. The largest variation in a single patient was from 0.110 mcg to 0.60 mcg per milliliter. Previous data has led us to believe that the blood level of serotonin in the peripheral blood is a stable or relatively stable component. The present data does not show a relationship between plasma serotonin level and stage of sleep, but does show that there is a wide fluctuation in the plasma serotonin levels during sleep.

5-Hydroxytryptophan (5-HTP) Effects on the Sleep of Man

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National Institute of Mental Health and National Heart Institute

D,L-5-HTP (200 mg 135 min and 400 mg 15 min before bedtime) was administered to 6 normal females for 5 consecutive nights. Immediately prior to and following active drug administration 5 consecutive nights of pre- and post-drug placebo baselines were made. Pre- and post-drug placebo mean REM sleep values were 91.5 and 96.8 min, respectively, while 5-HTP increased REM sleep to 117.8 min (Friedman's analysis of variance, $\chi_r^2 = 9.3$, $df = 2$, $p < .01$). Mean NREM sleep values pre- and post-placebo were 357.7 and 349.2, respectively, while 5-HTP decreased NREM sleep to 334.4 ($\chi_r^2 = 12.83$, $df = 2$, $p < .001$). There were no other statistically significant changes in sleep stages. 5-HTP ability to produce modest increases in REM sleep above baseline in normals and the previously reported ability of 5-HTP to reverse parachlorophenylalanine REM suppression in man appears to suggest serotonin and/or a metabolite as a role in the production of REM sleep in man.

Reversal of Parachlorophenylalanine (PCPA) REM Suppression in Man by 5-Hydroxytryptophan (5-HTP)

RICHARD J. WYATT, THOMAS N. CHASE, KARL ENGLEMAN, DAVID J. KUPFER, JIMMY SCOTT, ALBERT SJOERDSMA, AND FREDERICK SNYDER

National Institute of Mental Health and National Heart Institute

Since our initial report that PCPA produced profound suppression of

REM sleep without affecting NREM sleep in a group of 4 carcinoid patients, we have consistently had similar results in 7 more patients, with *other* medical diseases, to whom PCPA was being administered as an experimental therapy (maximum dosage 4 g/24 hours, 50 mg/kg). One patient has been maintained on PCPA for 1.5 years with REM sleep at one-third pre-drug baseline. To 4 patients taking PCPA with reduced REM sleep D,L- 5-HTP (maximum oral 800 mg/night in divided dosages 2 hours and 15 min before bedtime) was given. REM sleep was partially or completely restored in 3 of the patients and not at all in the fourth. The patient with complete restoration had a baseline REM sleep of 98 min (5 nights), which decreased to 25 min on 3 g/24 hours PCPA, increased to a mean of 94 min (6 nights) with 5-HTP, and returned to 25 min the night 5-HTP was discontinued.

The Effects of Chronic Oral Ingestion of 5-Hydroxytryptophan (5-HTP) on Physiology and Blood Levels of 5-Hydroxytryptamine (5-HT) in Two Schizophrenic Children

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Two schizophrenic children, aged 5 and 7, were given oral D,L 5-HTP, receiving a maximum dosage of 3.0 mg/kg/24 hours in divided doses. While on the drug, the children showed: 1) no changes in pathologic behavior noted on clinical observation or in systematic quantified behavior rating sessions; 2) an increase in total sleep time and a larger increase in total REM time; 3) no effects on stage 3 or stage 4 sleep times; 4) a tendency for an increased number of eye movements per 20 sec epoch of REM time; 5) a marked decrease (compared to an earlier deprivation response) in per cent makeup following 2 nights of selective REM deprivation; 6) an increase in blood 5-HT levels of 35% (5 year old) and 5% (7 year old) from baseline levels that were at the low end of the normal range of 0.1 to 0.3 μg/cc (the assay procedure excluded 5-HTP as a determinant of 5-HT levels); and 7) no side effects such as nausea, diarrhea, flushing, or hypertension. After the drug was discontinued: 1) the nightly REM time returned to below baseline in one *S* and toward baseline in the other, and 2) blood 5-HT levels returned to baseline levels.

* UCLA Medical Center.

A PGO Spike Profile in the PCPA Cat

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Stanford University Medical Center

Variations in the rate (spikes/min) of PGO spike activity recorded from lateral geniculate nucleus in (a) REM sleep and (b) a standard 1 min period immediately prior to REM period (pre-REM) are sensitive measures of the incipient sleep-wakefulness and behavioral changes seen with chronic administration of parachlorophenylalamine (PCPA) in cats. Changes in both REM and pre-REM spike rates occur long before any other PCPA sign (within 8 hours of the first injection). Initially (PCPA day 1–2) the pre-REM spike rate drops to about one-third its baseline rate while the REM

spike rate increases in frequency. This is followed (PCPA day 4–8) by a reversal in rates in which the pre-REM rate increases to above baseline values and the REM rate slowly decreases to one-third baseline rates. If PCPA is discontinued at this point, a very gradual recovery (30–40 days) in spike rates takes place. Drug discontinuance is also initially accompanied by a transient decrease in pre-REM spike rate concomitant with behavioral changes that are characteristic of the initial phase of PCPA administration. It is possible that the spike rate changes reflect the biochemical and neuroregulatory dynamics that occur in the biogenic amines during chronic PCPA administration.

Amorphogenic Effect of Parachlorophenylalanine (PCPA) in Neonatal Cat

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Two groups of neonatal kittens (a total of 7) were given daily subcutaneous injections of PCPA from birth. Kittens were initially injected with 10 mg/kg of PCPA. This dosage was maintained for 7 days and then increased to 15 mg/kg. This pattern of increasing dosage was followed to a maximum of 45 mg/kg, being given daily until 60 days after the initial injections. The kittens were then allowed to recover for up to one year prior to sacrifice. A severe ataxia developed after drug administration which did not regress when PCPA was discontinued. At sacrifice, the most striking gross pathological finding was a nearly complete paleo-neocerebellar agenesis in the PCPA kittens including rarefaction of the granular cell layer and improper alignment of the Purkinje cells. This was seen in all PCPA kittens but never in the litter-mates. Important morphological changes occur in the kitten cerebellum after birth. It is probable that PCPA is severely affecting the normal morphogenesis of cerebellar tissue. Studies are now in progress to clarify this possible toxic involvement of PCPA in cerebellar development as well as its possible effect on other maturational processes.

L-Tryptophane and 50H-Tryptophane: Effects on Human Sleep

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Ten normal human adults without sleep problems were each studied after adaptation in the laboratory for a number of single nights on tryptophane. Results, for a total of 63 control nights compared to 38 tryptophane nights (5–10 grams), indicated that tryptophane significantly lowered mean sleep latency; mean sleep time, D-time, and stage 3-4 time were all slightly but not significantly higher. In a preliminary study of 4 normal *S*s, D-L 5HTP 50 mg p.o. at bedtime on 2 occasions produced no significant effects on recorded sleep. Twenty-four chronic mental patients with insomnia were studied for 8 nights each in addition to adaptation, by a technique involving behavioral observation every 15 min during the night. Each patient received placebo on 4 nights, and tryptophane 2, 3, 4, and 5 g once on each of 4 randomly distributed nights. L-tryptophane in a dose of 4 or 5 g significantly increased total sleep time by the behavioral measures. Sleep latency and number of awakenings were significantly decreased. The lower doses had no significant effect, but changes were in the same direction.

Subjective reports indicated that sleep after L-tryptophane was experienced as the same or slightly better than sleep after placebo.

The Effect of Monoamine Oxidase Inhibitor (Pargyline*) on the Central Monoamine Levels and Sleep in the PCPA Cat

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Stanford University Medical Center

Ten male cats were given subcutaneous injections of parachlorophenylalanine (PCPA) at 150 mg/kg for 4 days. At the end of the fourth day, they were sacrificed. The brains were removed and dissected into 5 parts (cortex, midbrain, hypothalamus, cerebellum, and pons-medulla) and analyzed for levels of 5-HT, NE, and DA. Three cats were injected similarly with PCPA for 4 days, but 2 hours before being sacrificed at the end of the fourth day, were additionally injected with 25 mg/kg Pargyline HCL i.p. Their brains were dissected and analyzed in the same manner as group one. Biochemical analysis demonstrated no significant differences in the brain levels of the amines measured between the MAOI pretreated and untreated cats. One cat with MAOI pretreatment was monitored polygraphically. MAOI administration on PCPA day 5 was followed by a suppression of REM sleep, and PCPA induced waking lateral geniculate spiking activity, with a concomitant increase in slow wave sleep to baseline amounts. These polygraphic results, coupled with the monoamine determination, suggest that modulation and control of the sleep-wakefulness cycle in the PCPA cat may involve more obscure mechanisms than simple changes in levels of brain monoamines.

* Drug supplied by Abbott Laboratories.

HORMONES AND ENZYMES

Serum Enzyme Changes in Sleep Deprivation

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Substantial increases in serum creatine phosphokinase (CPK) and aldolase activities occur in many acutely psychotic patients. Further investigation has shown a frequent, but not invariant relationship between the sleep disturbance and the serum CPK (and aldolase) activity in acutely psychotic patients. We now report that elevated serum CPK activity and aldolase activity occurs in normal *S*s during and subsequent to experimental sleep deprivation but that many characteristics of these increases in enzyme activity differentiate them from those which occur in acutely psychotic patients. The aldolase activities noted in 7 or 8 *S*s on deprivation-day (D1) or recovery-day (R3) or both were quite striking because aldolase activity of greater than 5 mU/ml is far beyond normal limits and is rarely noted even in acutely psychotic patients. The increases in CPK activities on D1 and R3, by contrast, were far smaller than those found in acutely psychotic patients. Factors which could produce increased serum enzyme activity such as physical activity, psychic stress, and tissue alterations appear unlikely to have been responsible for the increases. The possibility exists that the large increases in serum aldolase activity found at D1 and R3 could be a consequence of the sleep deprivation per se.

Human Growth Hormone in Newborn Infants During Sleep-Wake Periods

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In adults human growth hormone (HGH) is high during sleep, especially during the first 2 hours of sleep, and is frequently less than 2 ng/ml during wakefulness, but it is not known at what age this relationship develops. Since infants also exhibit sleep-waking cycles, normal full-term newborn infants have been studied during a 3-hour period in which EEG, EMG, EKG, and eye movements were recorded. Plasma HGH samples were obtained every 20–30 min in some infants by indwelling venous catheter, but in most by heel stick. Five infants of 2 days and 8 infants of 4–8 days of age have been studied thus far. In the 2-day-old group the average plasma HGH in ng/ml (mean ±S.E.) following at least 5 min of sleep (active and quiet) were 33.4 ±7 and 52.8 ±11, and 43.5 ±36 following 5 min of waking. Comparable values for the 4–8-day-old group were 9.1 ±1.1, 9.5 ±1.3, and 8.3 ±1.2. Wide variation in individual samples was found for the 2-day old *S*s (3–150 ng/ml) while this was less so for the older groups (0–20.2 ng/ml). It thus appears that no clear correlation between plasma HGH levels and sleep-wake cycles was evident in these infants.

Behavioral State, Age, and Plasma Growth Hormone Levels in Human Neonates

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Human Growth Hormone (HGH) secretion has been associated with stages 3 and 4 in the adult. The present study attempted to investigate the relationship between plasma HGH and sleep-wake states over the first 15 weeks of life. Four infants were studied at least 3 times, at weekly intervals, during REM and NREM sleep, Quiet Wakefulness, and Crying. After 20 min in a single state (determined polygraphically and by behavioral observations), a heel stick was performed and the plasma analyzed by radioimmunoassay. The four states were studied during a single interfeeding period on each experimental day. The results are preliminary and require further investigation. Certain trends are definitely suggested: 1) 23 of 24 samples obtained during Quiet Wakefulness had HGH levels below 5 ng/ml; the mean level during Quiet Wakefulness was 1.4 ng/ml; these low values have not been reported previously during the newborn period and are typical of quiet resting levels in the adult; 2) a stress response manifested by increased HGH levels associated with Crying was not observed until the eleventh week of age, and then not consistently; thus cortisol and HGH responses seem to develop differentially; 3) no plasma HGH differences were noted between REM and NREM sleep as in the adult; the infant of this age, however, does not have stages 3 and 4 sleep. Thus it is important to control behavioral state when studying HGH in infancy.

