EFFECT OF REM SLEEP DEPRIVATION ON PSYCHOLOGICAL FUNCTIONING

STANLEY R. CLEMES, Ph.D.3 AND WILLIAM C. DEMENT, M.D.3

Since the discovery that dreaming is accompanied by periods of rapid, binocularly synchronous eye movements (REMs), a number of investigators have attempted to learn more about the function of the dream state and its relation to waking behavior by depriving subjects of REM sleep. This has been accomplished by arousing subjects at the onset of REMperiods. Although both human and animal subjects have been used, the most definitive studies to date have been performed on animals such as the cat (3-5). These studies have suggested an augmentation of drive-oriented behavior in REMdeprived cats, as evidenced by increased hypersexual behavior, and restlessness, ravenous appetite. Psychological and behavioral observations in REM-deprived human subjects have also suggested an increase in drive, but unfortunately only anecdotal findings have been reported (1, 2, 6, 12).

With these findings in mind, a battery of tests was designed to: 1) confirm the presence of psychological changes as a function of REM sleep deprivation in human subjects; and 2) determine if the

¹ Mental Research Institute, Palo Alto, Califormia. Reprint requests should be addressed to Doctor Dement. This research was supported by grant MH-08185 from the National Institute of Mental Health and Research Career Development Award 1-K3-MH-5804 from U.S.P.H.S.

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2 Department of Psychiatry, Stanford University School of Medicine, Stanford Medical Center, Palo

Vito, California, 94304.

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METHOD

SUBJECTS

Six junior college students were selected from approximately 12 men who responded to a request for volunteers. Selections were made to insure relative homogeneity for age and socioeconomic status, and to exclude candidates with gross emotional problems. Each subject was paid five dollars per night for sleeping in the laboratory and an additional 50 dollars as a bonus for completing the entire study. Their ages ranged from 18 to 20. The subjects were kept ignorant of the true nature of the experiment and were told only that it was a study of "disturbed sleep."

REM DEPRIVATION PROCEDURE

Three of the subjects (Group 1) were partially sleep-deprived (NRD), i.e., had control arousals during non-rapid eye movement (NREM) sleep for six nights. No baseline sleep was recorded. They were requested to abstain from sleeping throughout the day so that all sleep would be confined to the nightly laboratory situation. On the day following the sixth night, a battery of psychological tests was administered. Seven days later, the subjects were returned to the laboratory and underwent six consecutive nights of selective REM sleep deprivation (RD), which was accomplished by interrupting each REM period at its onset. On the day following the sixth REM deprivation night. the battery of psychological tests was re-

TABLE 1 Number of Arousals

Group	Days						Totals No. of
and Subject	1	2	3	4	3	6	Arousals
Group 1*							
NRD	1		19	25	26	28	126
A	12	16	16	19	21	22	102
\mathbf{R}	10	14		21	22	24	107
E	10	12	18	21	20	21	
RD	1 223		0.1	26	21	34	137
A	13	19	24		31	30	149
R	11	27	22	28	39	46	187
E	17	20	30	35	29	40	10.
Group 2†							1
RD	1000	7220		0.	20	35	171
В	21	28	32	25	30		119
Em	5	21	26	18	22	27	127
S	15	17	22	25	19	29	121
NRD			100	22	00	00	158
В	19	25	27	26	28	33	
Em	10	19	25	21	23	27	125
S	15	17	20	24	20	29	125

 This group was partially sleep-deprived (NRD) the first six nights; on the second six nights it was selectively REM sleep-deprived (RD).

† For this group sleep deprivation conditions were reversed from those of Group 1.

administered. The number of NREM awakenings during the first six nights in this group was arranged so as to approximately equal the number of arousals that would be required during the second run of selective REM deprivation. However, these predictions were rarely completely accurate (Table 1).

The second group of three subjects (Group 2) underwent RD on their first six nights in the laboratory and a week later received a nearly equal series of NREM awakenings on each night. They also were tested on the days following the sixth experimental and the sixth control nights. The only time the test administrator had contact with the subjects was during the testing periods, and he was ignorant of which condition applied to any subject during any given testing period.

On the night (seventh of the series) following both RD and NRD, all subjects were monitored without disturbance

throughout the entire sleep period. The total REM sleep time on these nights served as a check on the effectiveness of the RD and NRD conditions. In all cases, substantial REM rebounds followed RD, and minimal or no increase in REM sleep time followed NRD.