Behavioral State, Age, and Plasma Cortisol Response in the Human Newborn

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The relationship between sleep-wake states, level of psychological "arousal," age, and plasma cortisol levels in normal human neonates was studied. Plasma samples were obtained from 4 infants during four behavioral states—the REM and NREM stages of sleep, Crying, and Quiet Wakefulness—monitored polygraphically and by behavioral observations. The samples were taken by heel stick 20 min after entry into each state, and all four states were studied during a single interfeeding period. Each infant was studied at least 5 times at approximately weekly intervals. Ages ranged from 1–15 weeks. Mean cortisol levels ($\mu g\%$) for the four states were: NREM, 1.9; REM, 3.7; Quiet Wakefulness, 4.3; and Crying, 13.0. The results were generally consistent, and the pattern did not change within the age period studied. In 19 of 28 instances, the plasma cortisol was the highest after 20 min of aroused crying, with 13 of the 20 crying samples above 12 $\mu g\%$ ($p < .001$). Levels during REM and NREM sleep were low and indistinguishable, with 33 of the 40 samples below 4 $\mu g\%$. Levels during Quiet Wakefulness were more variable and intermediate. No relationship between plasma cortisol levels and clock time, time since feeding, sleep onset time, or age could be established. Thus the adrenocortical response to "aroused" crying seems well established in the human infant by 1 week of age.

Sleep Stage Pattern in Depression in Relation to Nocturnal Plasma Cortisol and Human Growth Hormone

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The sleep aberrations and diurnal fluctuation in symptomatology characteristic of depression have prompted interest in possible relationships to the circadian rhythm of secretion of cortisol and human growth hormone (HGH). Previous studies have reported elevated morning plasma cortisol. Accordingly, continuous EEG and EOG monitoring was coupled with frequent (20 min) plasma withdrawals because of the pulsatile secretion of cortisol into the circulation. Employing a long indwelling catheter, we monitored 8 hospitalized depressed patients, aged 59–68, during sleep before and after treatment, generally following a course of ECT. Polygraphic sleep disturbances typical of depression were confirmed. However, after ECT, only amelioration, not reversal, of the pattern of frequent awakenings and reduction of TST, REM, and stages 3 and 4 was found. In depressives, the curve of plasma cortisol and the number of peaks was grossly similar to normals. However, early in the night, values did not reach basal levels. Early cortisol peaks were nearly always associated with awakenings, later peaks were very high. In some patients there was an absence of the early night HGH peak usually associated in young normals with SWS, but SWS was minimal. This peak was less evident *after* re-

covery. These patients often failed to show waking HGH responses to insulin infusion.

The Effect of Slow Wave Sleep Suppression on Blood Plasma Human Growth Hormone Levels

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To test the hypothesis that the rise in plasma human growth hormone (HGH) observed shortly after sleep onset is related to slow wave sleep (SWS), sleep recordings were taken on 10 young adult males on each of 6 nights: 1) adaptation to lab, 2 and 3) normal undisturbed sleep, 4) normal sleep, 5) SWS deprivation, and 6) SWS recovery. Blood samples for HGH determinations were drawn every 20 min throughout 4, 5, and 6. SWS deprivation was achieved by use of a tone. Stages 3 and 4 were significantly reduced on 5; there was no "rebound" of these stages on 6. The latency to stage 4 onset was shorter on 6 than on 2 and 3. The total concentration of HGH during the whole night and the mean concentration during the first third of the night were less on 5 than on 4. There was a tendency, not significant, for the latency to the first HGH peak to be shorter on 6. SWS onset usually preceded the first HGH peak, but the opposite relationship was occasionally observed. It is concluded that the times of SWS and the HGH response are related, probably by being dependent upon a third factor, such as time of sleep onset.

DREAM CONTENT AND RECALL

An Investigation of the Factors Responsible for Differences Between Night, Morning, and Evening Reports of the Same Dreams

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Night, morning, and evening reports of the same dreams were collected in 8 *S*s (4 monolingual French, and 4 monolingual English) during 3 nights with 2 awakenings (after REM 2 and 3). Forty-two dreams were collected. The content analysis of the dreams consisted in a breakdown of dreams in nouns, verbs, and adjectives; and further into "conserved," "forgotten," "added," and "transformed" items. Data of French and English speaking *S*s were submitted separately to a principal component analysis. Two main factors emerged consistently in both samples: 1) a factor we named "Recall Ability" (contribution 70–84%); items with high positive loading on this factor are report length, forgotten, conserved, and added elements (French subjects only); and 2) a factor we named "Secondary Revision" (contribution 8–20%); in both samples the forgotten elements have a consistent negative loading, and the added elements, a consistent positive loading. Two other factors emerged consistently in both samples: 1) failure to recall (forgotten and transformed ele-

ments); and 2) linguistic factor, linked to the linguistic classification.

A Survey Approach to Normative Dream Content: Sex, Age, Marital Status, Race, and Educational Differences

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Dream reports were obtained from 182 of 300 respondents representative of the composition of the City of Cincinnati. The dream reports were scored for hostility and anxiety (Gottschalk-Gleser scales), the content variables of the Hall-Van de Castle scales, affective tone, indications of premonitions, the presence of death, institutional references, and "typical dream" themes. Men have more dreams with aggression, success, dreamer-involved misfortunes, castration anxiety, and overt hostility. Women have more dreams with characters, friendly interactions, passivity in initiating friendliness, emotions, indoor settings, and family themes. Older persons have more death in their dreams, younger persons more guilt. In contrast to single and married respondents, "been marrieds" have more death anxiety, family of marriage, and premonition dreams. White respondents have more covert hostility outward, while Negroes have more castration anxiety and penis envy. The least educated (0–8 years) have more death anxiety, total hostility outward, and family references, while the most educated (12+ years) have more dreamer-involved misfortunes. Dream content is most influenced by the sex of the dreamer. Age and marital status reveal some interesting but less frequent differences. Race did not have the number of differences we expected. Educational level showed the smallest number of differences.

The Relationship of Socio-Economic Status and Race to Dream Content

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During an interview focused on environmental health, 300 respondents were asked for a recent dream. Education, income, and occupation were weighted for socio-economic status. The 182 dreams were blindly scored using Gottschalk-Gleser and Hall-Van de Castle systems. Significant findings included: 1) more lower than upper class dreams contained characters; 2) the two lower classes manifested more death anxiety; 3) for whites, the two lower classes showed greater total anxiety, more mention of families, and more premonition dreams; 4) for white classes there was a consistent decrease in hostility inward from 30% in the lower to 0% in the upper class; for blacks, there was a steady increase from 12% for lower to 33% for the upper-middle class; 5) the two lower class dreams contained 76% of all misfortune scores in both races; 6) "environmental barrier" was a rare misfortune in upper class dreams but accounted for 80% of misfortune scores in the two lower classes; 7) there was a trend toward higher proportions of castration anxiety and penis envy in the dreams of Negroes; and 8) covert hostility outward was

significantly higher in white dreams. Our ultimate goal is a "sociology of dreams" to parallel the "new biology of dreaming."

The REM Stage in Patients with War Neuroses

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We studied REM sleep in patients with war neuroses because of their repetitive nightmares. Because of the overwhelming of the ego by trauma the relationship of psychological state to REM sleep was also studied. This was suggested by earlier work demonstrating REM stage involvement in adaptation to stress. Sleep recordings were obtained once a week for a period of weeks or months. Five-min verbal samples were collected before and after sleep. On half the nights REM awakening dream reports were requested. A major finding in 6 of 9 patients was 12 REM latencies under 40 min, including some sleep onset REM. Using a scoring system devised for psychoanalytic interviews, we scored the 5-min samples for defensive strain (need to cope). On the basis of these scores, three independent scorers predicted rank orders of REM latency for each patient with statistically significant accuracy. Changes from p.m. to a.m. defensive strain were used to predict REM times. Other findings were: strikingly few dream reports; two war nightmares occurred and were in REM sleep; and an unusually high REM density. This study provides significant evidence of the relationship between state and the physiological aspects of REM sleep such as REM latency.

Dreams of Depressed Patients, Non-Depressed Patients, and Normals

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Ninety-seven psychiatric inpatients, 48 males (M), and 49 females (F), were categorized as depressed (D), and 337 (112 M, 225 F) as non-depressed (P) on the basis of MMPI profiles. Recently recalled dreams from each group were compared against dreams from a normal (N) group of 100 M and 100 F college students. Mean ages were: D, 38; P, 35; and N, 21. Mean years of education were: D, 11.9; P, 12.8; and N, 13.5. Mean dream word length was: D, 54; P, 45; and N, 119. Dreams were scored on the Hall-Van de Castle scales. Dreams of D males, in comparison to both other male groups, had less color, more adjectives describing wrongness and unattractiveness, more parental figures, changes of one character to another, and less reference to the human body. D males, in comparison to P males, had more adjectives referring to youngness, more characters of uncertain relationship to the dreamer, and more unfamiliar settings. Dreams of D females, in comparison to both other female groups, had less color in them, more adjectives describing wrongness and unattractiveness, less personal emotion, and the dreamer engaged in less physical and movement activities. D females, in comparison to P females, had less adjectives describing rightness and attractiveness, the dreamer experienced less personal happiness, and reported more outdoor settings.

Hall-Van de Castle Scoring of the Dreams of the Depressed

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The characters, social interactions, emotions, and activity scales of the Hall-Van de Castle system were applied to the laboratory collected dreams of the depressed before and after "successful" treatment with anti-depressant drugs. Over the 40 nights of dreaming (5 male and 5 female *S*s, each for 4 nights), there was a total of 38 dreams in the 2 pre-treatment nights (17 male and 21 female) and 32 dreams in the 2 post-treatment nights (16 male and 16 female). There were 24 words/dream in the first 2 nights (33 for male and 17 for female) and 25 words/dream the last 2 nights (23 for male and 27 for female). The most striking content findings were that, following treatment, emotions increased in males, while in females social interactions decreased and activities increased. Both sexes always dreamt more about the family, and individuals rather than groups. In the pre-treatment situation, both sexes dreamt most about males; following treatment, males dreamt more about females.

Hypnagogic Mentation of Repressors and Sensitizers as Influenced by Hostile and Friendly Pre-Sleep-Conditions

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*S*s were selected from a large pool of coeds (N = 129) on the basis of their scores on Byrne's Revised Repression-Sensitization Scale: 20 were repressors (R-S range = 5–29) and 20 sensitizers (R-S range = 64–90). Just before retiring, *S*s responded to 5 TAT cards (1, 2, 7GF, 8GF, 9GF) for a test administrator who was either Friendly (N = 10 from each *S* group) or Hostile (N = 10 from each *S* group). Effects of subject and presleep-manipulation variables on mentation collected on two awakenings made during descending stage 1 were tested in a 2 × 2 factorial design. No significant differences were found, either between the Hostile and Friendly conditions or between Repressors and Sensitizers, for the following variables: percentage recall; *S*s' own ratings of hedonic tone and active participation; *S*s' judgments of sleep depth; judges' ratings of sexuality, hostility, imagination, and hedonic tone.

The Incidence of Novelty in Dreams

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Sixteen young adult female *S*s were awakened from each REM period of 2 nights and specifically questioned about the novelty of each element (character, physical surrounding or object, activity, or interaction) in the reported dreams. A judge assigned each element to one of the following 6 novelty categories: 1) replication of waking experiences; 2) replication of wakefulness but with minor change; 3) replication of wakefulness but with major change; 4) not previously experienced, but not otherwise unusual; 5) not previously experienced and slightly unusual; and 6) not previously experienced and very unusual. The percentages of physical surroundings and objects assigned to each novelty category were: 1, 24%; 2, 12%; 3, 8%;

4, 42%; 5, 10%; and 6, 5%. For characters the percentages were: 1, 46%; 2, 6%; 3, 6%; 4, 37%; 5, 4%; and 6, 1%. For activities and social interactions the percentages were: 1, 6%; 2, 34%; 3, 17%; 4, 16%; 5, 21%; and 6, 7%. Most striking were the relatively low percentages in categories which indicate gross deviations from reality (3 and 6), and the relatively high percentages of new but not unusual elements (Category 4). The results indicate that drastic alterations from waking experience or very bizarre elements are relatively rare in dreams. However, there is considerable novelty in dreams in the form of not previously experienced, but not otherwise strange, elements.

Similarity of REM and Sleep Onset Stage 1 Reports

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One hundred ninety-five sleep onset (SO) stage 1 and 63 REM reports were obtained from 12 females and 11 males who also answered a questionnaire about the characteristics of reported mentation (e.g., whether visual, emotional, hallucinatory, pleasant, contemporary, etc.) at each awakening. Four trained judges, naive about the awakening distribution, were given coded report transcripts and asked to identify the SO and REM reports by using three kinds of criteria: 1) published reports about possible differences between SO and REM reports, 2) tabulations of SO and REM report characteristics from pilot nights of this study, and 3) practice on reports from pilot nights. Judges rated the report collection 5 times, each successive time with more information from the questionnaire. Results were that at all levels of information judges almost always did significantly better in correctly identifying SO reports than in identifying REM reports. Furthermore, assuming a chance frequency of 50% hits, judges almost always did significantly better than chance for SO reports and seldom better than chance for REM reports. This suggests: 1) there are two kinds of SO reports, one distinct from REM reports and the other not; and 2) REM sleep does not contain a unique mentation.

A Replication of the Hall-Van de Castle Character Scale Norms

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We collected 418 dream reports, 50 to 300 words in length, from 26 male and 39 female undergraduate students. These dream reports were scored for characters using the Hall-Van de Castle scale. We found a striking similarity between the distribution of characters in our sample and Hall's on 34 character classifications. To illustrate the similarity, the proportions of seven character classifications of our sample (C) and his (H) are given for male and female *S*s. (The Hall (H) values for male and female *S*s are given first and those for the Cincinnati Sample (C) follow.) Total human characters: Males, .939 (H) and .942 (C); Females, .958 (H) and .952 (C). Total male characters: Males, .530 (H) and .455 (C); Females, .372 (H) and .389 (C). Total female characters: Males, .258 (H) and .258 (C); Females, .401 (H) and .286 (C). Family characters: Males, .095 (H)

and .093 (C); Females, .147 (H) and .185 (C). Characters related to dreamer: Males, .023 (H) and .025 (C); Females, .045 (H) and .047 (C). Characters known to the dreamer: Males, .313 (H) and .297 (C); Females, .368 (H) and .359 (C). Strangers: Males, .232 (H) and .165 (C); Females, .171 (H) and .137 (C). Females in the Cincinnati (C) sample dreamt more about family members than strangers, and males than females, while the reverse was true in Hall's population.

PSYCHOPHYSIOLOGY OF DREAMS

Covert Oral Behavior During Conversational and Visual Dreams

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Heightened covert oral behavior occurs during the performance of a wide variety of language tasks (silent reading, writing, thinking, etc.), leading to the conclusion that this response class performs a language function. An extension of these findings leads to the hypothesis that increases in covert oral behavior should occur during dreams in which conversations are reported as dream content. A female college student slept in the laboratory for 4 consecutive nights while EMGs were continuously recorded from her chin, lips, and neck; frontal lobe EEG and horizontal eye movements were also recorded (on a seven-track data tape recorder). The *S* was awakened shortly after each dream (as determined by cessation of REMs), and reported the content. Three judges listened to the taped reports of the vividly recalled dreams and independently rated them on a 5-point scale ranging from primarily visual to primarily conversational. Eleven dreams of high clarity were reported; 3 were unanimously rated as mainly conversational in content and 2 as essentially visual. The analog EMG data were integrated and digitized during REM sleep and during comparable NREM periods. Mean amplitude values of the two measures of covert oral behavior (lip and chin EMG) were noticeably higher during the REM periods of the conversational dreams than during both the NREM periods and the REM periods for the visual dreams. On the other hand, there were no increases for the covert oral measures from NREM to REM periods for the visual dreams. Little change occurred for neck EMG. Though based on limited data, these findings are consistent with those obtained on waking subjects—covert oral behavior may serve a language function during dreams too.

Dreaming as a Function of Sympathetic Arousal

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The relationship between autonomic arousal and "dreamlike" cognition was investigated. It was hypothesized that the level of autonomic activity is a precondition which determines how the sleeper interprets impinging stimuli and memories; i.e., if the sympathetic nervous system is reasonably quiescent, ongoing cognition may be experienced as thought, but it may be experienced as dreams if the sympathetic nervous system is comparatively active. To test this hypothesis autonomic activity was affected by subdermally injecting .5 cc (1/1000) of

epinephrine, during stage 4 sleep, into 8 *S*s. An equivalent amount of saline was injected during the same night in another passage through stage 4. *S*s were awakened 10 min after each injection and asked to report on their cognitions. Analyses of the data show that: 1) sleep stages were not changed as a result of injection; 2) there was an increase in the mean HR interbeat duration time in the 10 min period after injection of epinephrine as compared to the 10 min period prior to injection; this was not true for the injection of saline; and 3) the cognition reports received after injection of epinephrine were rated as more vivid ($p < .01$), more bizarre ($p < .10$), more emotional ($p < .01$), and more perceptual than conceptual in content ($p < .01$) than those reports received after the saline injection.

Psychophysiological Correlates of NREM Mentation

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University of Virginia School of Medicine

Fifteen male *S*s slept 3 nights with 2 late NREM awakenings (mostly stage 2) made nightly. Psychophysiological measures were continuously recorded. NREM reports with content present were compared within each *S* by the first author without knowledge of psychophysiological scores. No quantitative scores were assigned, but the NREM report judged as highest and the NREM report judged lowest on overall emotionality, vividness of visual imagery, and activity were selected for each *S*. Two pairs of contrasted reports were obtained from 6 *S*s, making a total of 21 NREM pairs available. Psychophysiological scores were computed for the 6 min interval preceding each NREM awakening by Hauri without knowledge of NREM ratings. Differences between each minute's mean HR were squared, summed, and averaged for the variability measure. Results for HR variability were significant ($p < .01$). Two tie scores were obtained and for 16 of the 19 remaining, the NREM member judged as higher on emotionality, visual imagery, and activity had greater HR variability. Fairly similar results were obtained for pulse volume variability scores. These results suggest that psychophysiological parallelism between autonomic measures and quality of mentation may exist throughout the whole range of sleep.

Dream Content and Physiological Arousal

Peter Hauri and Robert L. Van de Castle

University of Virginia School of Medicine

Fifteen students each slept for 3 lab nights, while their heart rate, vasoconstrictions, respiratory rate, and GSR were continuously recorded. Two awakenings from the *S*s' third and fourth REM periods yielded a total of 76 dreams ratable for emotionality, physical activity of the dreamer, and his involvement in the dream. Means and variability (Hotelling's T) of the 4 physiological measures were computed for total REM period (usually 12–15 min), for the last 6 min of the REM period, and for the last min before awakening. Results showed that even though *emotionality* was rated for the entire dream, it related best ($p < .001$) to HR variability during the last 6 min, and to mean GSR activity during the last 1 min. Significant relationships ($p > .05$) of emotionality with vasoconstrictions and respiration also occurred during the last 6 min.

Thus, emotional arousal during the total dream related to physiological arousal at the end of the REM period, suggesting that physiological arousal depended partly on prior emotional dream arousal. *Involvement* did not follow this pattern; it related best ($p > .005$) with mean HR during the *total* dream. Finally, *physical activity* related to none of the physiological parameters, apparently because feedback mechanisms mediating arousal after exercise do not function if such exercise is "merely hallucinated."

THE NEED FOR DREAMS

Light and Deep Sleeper Differences: Fantasy Scores from REM Stage 2 and REM Deprivation Awakenings

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The Auditory Awakening Threshold (AAT) was established for 24 male student *S*s to an 800 Hz tone which increased from 35 to 110 db in 5 db steps. Seven awakenings were made to this stimulus over 1 night to sample stages of sleep and times of night. Five light and 5 deep sleepers were selected and REM deprived 3 nights. Foulkes Dream Fantasy Scale (DF) scores were assigned to all awakenings. Light sleepers had significantly higher DF REM content scores than stage 2 content and significantly higher REM deprivation than stage 2 scores, but had no significant difference between REM deprivation and REM scores. DF scores for deep sleepers were lower than those of light sleepers for all stages. There were no significant differences between any of the deep sleeper scores. Light sleepers had more immediate REM onset eye movements than deep sleepers and these were significantly related to the DF score. Light sleepers had significantly lower REM per cent Base Rate than deep sleepers, were more easily aroused from sleep, had greater REM dream fantasy normally, when REM deprived intensified their REM onset fantasy more quickly, and showed less REM recovery rebound.

Recurrent Dream Fragments in Dreams and Fantasies Elicited in Interrupted and Completed REM Periods

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This investigation continues our earlier work on the need for dreaming by exploring whether there also exists a need for particular dream contents. Two young women *S*s who reported having regularly-recurrent unpleasant dreams were run in the laboratory for 3 consecutive nights during which each REM period was interrupted, and for 5 consecutive nights during which they were permitted to complete their REM periods before awakenings. Dream reports and projective test responses were collected after each awakening, and mood ratings were obtained at regular intervals during the waking day. Although only a single repetitive dream occurred in its entirety, content clearly related to recurrent dream themes appeared frequently, not only in dream reports but also in the projective test responses. This content was characterized by pressureful but ineffectual activity,

and the emotional tone was intensely unpleasant. REM period interruption both heightened the incidence and intensified the quality of the recurrent dream themes. In both conditions, however, a lowered mood generally preceded and followed high recurrence nights. From these results it appears that recurrent dreams have little adaptive value, and that they are an aspect of a more general dysphoric cycle which expresses itself both in dreams and in the waking state.

The Effects of REM Period Deprivation on Sleep Mentation

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The City College Research Foundation of the City College of New York

Our experiment tests the hypothesis that REM deprivation would increase REM and NREM dreaming. Procedure: 1 laboratory adaptation, 2 initial baseline, 2 REM recovery (high REM "pressure"), and 2 terminal baseline nights. Mentation reports were collected from both halves of the night; 2 from REM periods and 2 from NREM 5 min and NREM 15 min after the previous REM period termination. REM deprivation was produced by combination of drug REM "suppressors" and sleep interruption at REM period onset. *S*s were 10 male college students. Preliminary analysis used the mean total word count of reports. (Total word count of reports and dreaming showed strong positive correlation.)

Contrary to our original hypothesis, high REM "pressure" is associated with reduction in word counts of REM and NREM 5 min reports and without effect on NREM 15 min reports. Although fatigue and motivational factors may play a role, they cannot explain the lack of effect on NREM 15 min reports. The results are compatible with the hypothesis that REM deprivation disrupts cognitive mechanisms impairing the ability to recall and perhaps synthesize dreams.

The Effect of Dream Opportunity on Daytime Problem Resolution: A Preliminary Report of a Pilot Study

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To investigate a possible function of dream experience, the quality of solutions offered to matched problems, with equal periods of time given to think them over, were compared under four conditions: 1) 7 hours of normal daytime wakefulness, 2) 7 hours of normal sleep, 3) 7 hours of REM deprivation sleep, and 4) 7 hours of sleep with NREM interruption. The problems consisted of 4 cards from the Thematic Apperception Test (TAT 18BM, 8BM, 6BM, and 13MF). *S* was instructed on each occasion: "Here is someone in a lot of trouble. Look at the card and get it well in mind. I want you to think about it and tell me (when you come back or wake up) if it were you, what would you do?" Preliminary data analysis comparing the solutions of 10 *S*s under conditions 1 and 2 showed solutions reached after a night of sleep with dreaming to be more active, reasonable, and more ego integrated then those reached after equal periods of normal wakefulness.

METHODS AND MEASUREMENTS

The Effect of Dream Length on Dream Content

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To compare two dream report populations which differ in length a correction by word count is made. This correction for word length makes an assumption about the relationship between word length and item frequency. Specifically, it assumes that item frequency (y) is a linear function of word length (x) with 0 intersect ($y = ax + b$, where $a > 0$ and $b = 0$). If this assumption is not satisfied then the ratio of word length to item frequency is not constant and comparisons between dream reports of different word lengths would not be justified. To test this assumption, 678 morning recalled dreams were collected from 70 college students. The dreams were scored for characters and sub-categories of characters and were analyzed at 10 and 20 word intervals. The results indicated that the assumptions were generally unsatisfied. Either the function for a given character scale did not intersect 0, was not linear, or both. It was concluded that the exact relationship between word length and item frequency needs to be specified. Until this has been achieved the use of a division by word length correction should be viewed with caution.