Throughout the study, each subject arrived at the laboratory about midnight. Electrodes for recording eye movements. EEG, and tonic muscle potentials were attached and the subjects were put to bed, where they typically remained for seven or eight hours. Recordings were made by a Model 6 electroencephalograph which ran continuously throughout the night. NREM awakenings were spaced to approximately duplicate the expected pattern of REM arousals. Subjects were aroused as soon as the EEG record showed evidence of low-voltage, non-spindle pattern in the presence of REM potentials. On RD nights, the reduction of REM time in comparison to the NRD nights was approximately 90 per cent. It was hoped that total sleep time and number of awakenings would be equal or nearly equal in the two conditions for each subject, with amount of REM sleep being the only substantial variable. However, this was accomplished only in the group which was REM-deprived first (Group 2), since in this case precise information was then available upon which to schedule the subsequent NREM series, i.e., total sleep time and number of awakenings could be exactly duplicated. On the other hand, when subjects underwent the NRD condition first (Group 1), total sleep time was generally overestimated (Tables 1 and 2). Thus in Group 1, mean total sleep time during the second six nights was one hour, 11 minutes less than during the first six nights; in Group 2, the mean amounts differed by only five minutes. Because of the frequent arousals and waking periods following each arousal. total sleep time in all cases was somewhat

s than the subjects ordinarily slept at me. In general, the subjects were not thered by fatigue or sleepiness.

The discrepancy in number of awakengs for Group 1 can be seen in Table 1, rticularly apparent for Subject E, who d 107 control arousals and 187 REM privation arousals. On the other hand, a totals for Group 2 are almost identical, the typical effect of an overall increase in mber of awakenings necessary to intrupt each REM period at its onset may seen in the RD series.

YCHOLOGICAL EVALUATION

Psychological tests were selected to easure the following modes of behavior: aesthetic preferences (Welsh Figure eference Test); 2) fantasy (Holtzman kblot Test and responses to TAT-styled etures); and 3) self-report of moods wowlis-Green Mood Check List). The ests are briefly described below.

The Welsh Figure Preference Test (15) nsists of 144 designs, and the subject licates whether he likes or dislikes each sign. The test was scored on two of the pirically derived scales, the Barronelsh Art Scale and the Neuropsychiatric ale (15).

The Holtzman Inkblot Test (8) consists 45 ink blot designs. The subject is ked to give one response per card, and questioned about his percept after each sponse. The responses are scored on variates similar to those used with the Rorhach Test.

A set of six TAT-type cards was used this study. One card (13MF) was ected from the regular TAT Test, but to other five were especially constructed

Three additional tests were included in the tery but have been excluded from the discusal because of practice effect. Changes attributate to practice were so marked that they obscured differences attributable to altered conditions the experimental design. The following tests re deleted: Stroop Color-Word Test (14), The abedded Figures Test (7) and the Circle Instition Tests (13).

TABLE 2
Total Nightly Sleep Times (TST) and Total Nightly
REM Times (TREMT) in Hours and Minutes

Group and Subject	Me (First	ans 6 nights)	Means (Second 6 nights)		
	TST	TREMT	TST	TREMT	
Group 1*		27 2-0		1	
A	6:43	1:21	5:35	0:16	
R	5:50	1:26	4:47	0:09	
E	6:32	1 50	5 12	0:05	
Overall mean	6:22	1:32	5:11	0:10	
Group 2*				1	
В	5:36	0:14	5:15	1:06	
Em	5:00	0:12	4:55	1:01	
S	5:54	0:06	6:05	1:26	
Overall mean	5:30	0:11	5:25	1:11	

^{*} See footnotes to Table 1.

for this project. Pictures on these five were reproduced on cards the same size as the TAT pictures. Subjects were asked to tell a story about each picture, and questioning was held to a minimum.

The Nowlis-Green Mood Check List (11) consists of 71 adjectives which have been factor analyzed into eight scales: Concentration, Aggression, Pleasantness, Activation-Deactivation, Egotism, Social Affection, Depression, and Anxiety. Subjects indicate their feelings by rating each adjective on a four-point scale.

Subjects in this study completed one check list on each of the three days preceding their first experimental period, and on each day that they were at the laboratory during the two experimental periods. All other tests were administered twice to each subject: first on the day following the six nights of RD or NRD, and second following the six nights of the alternate experimental period.