Interlaboratory Reliability of the Hall-Van de Castle Characters, Social Interactions, Activities, and Emotions Scales

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To pursue the interlaboratory reliability of the Hall-Van de Castle Scales, two independent dream populations were blindly scored by two raters without prior consultation. Average dream length was 24.5 words in the depressive population (91 dreams) and 75 words in the schizophrenic population (217 dreams). Percentage agreements were determined using the class (scale) as the unit of analysis. Our percentage agreements on the characters scale for the dreams of the depressed and schizophrenics did not differ significantly from the reliabilities reported by Hall. Our greatest deviation from Hall was in agreeing on the presence of a character. Our scoring reliability (percentage agreement) on the activities, social interactions, and emotions scales were lower than that for characters on most of the analyses in both depressed (D) and schizophrenic (S) populations. Activities: presence, 55.4% (D) and 60.4% (S); subclass, 94.1% (D) and 83.4% (S); perfect, 52.2% (D) and 49.9% (S); and perfect if present, 94.1% (D) and 82.6% (S). Social Interactions: presence, 19.4% (D) and 41.9% (S); subclass, 100.0% (D) and 92.7% (S); "Intensity," 66.7% (D) and 78.2% (S); perfect, 12.9% (D) and 26.0% (S); perfect if present, 67.7% (D) and 61.8% (S). Emotions: presence, 50.0% (D) and

48.8% (S); subclass, 100.0% (D) and 90.5% (S); perfect, 43.8% (D) and 44.2% (S); perfect if present, 87.5% (D) and 90.5% (S). Our rater disagreements were consistent, and suggestive of the raters operating under different assumptions which, if resolved, might result in higher percentage agreements.

Comparison of Behavioral and EEG Criteria of Sleep of Humans

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An attempt was made to correlate the behavioral determinants of sleep with standard EEG stages of sleep-REM. The behavioral observations were part of the routinely obtained sleep charts made by ward nursing personnel on a psychiatric inpatient service. Eighteen nights of sleep on 13 male psychiatric patients were studied. The all-night EEG was obtained from single channel FM radiotransmitters and compared with the behavioral sleep chart, which was recorded at 30 min intervals. Nursing personnel were not aware that correlations were being made. The radiotelemetry provided minimal discomfort to the *S* and minimal disruption of the hospital routine. Behavioral estimations of the wake-sleep states were in agreement with EEG criteria 93% of the time. The majority of errors (85%) occurred when the patients were scored asleep behaviorally but were awake by EEG. One-third of the bed checks made by nursing personnel produced transient EEG arousals but the EEG quickly returned to the pre-check level of sleep.

Reported vs Recorded Sleep Patterns

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Twenty-one carefully screened normal *S*s, familiarized to the sleep laboratory, filled out sleep and dream logs both at home and after one or more nights in the laboratory. Subjective descriptions of sleep ordinarily associated with reports of poor sleep (more body movements, still tired on awakening) were related to transient episodes of wakefulness (number of awakenings, amounts of wakefulness) rather than to amounts of REM, stage 3, or stage 4 sleep. Abrupt as opposed to gradual awakenings favored REM period dream recall. Terminal as opposed to earlier REM periods tended to be associated with detailed rather than vague or no-content dream reports. Presleep tension favored longer sleep latencies, while unusual fatigue promoted transient intercurrent wakefulness. By a number of criteria, *S*s slept better at home than in the laboratory. They were able accurately to estimate sleep latencies. Their estimates of the number of episodes of intercurrent wakefulness were related to prolonged (>4 min) rather than to brief (<4 min) awakenings, while estimates of body movements frequency were significantly related to the number of recorded gross body movements, especially to those associated with waking alpha.

Sleep Staging by Hybrid Computation

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This paper describes the architecture of a sleep-analyzing hybrid computer designed for automatic sleep staging. The intent of the computer is to process the EEG data in a manner very similar to that carried out in manual sleep scoring. To accomplish the data processing, special detectors have been developed for detecting sleep spindles, K-complexes, and REM activity. Highly selective bandpass filters are used for the detection of alpha and delta activity, and high pass filters are used for the identification of muscle artifact. Cross channel correlation is used to enhance the detection accuracy. The sleep stage is determined by carrying out the following logical operations: 1) was there more than 30 sec of delta in a one min interval? Yes – Stage 4 (stop), No – continue; 2) was there more than 12 sec of delta in a one min interval? Yes – Stage 3 (stop), No – continue; 3) was there more than 30 sec of alpha in a one min interval? Yes – Stage 0 (stop), No – continue; 4) was there more than one K-complex or spindle in a one min interval? Yes – Stage 2 (stop), No – Continue; and 5) stage 1 – process REM to determine whether or not in REM sleep.

A Scoring System for Children's Dreams

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In the course of an ongoing longitudinal study of the dreams of 30 children, the need for a systematic and highly explicit scoring system became apparent. We have attempted to devise a system which is consistent with our own specific experimental objectives but which also may be of more general interest. In its current form, the system consists of: 1) a procedure for generating substantive word counts; 2) sets of categories and rules for scoring characters, setting, sensory and motor variables ascribed to dream characters, and cognitive and affective-motivational variables ascribed to dream characters; and 3) rating scales for hedonic tone, active participation, dream distortion, and visualization, scores on each of which generally can be obtained through mechanical application of rules to variables scored under subsection (2). To assist in the training of raters, a manual has been developed. The manual includes definitions of variables, scoring rules, and 24 dream interviews, first presented unscored and then with annotated scoring and completed individual dream-rating sheets. Copies of the manual are available upon request.

The Dreamlike Fantasy Scale: A Rating Manual

DAVID FOULKES

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The Dreamlike Fantasy Scale originally was constructed on the basis of observations of mental activity at sleep onset indicating a progression from "thought-like" mentation to pictorial mentation to hallucinatory dream-like imagery. The scale was designed for use in conjunction with a particular interview format, and probably can only be so used. This interview was arranged so that the *S* will do most of the scaling himself. The scale was constructed to be most useful with nocturnal interviews conducted following arousals from dif-

ferent stages of sleep or from NREM sleep alone. Since most REM reports will be classified at the two uppermost points of the scale, the scale ordinarily cannot be very discriminating among REM dreams. An updated manual has been prepared to facilitate use of the scale. It includes definitions of scale values, instructions for applying these values, a recommended flow-chart of noctural interviews, and summaries of published data on inter-judge reliability and on treatment-and-subject discriminations achieved with the scale. Copies of the manual are available on request.

Extra-ocular Potentials: A Possible Indicator of PGO Activity in the Human

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The observation of spiking in the extra-ocular muscles of the cat coincident with intracerebral ponto-geniculate-occipital (PGO) spikes suggested that eye muscle activity might provide a partial indication of PGO events in humans. Potentials from ordinary disc electrodes near the eye were highly amplified, filtered to reject slow activity, and integrated. The technique yielded phasic integrated potentials (PIPs) with characteristics reminiscent of PGO activity in the cat. Virtually all unambiguous eye movements during REM periods were accompanied by PIPs which usually appeared slightly in advance of the eye movements. PIPs were also plentiful in stage REM independent of recordable eye movements. PIPs appeared sporadically in all NREM stages, most reliably in advance of stage REM. They appeared singly or in bursts of 1–5 sec duration at the rate of about 2–5 PIPs per sec. They could be recorded in the absence of phasic activity from electrodes over other facial muscles. Undoubtedly, some PIPs result from orbicularis spikes which, although not as frequent as eye muscle spikes in the cat, are not always correlated with PGO spikes. The differentiation of orbicularis and eye muscle activity in the human remains a problem for the technique.

Partitioning Sources of Variability in the Electroencephalogram (EEG)

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Since alternations in EEG stage precede and follow body movements (Dement and Kleitman, 1957), variables related to movements are assumed to contribute to the EEG signal. Therefore, assessment of movement variables is required of any research design which attempts to partition EEG into proportions of neural activation derived from: 1) internal, 2) afferent, or 3) afferent-efferent loop activities. To partition variance one starts with the lowest natural stimulation possible, viz., sleep under zero gravity or minimum discomfort from gravity $\times$ body orientation $\times$ time interactions. At least two hypotheses and tests in sleep arise: 1) body reorientations are made to terminate mounting discomfort linked to pressure in time; test – sleepers rotated sufficiently often to keep pressure discomfort below threshold will cease their body movements; and 2) body or limb movements are made to terminate nonpressure related discomfort; test – sleepers receiving appropriate forced and periodic movements of the limbs with and without pressure relief (rotation) will make no voluntary movements. A bed which ro-

tates sleepers longitudinally has been constructed to assess hypothesis (1) above; with modification (2) may follow. Thus, the contributions of physical features of beds (e.g. surface, time of support) and sleepers (e.g., mass) to activation patterns (EEG) may be partitioned.

SEX AND SLEEP

Variations of Plasma Gonadotropin in Normal Subjects During the Sleep-Wake Cycle

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Evidence from various sources suggests that there is a circadian influence on the mid-menstrual cycle release of ovulating hormone in female rats and chickens. Further work in the rabbit, a reflex ovulator, suggests a relationship to paradoxical sleep. Five human females and 3 males slept in an isolated room and EEG, EOG, and EMG were recorded. Blood was withdrawn at 15–30 min intervals via an indwelling catheter. The samples were heparinized, and centrifuged, and the plasma was removed and immediately frozen for later radioimmunoassay analysis of luetinizing hormone (LH). The female *S*s were screened for the normality of their menstrual cycles. The *S*s were then studied just before the time of their predicted ovulation. Preliminary results suggest that there is a periodicity of plasma LH throughout the night during sleep. This was most striking at the time of ovulation, at which time the well-known mid-menstrual cycle peak occurs. No obvious correlation was found between this periodicity and the stages of sleep nor with the time of night. Periodicity in the males was less apparent. In 2 females, the mid-menstrual cycle LH peak seemed to be triggered at 6:15 a.m., in close temporal relationship to the final REM period of the night.

The Sleep of Regularly Menstruating Women and of Women Taking an Oral Contraceptive

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A group of 3 women with regular menstrual cycles and a matched group taking a 2 mg combined form of oral contraceptive were studied through 3 cycles each with sleep monitored for 2 consecutive nights several days prior to the onset of bleeding (T_1), during the days of bleeding (T_2), and during days 7–9 (T_3). The design was counterbalanced with respect to time of cycle and order of night in the lab; *S*s served as their own controls; sleep logs were kept by each *S*; and the recorded waking resting body temperatures confirmed the expected biphasic temperature curves in the regularly menstruating and presumably ovulating women. This study showed no dramatic shifts in mean amounts of stages 3 and 4 and REM sleep at different times of the cycle when hormone levels are in greatest contrast. However, the coefficient of variability showed great differences, for example, in the highly variable latency to stage 3 premenstrually, in the ovulating group. It is suggested that hormone shifts do affect sleep patterns, leading to greater variability in the ovulating group compared to the pill-taking group, with possible timing effects reflected in shifting latencies.

Vaginal Blood Flow During Sleep

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Since the confirmation of Ohlmeyer's (1944) finding that periodic erections occur during sleep, investigations have been directed at finding an analogous phenomenon in females. An isothermal relative blood flow device has been developed which reliably registers changes in vaginal blood flow (VBF) concomitant with fantasy-produced subjective sexual arousal. Body movements and non-specific physiological stress have minimal effects on the measurement. The occurrence of VBF changes during sleep was studied in 2 *Ss* who each slept in the laboratory for 3 nights of uninterrupted sleep. Both *Ss* were in various phases of their menstrual cycle during the monitored nights. Each sleep run was preceded by at least 2 waking fantasy trials. A total of 20 REM periods were observed. In 19 of these periods, VBF activity was present either as a pattern similar to the fantasy arousal response or as a marked increase in irregularity. Seventeen VBF activity periods were also observed in NREM sleep. These VBF patterns could not be distinguished from those observed during REM. No consistent relationship between NREM VBF patterns and EEG could be detected. The observed changes in VBF in the sleeping female appear analogous to the pattern of penile erections observed in the sleeping male.

The Clitoral Erection Cycle During Sleep

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It has been observed that in males penile erections accompany REM sleep. Comparable observations of clitoral erections in females have not been made because of technical difficulties in producing a strain gauge for the normal clitoris. The study of females with congenital clitoral enlargement and the development of a mercury strain transducer have made such observations possible. Two females with genetically enlarged clitorises, due to virilizing congenital adrenal hyperplasia (CAH), were compared with two males with the same disorder and with two healthy males. EEG sleep patterns and nocturnal erections were monitored on 3 or more nights for each *S*. The number of nocturnal erections observed in both female and male CAH *Ss* was similar to the number observed in the healthy males. Moreover, in all *Ss* the majority of the erections accompanied REM.

The Effect of Sexual Intercourse on Sleep Patterns and Nocturnal Penile Erections

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The role of frequency of sexual intercourse in the psychobiological processes has been a subject of controversy throughout medical history. Until recently, however, technological limitations have prevented the empirical testing of even the most rational of theories. The fact that penile erections frequently accompany REM sleep, during which dreams are most often reported, has led to the hypothesis that nocturnal erections are somatic manifestations of instinctual drive. A test of this hypothesis was attempted by restricting sexual activity and observing the amount and types of erec-

tions occurring during and after the deprivation. EEG, EOG, and tumescence tracings were taken for 10 previously lab-adapted, normal, married males, aged 22–32, throughout a night (SD) following an average of 10 days of sexual abstinence. The following evening, the *Ss* had intercourse and then reported for a second night of recording (PD). While total sleep time and REM density were similar for the two conditions, percent stage 3 was greater on PD. On SD, there were fewer erections, there was a longer time between erections, and the second tumescence episode was longer than on PD. Therefore, sexual abstinence did not produce gross sleep disturbances, nor did it increase the amount of nocturnal tumescence, although there were modifications in the frequency of the episodes.

ONTOGENY

Evidence for Paradoxical Sleep in Utero in the Guinea Pig

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Light ether anesthesia was used during the implantation of electrodes in the mother. A laparatomy was performed; after incision of the uterine wall and the amniotic membrane, the electrodes were implanted in 17 fetal guinea pigs between the 42nd and the 67th day of gestation. The fetal behavior was continuously observed throughout the polygraphic recordings to permit the subsequent interpretation of the states of wakefulness activity. In the fetus REM periods have been identified as early as 48 days of conceptional age with the aid of the observation of REM accompanied by a fast ECoG activity. Their mean duration was 80 sec (about 40% of recording time). EEG pattern of NREM appeared around the 51st day. These data reveal the existence of REM during prenatal life. Fetal REM periods may even appear during arousal of the mother and do not occur at the same time in all the fetuses.

Eye-Movement-Density and Brain-Maturation

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The time-intervals (I) separating 62,341 eye movements were measured in premature and newborn babies. The $I < 1$ sec decreased in the 37–39 week age group. No change was seen in the $I > 1$ sec. This decrease in eye-movement-density coincides with the development of the cortical structures and their inhibitory functions. The interval between REM stages decreases with maturation. From fullterm on, there is a large variability in $I < 1$ sec during the successive REM stages. This variability is more pronounced in normal children of older age groups, as if their appearance depends on alternatively excitatory and inhibitory processes occurring irregularly during successive REM stages. The correlation between the individual REM times and the $I < 1$ sec becomes significant toward fullterm only, whereas it is significant in each age group for the $I > 1$ sec. These two classes of intervals seem to belong to different populations, and

only the I < 1 sec vary with maturation. The intra-individual correlation between REM time and the I < 1 sec is significant at $p = .05$ in 1 out of 5 cases in the 33–36 week group, and in 2 out of 6 cases in the 37–39 week group. In the 40–41 week group, the correlation is significant at $p = .01$ in 7 out of 13, and at $p = .05$ in 3 out of 13 cases.

Genetic Determinants of the Sleep Response

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Cortical and hippocampal EEG recordings were obtained from 7 rats each of two inbred strains (ACI/Mai and F344/f Mai). These two strains, with more than 76 generations of inbreeding, exhibited large differences in total sleep. The ACI strain consistently exhibited more sleep, 64.5% vs 50.1%. During the light cycle the ACIs had significantly more paradoxical sleep, 15.2% vs 11.1%, although paradoxical sleep across the entire 24-hour period did not differ. In addition, the ACI strain had more sleep episodes greater in length than 15+ min with a mean of 22.7 vs 14.0, and fewer 1–6 min episodes than did the F344s, with a mean of 11.3 vs 24.0. Both strains of inbred animals also showed smaller intragroup variances, as compared with genetically heterogeneous animals. There is, then, the indication that animals from genetic pools exhibit distinguishable sleep behavior in both amount and pattern. It should be noted that the F344 strain is albino and the ACI is pigmented. The role of this difference on the visually sensitive sleep response is being investigated.

Effects of Stress on Neonatal Sleep

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We observed lengthy sleep-onset NREM periods following routine blood drawing in normal newborns. This led us to explore the effects of a stress-producing event on sleep by using circumcision (done without anesthesia) as an independent variable. In two exploratory studies, most infants showed a primary increase in NREM sleep of major proportion in the 12 hours following circumcision. In the current study, 20 normal male infants had 10-hour continuous recordings on 2 successive nights beginning at 24 hours of age. Half of the infants had circumcisions and heel pricks delayed until after the period of study; the other half began the second night of recordings with a circumcision. Eight out of 10 circumcised infants showed major increases in NREM sleep with increases varying from 41% to 121%. NREM sleep values of non-circumcised infants were stable from Night 1 to Night 2 with the greatest single increase being less than 3%. Results are highly significant. We have seen long periods of wakefulness with vigorous crying in newborns who have not had circumcisions, and there has not been a major increase in NREM sleep; therefore, we speculate that exercise is not the predominant factor in producing this effect.

Study of Auditory Reactivity During Sleep in the Human Premature Baby

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A study of 10 babies born between

the 28th and 32nd week (gestational age) was made from polygraphic recordings including EEG, respiration, EKG, and 4 limbs EMG. Long distance transmission, by wires, from the premature unit, and permanent control by a circuit video recorder gave a recording under normal conditions. The stimulus chosen was a click. Two types of reactions have been studied, EEG responses and the motor responses. Both these responses had a latency less than 250 msec. A statistical analysis showed that: 1) motor responses diminished with maturation during quiet sleep, but were always more frequent during active sleep; 2) palpebral responses or blinks increased with maturation during active sleep; and 3) individualization of the two states of sleep is precocious; in particular EEG responses (vertex-spikes) were more frequent in quiet sleep beginning with the 32nd week. The period from 32 to 33 weeks seems to have its own individuality since it is there that we can observe the concurrent appearance of an organization of sleep and the beginning of changes in the reactivity.

INSOMNIA AND ITS TREATMENT

A Scaling System for a Qualitative Description of Sleep

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A two-part scaling system was developed to meet the need for the description of qualitative aspects and temporal patterning of sleep. The first part consists of four general descriptors: sleep length, latency to stage 3, REM density, and a muscle artifact quotient. The second part scales each cycle of the night. Both the general descriptors and the individual cycles are scaled from 0 to 9, depending on quality. This scaling system was used to analyze the sleep patterns of a group with poor sleep and of a control group with no sleep disturbances. Large differences were found in REM density and in muscle artifact. Scale values of cycles more frequently fell between 4 and 6 for poor sleep and between 7 and 9 for good sleep. The difference is greatest in the first two cycles. An individual's sleep patterns were consistent from night to night while the sleep patterns of the two groups differed markedly. The system characterizes the total sleep as well as indicating the number of cycles and their quality. It provides a brief description of a night's sleep, and the nature of any irregularities, and shows the part of the night affected.

A Comparative Study of the Effects of Methaqualone (Quaalude) and Glutethimide (Doriden) on Sleep in Male Chronic Insomniacs

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Methaqualone (300 mg) and glutethimide (500 mg) were administered during 3 consecutive nights (single-blind design) to 10 male *Ss* with a long history of insomnia. Drug nights were preceded by 3 placebo nights and followed by 4 placebo nights. The *Ss* were recorded continuously during 420 min regardless of being asleep or not. The data, in terms of time spent in the different stages of sleep, were as follows: 1) methaqualone decreased stage 0, increased stage 2, and decreased stage 4; 2) REM was not changed dur-

ing drug nights but increased above control levels during recovery nights; 3) glutethimide decreased stage 0, increased stage 2, and decreased REM; there was a rebound increase during recovery nights; and 4) both drugs increased the latency to the first REM period and decreased the mean duration of REM episodes and the number of eye movements. No immediate explanation was found for the increase in REM following 3 nights of methaqualone administration, nights during which this stage of sleep was not affected in duration.

The Effect of Placebo and Hypnotic Drugs on Human Sleep

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Effects of phenobarbital, pentobarbital, chloral hydrate, and trichloryl (active metabolite of chloral hydrate), and placebo on sleep were investigated in 5 healthy adult *S*s. Medication was given at the time of arrival at the laboratory (a half hour before usual bed time). All drugs and placebos were studied for 2 consecutive nights each. Sequence of drugs in Part I (tablet) was: trichloryl, 1.0 gm; placebo; and phenobarbital, 100 mg. Sequence of drugs in Part II (liquid) was: trichloryl, 750 mg; pentobarbital, 100 mg; chloral hydrate, 500 mg; and placebo. All *S*s initially slept for 4 control nights without any medication or placebo. Neither the EEG technician, *S*s, or EEG data scorer knew the ordering of these compounds. Continuous recordings of the EEG and EOG of all *S*s for all nights of sleep were obtained and visually scored. Results: 1) both drugs and placebo decreased REM time, when compared to control nights; trichloryl produced the least amount of decrease with no rebound phenomena noted; 2) both drugs and placebo increased stage 4 sleep, when compared with control nights, with higher increases for chloral hydrate and trichloryl; and 3) compared to placebo, pentobarbital showed a decrease of stage 4 while the other drugs showed increases.

Stage 4 Sleep: Studies of Hypnotic, Tranquilizing, and Antidepressant Drugs

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UCLA Sleep Research and Treatment Facility

Hypnotic and tranquilizing drugs: With administration of Doriden and three benzodiazepine drugs (Valium, Librium, and Dalmane), gradual decreases in stage 4 occurred. With Nembutal, an abrupt decrease occurred on the first drug night. In no case was there a rebound above baseline following withdrawal. In separate long-term studies, drug administration extended 2 weeks (Dalmane) and 1 month (Valium); both drugs produced marked decreases in stage 4 sleep. *Antidepressants:* 1) A young girl with a history of frequent night-time "seizure-like movements" was studied. After one month of administration of desipramine 75 mg, sleep laboratory study showed decreased REM sleep as expected; however, stage 4 sleep was not increased; in fact, it was slightly decreased. Clinically, there was a marked decrease in the "movement episodes." 2) Two insomniac patients were placed on desipramine and imapramine respectively. After approximately 1 month on the drug, REM sleep was decreased while there was clearly *no* increase in either stages 3 or 4 or the combined totals. Thus many

drugs decrease stage 4 sleep. In general, decreases in stage 4 are more gradual than those in REM sleep with drug administration. Following drug withdrawal, *recovery is more delayed* and there *is no rebound* (unless it appears later).

Treatment of Disordered Sleep: Laboratory and Clinical Studies

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Hypnotic drug dependence: In order to markedly minimize REM rebound we withdraw patients at the rate of one therapeutic dose every 5 or 6 days. Exercise (not prior to bedtime), reassurance, and instruction about possible psychological changes are of value. *Insomnia:* We treat difficulty in falling asleep with chloral hydrate, Valium, or flurazepam (Dalmane) as follows: in cases of mild and transient difficulty, either chloral hydrate 1000 mg, Valium 10 mg, or Dalmane 15 mg is used; with more severe or protracted difficulty, Dalmane 30 mg is used; for difficulty staying asleep or early final awakening, we have found that antidepressant medication, given throughout the day, is of considerable benefit; if these patients also have difficulty in falling asleep, Dalmane at h.s. (before sleep) is added. *Coronary artery and duodenal ulcer disease and ophthalmologic conditions:* It is possible that these conditions may exacerbate during REM sleep. Potential benefits of REM suppressant drugs should be thoroughly investigated in these conditions. However, the risk of withdrawal REM rebound should also be considered. *Childhood sleep disorders:* In sleepwalking we are evaluating a known stage 4 suppressor, Valium. We have found that Tofranil markedly decreases enuretic frequency if dosage is adjusted.

Hypnotic Drugs and Their Effectiveness: Sleep Laboratories Studies

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Three separate studies with insomniac *Ss* were conducted to evaluate the effectiveness of various sleep medications in inducing or maintaining sleep or both. The drugs evaluated were chloral hydrate (Noctec) 1000 mg, flurazepam (Dalmane) 30 mg, and glutethimide (Doriden) 500 mg. Each drug was evaluated separately (N = 4) with the following 22 night schedule: nights 1–4, placebo, laboratory; nights 5–7, drug, laboratory; nights 8–15, drug, home; nights 16–18, drug, laboratory; and nights 19–22, placebo, laboratory. Sleep latency was significantly decreased on the initial set of drug nights for both chloral hydrate 1000 mg and glutethimide 500 mg. Effectiveness of these drugs diminished quickly at home (8–15), and this was confirmed on the second set of drug nights (16–18). Flurazepam administration resulted in a significant decrease in sleep latency, wake-time after sleep onset, and the total number of wakes. These favorable changes in sleep induction and maintenance were maintained throughout the two-week drug administration period (nights 5–18). These studies clearly indicate that the *type* of hypnotic effectiveness (or lack thereof) as well as the *length* of this effectiveness can be accurately

and objectively delineated in the sleep laboratory.

Evaluation of Subsequent Performance Following Hypnotic Drug Use

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In addition to determining a drug's effectiveness and whether it alters normal sleep patterns, we need to know what effects, if any, hypnotic drugs have on waking behavior and performance. We have studied these parameters using a number of hypnotic drugs during an interval of wakefulness following premature interruption of a night's sleep. The drugs evaluated along with placebo were chloral hydrate 100 mg, chlordiazepoxide HCL (Librium) 25 mg, and secobarbital (Seconal) 100 mg. The experimental protocol for each *S* was as follows: B = Baseline and E = Experimental nights: BBBEEEEE. On each baseline night placebo was given, while on the experimental nights active drug or placebo was given. Order of drug administration was counterbalanced. Drugs and placebo were given at lights out (approximately 6:30 p.m.) and the *S*s were allowed 4 hours between lights-out and-lights on. Prior to the administration of the drugs or placebo, and at successive intervals for 4 hours following the 4 hours of sleep, mood and performance were evaluated with digit span, digit symbol, pursuit rotor, Wilkinson addition test, and modified mood scale. The drugs ranked as follows in order of those least affecting performance and mood: placebo, chloral hydrate, Librium, and Seconal.

Methodologic Considerations and Recommendations for Sleep Laboratory Drug Evaluation Studies

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UCLA Sleep Research and Treatment Facility

We feel that there are a number of crucial factors relating to how drugs should be evaluated in the sleep laboratory. 1) Recording a complete 8-hour sleep period with data analyzed over an entire night and within fractions of a given night: In drug studies, REM suppression may occur early and REM rebound late on the same drug night. 2) Recording a number of consecutive nights to include adaptation, baseline, drug, and withdrawal conditions: The use of consecutive nights also eliminates the factor of readaptation. Drug administration should extend for at least several consecutive nights to determine cumulative as well as initial drug efforts. The importance of measuring drug withdrawal and its clinical correlates is now well established. 3) Scoring of all sleep stages: We have found many drugs which significantly alter stage 4 as well as REM sleep. 4) Studying each drug independently of any other drug since sleep of one night is dependent on the sleep of the previous night. 5) Utilizing insomniac *S*s and lengthy periods of drug administration (at least 2 weeks) if hypnotic effectiveness is under evaluation: While the presence or absence of effectiveness of a drug could be determined in a few nights of drug administration, the length of effectiveness, i.e. whether tolerance develops, can only be studied with a prolonged drug administration period.

Flurazepam (Dalmane) as a Hypnotic for Insomniac Psychiatric Patients

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Kales has shown that flurazepam 30 mg does not suppress REM sleep and is effective in reducing and maintaining sleep in insomniac subjects. Forty-nine male patients, aged 21–69, in a psychiatric ward, were given either placebo or flurazepam 30 mg for 7 nights after 1 baseline night without medication in a double-blind study. Prior to the study, all other psychotropic and hypnotic medication was discontinued. Twenty-six patients received flurazepam and 23 received placebo. Questionnaires were used by the patients to assess the quality and length of sleep, induction time, number and length of wakes, and side effects of the medication. The patients were observed by sleep investigators (not nurses) every 15 to 30 min all night for correlation of the above factors with those reported by patients. Data from both patients and observers showed flurazepam, when compared to placebo, reduced induction time, increased length of sleep, and reduced the number of awakenings. The changes in sleep in treatment nights relative to baseline nights for flurazepam and placebo were as follows: 1) *induction of sleep:* observed, −12 min vs no change; patients estimate, −21 min vs −10 min; 2) *duration of sleep:* observed, +42 min vs +12 min; patients estimate, +84 min vs +42 min; and 3) *number of awakenings:* observed, −.59 vs +.06; patients estimate, −1.26 vs −.91.

The Effect of Drugs on Sleep: Long-Term Human Studies

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Reserpine, amitriptyline, chlorpromazine, chloral hydrate, chlordiazepoxide, and placebo are being studied in a double blind experiment. *S*s, psychiatrically and psychologically screened "normals," took 1 capsule each night before sleep (h.s.) for 28 days; this period was followed by a second month during which no pills were taken. *S*s slept in the laboratory the first 5 nights upon starting drug, once/week for the next 3 weeks, 6 nights upon discontinuation of drug, and once/week for 3 more weeks. During the entire 2 month period *S*s kept a sleep log-diary and a weekly mood check-list. Preliminary results reported on 15 drug periods for 4 *S*s indicated that reserpine 0.5 mg/day h.s. tended to reduce delta sleep and increase D-time during the entire period of drug administration. Amitriptyline, 50 mg/day h.s., increased total sleep time with a definite decrease in D-time followed by a rebound on drug discontinuation. Chlorpromazine, 50 mg/day h.s., produced no marked change in sleep patterns. Chloral hydrate, 500 mg/day h.s., increased total sleep slightly, but gave a clear decrease in delta sleep in one *S*. D-time was normal or slightly low, but discontinuation produced a tendency to rebound even when there had been little original reduction. Chlordiazepoxide, 50 mg/day h.s., had no clear effects on total sleep or delta sleep. D-time was slightly decreased with little evidence of rebound.

The Effect of Methaqualone on Nocturnal Sleep

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The effect of 150 mg of methaqualone (Arnar-Stone Laboratories: Sopor) on the sleep of 6 young adult normal *Ss* was studied. *Ss* slept in the laboratory for 8 consecutive nights on the following placebo-drug-placebo schedule: PPPDDDPP. Apart from the usual first night reduction of stage REM, the distribution of sleep time among the different sleep stages was remarkably stable across the 8 nights. There were no drug related changes in stages 3 and 4; in this respect, 150 mg of methaqualone did not produce a deviation from normal sleep values; 150 mg of methaqualone did not decrease REM time. An evaluation of eye movements, however, revealed a REM suppressant effect not apparent in the duration of stage REM. A comparison of the third placebo night with the first drug night showed a significant decrease in eye movement density (percentage of 2.5 sec intervals in stage REM with unambiguous rapid eye movements) as a result of the drug (21% to 15%). The decrease in eye movement density without reduction of stage REM time again emphasizes the importance of phasic REM events.

ADDICTIVE DRUGS

Some Changes in Human Sleep During Chronic Intoxication with Morphine

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Sleep of 6 male post-addicts was studied for 11 nights during 3 phases of a chronic morphine cycle: 5 consecutive nights during an initial control phase, 1 night during an ascending dose phase (AP), and 5 consecutive nights during a stable dose phase (SP) when 240 mg of morphine daily had been maintained for about 9 weeks. REM sleep was significantly decreased during SP, although not as much as during AP, or as after 30 mg of morphine in a prior study. Frequency of REM sleep episodes remained significantly lower during AP and SP, but mean REM sleep episode duration showed no significant change. The prevalence of eye movements during REM sleep was decreased during AP, but returned to control level during SP. Delta sleep increased slightly and shifted toward later in the night during AP and SP, in contrast to its significant decrease after single doses of morphine. Waking state showed no significant change, in contrast to its significant increase after single doses of morphine. A delta-alpha-theta EEG pattern appeared during AP, but diminished during SP. Alpha waves increased in amplitude and variability during SP. Thus, various patterns of tolerance and emergent morphine effect were demonstrated in this study.

Sleep and Narcotic Tolerance

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The development of tolerance to a narcotic was shown in a longitudinal sleep study of ex-heroin addicts when "clean" for more than 6 months, and when on a moderate and finally a high

(90–100 mg) daily oral dose of methadone. This narcotic's initial effects on the sleep pattern were to increase latencies to and decrease amounts of both stages 3 and 4 sleep and REM sleep. As tolerance to methadone developed, latencies decreased and amounts of stages 3 and 4 and REM approached levels found when *S*s were "clean." Another study contrasted the sleep of three groups: ex-addicts stabilized on high doses of methadone for several years, ex-addicts (with similar mean length of addiction and mean age) abstinent for several years, and an age-matched control with no drug history. These studies showed greater numbers and duration of awakenings in both groups of ex-addicts, only partial tolerance to the narcotic's initial effect of increased awakenings, but development of full tolerance in stages 3 and 4 and REM sleep. Furthermore, as has been found in other narcotic effects, individuals showed varying tolerance development rates for the different sleep parameters.

Short Latency REM in Chronic Alcoholics

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As part of a study of the effects of alcohol on sleep and memory, 6 male alcoholics (average age 46), with no symptoms of alcohol withdrawal, no liver disease, and no psychiatric disorder other than chronic alcoholism, were continuously monitored polygraphically. This report is restricted to the 20-hour baseline recordings, during which 4 of the 6 *S*s showed a markedly disruptive sleep pattern with frequent awakenings interrupting both the NREM and REM components of sleep. We noticed that several REM periods occurred shortly after periods of wakefulness. In these 4 *S*s, 35 REM periods were observed. Thirteen of these (36%) were short-latency REM, defined as: 1) a REM period of at least 2 min duration; 2) a REM period beginning within 15 min of the end of wakefulness; 3) at least 30 min elapsed since the previous REM period; and 4) less than 10 min of accumulated sleep stages 2, 3, and 4 since the previous REM period. The other 2 *S*s showed no short-latency REM periods as defined by these criteria. We have found that short-latency REM may be observed in alcoholics in the absence of withdrawal symptoms or mental status abnormalities.

Changes in REM Sleep and Dreaming with Cigarette Smoking and Following Withdrawal

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Seven *S*s were studied for 9 to 11 consecutive nights each with EEG, EOG, EMG, and EKG monitored continuously for the 8-hour sleep period. The first 4 nights followed days during which *S*s continued to smoke as usual (2–3 packs per day). Starting on the fifth day, *S*s completely abstained from smoking so that nights 5–9 represented withdrawal nights. Two *S*s spent a tenth night and another 2 an eleventh night in the laboratory to allow for a more protracted study of the withdrawal period. The most striking finding was a moderate increase in the percentage and absolute amount of REM sleep on withdrawal nights as compared to "cigarette nights." The increase in percent and absolute REM sleep was accompanied by spon-

taneous reports of increased dreaming as well as a marked increase in the intensity of the dream content. Several *S*s reported unpleasant dreams; however one *S* reported increased dreaming but described his dreams as "more peaceful and calm" during withdrawal.

Sleep Laboratory and Clinical Studies of the Effects of Tofranil, Valium, and Placebo on Sleep Stages and Enuresis

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Four enuretic children with a history of bedwetting 4 or more nights per week were studied to determine the effects of Tofranil, Valium, and placebo on enuretic frequency and sleep stages. The study consisted of three separate investigations. In each study, after 4 placebo baseline nights, administration of either Tofranil, placebo, or Valium was started and continued for one month. Initial drug doses in the laboratory were Tofranil 50 mg and Valium 10 mg. The dose was increased each week if the children did not show a 50% reduction in enuresis for that week. *Results:* 1) *Tofranil:* A moderate reduction in REM sleep was noted throughout the one month administration period. Following drug withdrawal, there was an abrupt and marked REM rebound while stage 4 sleep slightly decreased. Tofranil was effective in treatment of enuresis when the dose was adjusted. This effect is apparently independent of sleep stage alterations. 2) *Valium:* No significant alterations in REM sleep were noted. Stage 4 sleep was markedly decreased with administration. Following withdrawal, stage 4 sleep re-appeared but not completely to baseline levels. Only one child had a reduction in enuretic frequency. 3) *Placebo:* No significant alterations in sleep stages or enuretic frequency.

Marijuana Intoxication: Reported Effects on Sleep

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One hundred fifty experienced marijuana users indicated by questionnaire how frequently various effects of being stoned were experienced (Never, Rarely, Sometimes, Very Often, Usually) (N, R, S, VO, U), and also the minimal degree of intoxication (MDI) needed for each effect (0–4 scale). Drowsiness before bedtime is common (VO = 25%, U = 12%), MDI = 2.0. Finding it easier to go to sleep at bedtime when stoned is common (VO = 19%, U = 57%), MDI = 1.2, with difficulty in going to sleep uncommon (N = 45%, R = 23%) and occurring at a higher MDI of 2.5 ($p < .001$). The night's sleep being particularly refreshing is common (VO = 20%, U = 26%), MDI = 1.4, with poor or restless sleep uncommon (N = 49%, R = 28%) and at a higher MDI of 2.3 ($p < .001$). Effect on recalled dream vividness is variable: for more vivid, VO = 16%, U = 12%, MDI = 1.7; for less vivid or forgotten, VO = 7%, U = 13%, MDI = 1.6; no significant differences. The data suggest that: 1) moderate levels of marijuana intoxication have a sedative effect but high levels may overstimulate, ward off drowsiness, and make sleep poor; and 2) more experience with altered states of consciousness (greater marijuana use and/or experience with other drugs) results in higher MDIs for negative effects (pre-bedtime drowsiness, difficulty getting to sleep, restless sleep).

PATHOLOGY

"Phasic REM" and Depression

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Each of 9 depressed inpatients slept for at least 10 nights in the lab. Beck Depression Inventories were administered every evening, and 3 measures were obtained: A *total Beck* score, Weckowicz's factor of *guilty depression*, and Pichot's factor of *vital* (somatic) *depression*. EEG sleep scores were correlated with the 3 Beck measures obtained before sleep (BS), and also with the 3 Beck measures obtained on the following evening (FE). In addition to the usual EEG scores a "per cent phasic REM" was computed by classifying each half minute scored REM either as "containing phasic elements," at least one eye movement (EM), or as "purely tonic" (no EM). Since interest was focused on daily fluctuations in depression and sleep, effects of the gradual trend toward less depression and better sleep in *Ss* was statistically partialled out. Of the over 40 different EEG measures scored, only "per cent phasic REM" showed a significant ($p > .01$) relationship to daily fluctuations in depression: *The more "per cent phasic REM" during sleep, the less waking depression.* "Per cent phasic REM" correlated significantly ($p > .05$) with guilty depression BS (but not FE), and ($p > .01$) with vital depression FE (but not BS), suggesting a temporal development from guilt BS to low "per cent phasic REM" to vital depression FE.

Sleep Disturbances in Chronic Schizophrenia

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It is still unclear as to whether reported deficits in stages 3 and 4 are transient or stable characteristics of chronic schizophrenic sleep. In order to investigate this problem, 9 chronic schizophrenic males, aged 24–61, were monitored for 8 consecutive nights. All *Ss* were on low to moderate maintenance dosages of phenothiazines. Records were scored according to the criteria recently proposed by the APSS Committee on scoring and terminology. Delta waves were defined as 1–2 Hz and greater than 75 microvolts in amplitude. Results were: The major finding of this study is the persistent absence of delta sleep over 8 consecutive nights in these patients. Although delta waves were frequently observed, they rarely reached scorable proportions. Five subjects had zero scorable stage 4 sleep and the others averaged less than 1% across the 8 night period. Stage 3 values were also markedly and consistently reduced. Means and standard deviations for other sleep variables were as follows: Stage REM per cent, $\bar{X} = 21.5$, S.D. = 7.1; REM latency, $\bar{X} = 91.9$, S.D. = 61.7; total sleep time, $\bar{X} = 377.7$, S.D. = 66.2; and sleep latency, $\bar{X} = 34.3$, S.D. = 31.3.

Effects of Dexedrine on Sleep Patterns of Hyperactive Children

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EEG sleep patterns were monitored before and after dextroamphetamine (Dexedrine) treatment in 3 boys (7, 8, and 9 years old) diagnosed as manifesting the hyperkinetic syndrome of childhood. The design of the study was: Placebo, 5 nights of recording; Dexedrine 5 mg, 3 nights. Then a two-week period of medication adjustment was followed by 3 nights of recording on

optimal dosage (15–20 mg daily), and 3 nights on placebo to obtain withdrawal responses. The drug was given in a single dose each morning. In one of the *S*s, these observations were supplemented with 5 nights of recording after 5 months of Dexedrine treatment. We found that the basal sleep patterns as well as the pattern and quality of the hyperactivity in the 3 children differed—thus, the syndrome appears heterogeneous. The most "classical" *S* showed almost complete remission of his symptoms. Nevertheless, after 5 months of treatment, his sleep pattern was unchanged from baseline levels. Finally, it is of interest that Dexedrine administration had little effect on eye movement density or stage 4 sleep even though it affected behavior.

The Influence of Valium, Thorazine, and Dilantin on Stage 4 Nightmares

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The most intense nightmares have been found to arise from stage 4 sleep. It seemed possible to suppress the nightmares using a stage 4-reducing drug. With Valium, a stage 4 suppressor (Kales), we have obtained a significant reduction of nightmares. In Subject A (5–15 mg Valium) nightmares dropped from 3.0 (7 nights) to .5 (13 nights) per night; in B (5–10 mg) from .89 (9 nights) to .55 (9 nights); and in C (5–7 mg) from 1.0 (10 nights) to .38 (8 nights). Delta sleep in each was markedly reduced. Subject C's repetitive nightmare (1 to 3 per week; running about the house, terrified, searching for an intruder) was totally abolished. To control for tranquilizing and anticonvulsant actions of Valium, Thorazine, and then Dilantin was administered to Subject A. Thorazine (25–50 mg) did not reduce number of nightmares (2.6 per night). (In fact, the two most severe occurred on Thorazine.) Dilantin (100 mg t.i.d.) had no influence on nightmares (3.0 per night). It was concluded that the tranquilizing and anticonvulsant properties of Valium were not responsible for the reduction in stage 4 nightmares and that the diminution of stage 4 seemed to be somehow causal.

Clinical Classification and Treatment of Narcolepsy and Hypersomnia

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The following are cases of narcolepsy and hypersomnia treated during the last year: 1) Narcolepsy with one or more of the following symptoms: a) overwhelming sleepy spells, b) sleep paralysis, c) hypnagogic hallucinations, d) cataplexy. Eight patients treated, aged 33–56, all responded well to Imipramine. Two of the 8 required Ritalin or amphetamines in addition. 2) Atypical hypersomnias suggesting organic pathology (mixed symptoms including sleepy spells): 6 patients, aged 26–57, treated with Ritalin, amphetamines, or Imipramine, all responded well except 1 patient with severely abnormal EEG. 3) L'ivresse de sommeil: 40 year old female responded well to amphetamine 30 mg and Ritalin 40 mg q.i.d. 4) Pickwickian Syndrome: 59 year old male—poor response without drug treatment. Therapy consists of attempting to reduce obesity. As noted in the work of Roth, Rechtschaffen, Dement, Hishakawa, and others, Imipramine has proved virtually 100% successful for sleep paralysis, hypnagogic hallucinations and cataplexy. The atypicals with suggested organicity require

Ritalin or amphetamines. Sleep spells may require Ritalin or amphetamines. All must be titrated like a diabetic in order to obtain optimum results. Two patients had marked hypertension. They had been on Dexedrene for 24 and 28 years respectively. Of the 16 patients treated, only 2 have had poor response. None have shown tolerance or addiction to amphetamines.

STIMULUS EFFECTS

Effects of Extended Practice on Sleep Learning

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This study explored the possibility that the conflicting findings in Soviet and Western research on sleep learning may be due to important differences in methodology. Eighteen hypnotically suggestible, alpha dominant males were given 2 adaptation nights and 5 nights of training in the learning of Russian-English paired associates in either stages REM, 2, or 4. With the exception of identical lists of 12 pairs presented on Training Nights 1 and 2, *Ss* were given a different list of 12 pairs each night. A set to learn and remember the materials was induced each night. Three independent measures of retention were taken each morning, but only the recognition test revealed reliable effects predictable from learning theory. The performance of *Ss* reporting having heard the materials during the night and/or who showed alpha activity during stimulus epochs and/or evidenced changes in guessing strategies was no different from that of *Ss* whose performance was uncontaminated by these artifacts. The pooled data suggest that the lack of extended practice may be the chief reason for the low levels of retention reported by previous Western investigators.

Sleep Changes Associated with Prolonged Confinement and Social Isolation

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The unrestricted sleep of 10 *Ss* undergoing 21-day confinement and social isolation was recorded for three 3-day periods at the beginning, middle, and end of confinement, and for 3 baseline and recovery nights. Experimental conditions resulted in marked restriction of physical activity and monotonous environment. Total daily sleep times during the initial, middle, and final periods of confinement were 620.76 min, 552.21 min, and 518.13 min. Stage 3 remained essentially unchanged throughout. However, stage 4 was lowest during the baseline period, 17.5 min; and days 1–3 of confinement, 21.1 min; rising to 29.2 min on days 10–12 ($p < .01$); with a value of 28.1 min on days 18–20; and 32.6 min during the recovery period. Questionnaires and clinical impression indicated that subjective arousal and stress was highest during the baseline and initial confinement periods, resulting in stage 4 suppression during those times. REM percentages were higher during baseline, 25.5%, than recovery nights, 21.1% ($p < .01$). During confinement REM values fell from 27.8% during days 1–3 to 24.9% during days 10–12 ($p < .01$) and 25.7% on days 18–20. The higher

REM time in the baseline and initial confinement period may be due to the marked novelty in the environment at those times, increasing the need for information-processing during REM.

A Long-Distance "Sensory Bombardment" ESP-Dream Study

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Eight *S*s spent 1 night each in the Maimonides Dream Laboratory. Standard EEG-EOG monitoring techniques were employed to detect stage REM. "Senders," upon arrival in another laboratory, 14 miles distant, were placed in a "sensory bombardment" audio-visual chamber in which they attempted to transmit randomly selected target programs consisting of 40 different (but thematically related) 2 in. × 2 in. slides, accompanied by a coordinated taped sound sequence. Slides were projected over the entire surface of an 8 ft × 8 ft semi-circular rear projection screen, behind which the "sender" was seated. Such slide programs were used as "The Birth of a Baby," "Artistic Productions of a Schizophrenic Patient," and "Outer Space Exploration." Evaluation was accomplished by giving three judges the dream protocol for each *S* as well as a listing of the 6 slide program target pool from which the actual target was randomly selected. On a blind basis, judges assigned ranks to the 6 titles in the pool on the basis of correspondences between dream protocol and target program. Ranks given the actual target of #1, #2, or #3 were considered "hits" while ranks of #4, #5, or #6 were considered "misses." Using median ranks of the three judges, a total distribution of 8 "hits" was yielded ($p = .004$).

The Influence of Relaxation upon Dreams and Sleep

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The effects of some particular relaxation exercises (M. Orlic) on sleep and on the frequency of kinesthetic fantasies in dreams are presently being investigated. Five *S*s were studied so far, during at least 5 nights (including 2 control nights and 2 nights with relaxation prior to sleep.) The content analysis of the dreams consisted in the selection of fast movements, slow movements and attitudes initiated by the subject, some human character, animals or objects. Some of the preliminary results may be summarized as follows: The distribution of the frequencies for different items of the dreams of the control nights is similar to that of the frequency from a larger dream sample of normal *S*s. There is a consistent increase from 30 to 57% in frequency of slow movements initiated by a human character. The importance of this increase on the relaxation nights is presently difficult to interpret because of an increase of human characters. Relaxation seems further to improve the nightrest and to influence the occurrence of REM sleep (now under systematic investigation).

A Review of the Maimonides Dream ESP Experiments: 1964–1969

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A laboratory approach to the telepathic dream became possible with the advent of psychophysiological techniques for the monitoring of dreams. In addition to the eight formal experimental studies undertaken at the Maimonides Dream Laboratory sev-

eral pilot sessions have been performed. Equally rigorous precautions against sensory leakage were taken with the pilot sessions as were taken with the experimental sessions. Judging of correspondence between the randomly selected target and dream content was accomplished by presenting outside judges with the entire target pool for that night and asking them to assign the rank of #1 to that target picture which most closely resembled *S*'s dreams and associational material. The other targets were also ranked on a similar basis. If the actual target was given a rank within the top half of the distribution, the rank was considered a "hit." There was a constant probability of .50 for a "hit" or a "miss" despite the target pool sizes of the 83 pilot telepathy sessions completed by the end of 1969. The judges assigned 64 "hits" and 19 "misses." This distribution is statistically significant (Cr = 4.90, $p < .00001$, two-tailed).

Short Latency REM After Frequently Interrupted NREM in Normals

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This experiment focused upon the dependency of REM on NREM. Night sleep, daytime naps, and restfulness with closed eyes were continuously monitored polygraphically on 4 nonconsecutive occasions in 3 male students over at least 24 hours beginning at 10 p.m. The baseline condition was undisturbed night sleep. After breakfast, *S*s were deprived by wakening of stages 3 and 4 and of stage 2 exceeding 3 min duration. For the experimental condition, the described awakening procedures were applied over all 24 hours of recording. Under baseline condition, 10 REM periods were observed during daytime napping. Seven of them occurred after highly disrupted NREM sleep or shortly after a meal, in 4 instances without stage 2, and 3 with less than 3 min of stage 2 between the last period of wakefulness and the onset of these REM periods. Of 18 REM periods observed during the experimental condition, only 2 started shortly after an awakening. The remaining 16 were preceded by varying amounts of stage 2, and sometimes 3 and 4 due to operators' inability to awaken *S*s by sound. These data show that short latency REM can be produced during daytime naps in *S*s who experienced undisturbed night sleep.

RESPONSE PROCESSES

Depth of Sleep and Auditory Thresholds During 24-Hour Recording

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In the present study we recorded responses to a steplike increase in the intensity of an auditory stimulus over a 24-hour period during sleep and resting measured by EEG. Eight students were instructed to respond with 3 eye movements, left to right, whenever they heard a sound. Experiments were initiated at random times. Stimulus intensity was started at audible thresholds for 3 sec with a 3 sec pause for the *S*s to respond. Intensity was increased stepwise until response occurred. Individual variation was marked, but the *S*s tended to follow certain patterns: 1) if a *S* had relatively high auditory threshold (AT) values for one specific stage, he also tended to present relatively high values in

other stages; 2) AT values for each EEG stage extended over a wide range during the 24 hours; 3) for all *S*s except one, stage 4 had the highest values; and 4) AT values in REM and stage 4 tended to be dependent upon real time. The highest values for these stages were recorded from 10 p.m. to 8 a.m. The data indicated three primary sources of variance in threshold levels during sleep and wakefulness: 1) the EEG stage of sleep, 2) real time, and 3) individual variations.

Electrographic Aspects of Sleep-Talking

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The electrographic characteristics of most sleep speech episodes are consistent with those criteria described for a "movement arousal" episode in the standardized scoring system edited by Rechtschaffen and Kales. The electrographic features of sleep speech episodes possess great variability, both within and across *S*s. The extremely common flurries of high voltage waves and K complexes which precede electrographic artifacts in NREM speech episodes suggest that sleep-talking and associated muscle tension may be concomitants of a process which is derived from earlier manifestations of cephalic changes. The fact that commonly sleep speech occurs in a matter of a few seconds after such electrographic changes, and tends to be quickly followed by a return to unambiguous sleep, speaks against the idea that sleep speech is essentially a reflection of an hypnopompic state. Our data are more consistent with the view that most sleep speech betokens and reflects in content the activity and nature of prior sleep mentation.

Habituation of the Orienting Response in Sleep

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The possibility of habituation in sleep was tested by presenting 70 db 1 sec duration tones to elicit the orienting response in awake *S*s, and in sleep stages REM, 2, and 4. Six interstimulus intervals were used: 10, 20, 30 sec; also three irregular intervals. Three *S*s underwent all conditions. Heart rate (HR), skin potential (SP), and EEG were dependent variables. HR and SP responses, analyzed separately for each subject-condition, showed significant habituation, except HR responses in waking and REM sleep. There were significant differences in rates of habituation for SP responses between states, habituation being fastest in waking and REM sleep. EEG responses were studied in sleep stages 2 (K complexes) and REM (alpha responses). Plotting responses in all conditions against trials gave significant regressions, the frequency of K complexes decreasing to a maintained response rate of 45% after some 25 stimuli, alpha responses exhibiting complete habituation to the control rate of 6% by the fortieth stimulus. It is concluded that, at least for the responses studied, habituation in sleep is possible in man, despite the supposed reduction in cortical inhibitory influences during sleep.

Heart Rate Responses to Auditory Clicks in Neonates: Effects of CNS State Upon Responsivity

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This study was undertaken to assess the effect of central nervous system (CNS) state upon heart rate (HR) responsivity to simple auditory stimuli. Two normal full-term infants were swaddled and studied on the second and third postnatal days. One hundred click stimuli (peak impact: 110 db) were presented at varying interstimulus intervals against a constant random noise background (55 db). EEG, EOG, EMG, and body-movement/respiration were monitored continuously. Each prestimulus epoch was rated independently by two judges as: active-awake, REM sleep, transition sleep, or NREM sleep. Epochs in which there was disagreement between judges were discarded from further analyses. A computer-based multivariate probabilistic scoring convention was utilized to measure HR response from a magnetic tape recording of the EKG. Both neonates were significantly more responsive in all sleep stages than in the active-waking state both days of testing. One infant also exhibited a small but significant increment in HR responsivity across sleep stages (REM < transition < NREM) which was reliable on retest. This effect was not observed on either day of testing in the second infant.

SLEEP UNDER UNUSUAL CONDITIONS

The Air-Fluidized Ceramic Bead Bed: A Psychophysiological Sleep Augmenter?

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Is there a safe, physiological way of assuring a good night's sleep to anyone who needs it? One possibility is offered by a new, somewhat costly, technological innovation known as the Royalaire[R] air-fluidized ceramic bead bed. Both ill and healthy sleepers appear to obtain unusually refreshing sleep while literally floating in the novel, pleasant micro-environment, which is eminently compatible with all other forms of medical treatment. In this first clinical and experimental assessment of effect on sleep, 15 out of 17 consecutive patients, selected for severe insomnia of varied origin (mild pain, depressive reaction, acute and chronic anxiety, drug withdrawal), experienced significant to complete relief of the symptom following 4 or 5 nights in the bed as sole hospital treatment. Marked carry-over of effect to subsequent nights at home was noted. Two neurotic females rejected a second night in the bed, alleging intolerable erotic stimulation. Mean percentage of slow wave sleep (stages 3 and 4) for second and third nights for 3 healthy, paid volunteers increased to 19.1% above a baseline value of 7.9% in our lab, while being distributed over all thirds of the night. Sleep onset and REM onset latency were decreased, and REM percent increased.

Nocturnal Sleep Patterns during Acute Exposure to High Altitude Hypoxia

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Disturbed sleep and insomnia are characteristic symptoms of acute mountain sickness which results from hypoxia at high altitudes. Measurements of pulmonary function and EEG-staged sleep were made in two visitors to the geographic South Pole (Barometric pressure = 485–525 mm Hg) during the first week. Although only one subject (S-50) experienced the discomfort of acute mountain sickness, both men rated their sleep "poor" and exhibited a complete loss of stages 3 and 4 in their sleep records for all nights recorded. Subject S-50 had further alterations in sleep with 100% increase in stage 1 and 50% decrease in stage REM. Both *S*s had high levels of ventilation associated with arterial PO_2 values of 47 mm Hg and 51 mm Hg. S-50 had a greater difficulty with respiration, exhibiting a ventilatory equivalent of 60 as opposed to 39 for the other *S* with the more normal response. The changes in slow wave sleep appeared unrelated to mood, affect, age, exercise, thyroid function, and pathophysiology. It is hypothesized that the hypoventilation normally associated with sleep exacerbates the existing state of hypoxia at high altitudes and that the elimination of slow wave sleep is a part of the adaptive effect to the hypoxia.

A South Polar Sleep and Dream Laboratory

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Unique challenges to ingenuity were presented the above team of sleep researchers from Oklahoma by the requirement to obtain high-quality all-night polygraphic sleep data during the 9 months of complete social isolation endured by personnel wintering over at Amundsen-Scott South Pole Station, Antarctica. Earth ground is unavailable, 9200 ft below the surface of the ice cap on which the station is situated; mean annual temperature is −60° F; relative humidity is nil; and radio wave propagation research programs fill the air with extreme amounts of electromagnetic energy. All-night recordings of EEG, EOG, EMG, EKG, and skin potential signals were acquired on magnetic tape using the Beckman "BRADS" System with FM tape recorder. Both subject safety and quality signal recording was achieved by construction of unique floating faraday-shielded spaces for sleeping and recording. This reduced electronic noise to a 3-sec pulse precisely every 15 min. Problems for which solutions were found included drying of electrode paste, signal continuity, widely fluctuating line voltage and frequency, stray magnetic fields along a 15,000 mile supply line, and breakage, over-heating and freezing of delicate electronic equipment.

The Effect of Noise on Sleep and Post-Sleep Behavior

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Six *S*s were run to evaluate the effects of noise on sleep and post-sleep behavior. The experiment consisted of 15 consecutive nights and days. The day testing consisted of 3 daily testing sessions of mood and performance tasks. The 15 nights were divided into 4 sections: 1) nights 1–5 were adaption nights, 2) nights 6–8 were used to awaken the *S*s (6–10 times a night using either continuous or impulsive noise), 3) nights 9–14 were sleep disruption nights (*S*'s sleep was disrupted without awakening *S*s), and 4) night 15 was a recovery night. The results of the mood scale indicated a change with the introduction of noise. However, these changes were not consistent across *S*s. The performance tasks more clearly showed a decrement with the introduction of noise. Decrements in performance were obtained with pursuit rotor, memory, time estimation, and vigilance tasks. The sleep records indicated that sleep disruption caused an increase in stages 1 and 2 of sleep, and a decrease in stages 3 and 4 and REM sleep. A more consistent indication of sleep disruption was an increase in number of stage changes per night. The decrease in daytime performance seems to be a function of sleep cycle disruption.

The Effect of Floating on Sleep Patterns

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The effects of simulated weightlessness, produced by a Dry Immersion Bed (DIB), on EEG sleep patterns were studied. Eleven male *S*s, aged 21–31, slept in the sleep laboratory for 1 adjustment night, then for 3 consecutive baseline (BL) nights, and finally for 1 DIB night. EEG sleep patterns were monitored continuously each night. The DIB condition produced lower total sleep times, reduced sleep efficiency (total sleep time/time in bed), and more stage shifts than on BL nights. DIB sleep latencies did not differ from BL values. The reduced sleep time was due to significantly more and longer awakenings during the DIB night. These awakenings occurred a greater number of times from stages 1 and 2. Percent stage 1 was greatest in the DIB condition. Percent REM was significantly less in the DIB condition because of shorter REM episodes. The number of episodes and latency to the first appearance of REM did not differ from BL values. Although percent stage 2 remained the same in the two conditions, the DIB condition produced more and shorter stage 2 intervals. Stages 3 and 4 were not affected by sleeping in the DIB, nor was there any effect on the number of body movements.

Sleep During Tektite I

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During Tektite I, 4 aquanauts spent 60 days in a nitrogen saturated en-

vironment 43 ft below the ocean's surface. Two pre-dive, dive, and two post-dive all-night EEG sleep recordings were obtained on 2 aquanauts; sleep logs were completed during the dive by all 4 aquanauts. During the dive, all-night recordings were obtained every night for the first 10 days, every night for the last 8 days, and every Sunday and Thursday during the remaining period. No major sleep difficulties were indicated during the dive. The total sleep time increased by 1 hour on the average, as did the min or percent of time spent in states 3 and 4. An integrated EEG delta (1–2 Hz) activity reflecting the intensity of slow wave sleep showed a similarly significant increase during dive. The average REM sleep percent of 2 aquanauts was 25, which was similar to the average of pre- and post-dive figures, although the minutes of REM increased during dive. A progressive shift toward later going to bed and getting up occurred, though this was resisted because of early morning research tasks. The sleep logs proved a reliable tool when compared with EEG sleep data.