SCORING PROCEDURES AND STATISTICAL MODEL

The Holtzman Inkblot Test was scored on the variables described by Holtzman (8).

'Two pictures involved social gatherings in which food was part of the scene. These were included because of previous findings (1, 3, 4) of increased appetite after REM sleep deprivation.

The subjects' mean scale scores for the first and for the second experimental sessions were computed for each of the eight mood scales on the Nowlis-Green Mood Check List.

Stories to the TAT pictures were scored on variables, partially selected on the basis of Murray's need-press theoretical framework (10):

- 1) Intensity of need—ratings on a seven-point scale indicated the strength of needs expressed by the story characters. In evaluating this dimension raters used cues from the subject's narrative, i.e., amount of time devoted to describing needs, persistence of hero toward satisfying his needs in spite of environmental obstacles, word intensity.
- 2) Intensity of feeling—the ratings on a seven-point scale showed the amount and degree of feeling expressed by the characters in the stories. In general, the rater used such cues as amount of detail and intensity of words used to describe a feeling, as well as the directness and intensity with which the hero expressed his feelings. Since the ratings were made from tape recordings of the stories and not just from transcripts, the rater felt she was also responding to the emotionality in the subject's voice.
- 3) Intensity of press—the degree to which situational factors and events appeared to be important to the characters portrayed in the stories was rated on a seven-point scale. In general, if the character reacted strongly to some environmental event, press was rated high; if the character showed minimal involvement, press was rated low.
- 4) Intensity of overt conflicts—the rater indicated on a seven-point scale the degree of conflict shown in the story, e.g., conflict of interest between two people, between a person and his environment, between one person and his family, or a person in conflict with himself, usually indicated by the expression of guilt.

- Imagination—a four-point scale was used to rate the originality of plot, character development, or other narrative details.
- 6) Story coherence—on this four-point scale, the rater indicated the extent to which the various threads of the plot were woven together in a logical fashion.

The unit of measurement in all of the above scales was the complete story. One rater evaluated all of the stories without knowledge of which experimental condition the subject had undergone. Another rater (SC) independently rated all of the stories for one subject and reached a 90 per cent agreement with the primary rater, whose ratings were considered reliable enough to use for analysis.

A simple analysis of variance model was constructed to test the effects of REM deprivation and treatment order. Each subject's score after NRD was subtracted from his score after RD. In Group 1, the test results after the first period of NRD are composed of the general mean for the individual plus the effects of being deprived of sleep. After the second period of RD, the test results consist of the subject's general mean, plus effects of RD plus effects of sleep loss. The difference between the test results of the two periods reflects the effect of RD. It should be pointed out that this model assumes no practice effects and also assumes approximately normal distribution of scores.

In Group 2, the test results after the first period (RD) would involve the subject's general mean, plus effect of RD, plus effect of sleep loss. After the second period (NRD), the test results would reflect the general mean, sleep loss, and residual effects of RD. Thus, the difference between the two scores measures the effect of RD minus the residual RD effect.

Table 3 presents the schema for the analysis of variance.

RESULTS

cores from the Holtzman Inkblot Test, picture stories, the Nowlis-Green Mood ck List, and the Welsh Figure Prefer-Test were subjected to the simple lysis of variance. None of the Mood ck List scales nor the two Welsh Figure ference Test subscales attained the .10 l of significance. With such a small samin each experimental group, at least five ects had to show a consistent trend in same direction before the results could h significance; moreover, the variability ifference scores had to be very low. On y variables, the relatively large differscore of a single subject reduced the ificance of the trend. Because of this, a ussion of group trends must await a ication study with a larger sample. results of the analysis of variance are marized in Table 4. Only those variawhich reached the .05 level of sigcance or, in one case, the .06 level are ented.

TABLE 3 Variance Schema

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1	Sum of Square	df
T	20\bar{\chi}_{\bar{\chi}}	1
r	$\begin{array}{l} \text{n } \Sigma \ (\tilde{\mathbf{x}}_{i_1} - \tilde{\mathbf{x}}_{i_1})^2 \\ \Sigma \ (\mathbf{x}_{ij} - \tilde{\mathbf{x}}_{i_1})^2 \end{array}$	1
1	$\Sigma (\mathbf{x}_{ij} - \tilde{\mathbf{x}}_{i.})^2$	2(n - 1)
1	ΣX_{ij}^2	2n

As indicated in Table 4, the subjects showed higher intensity of need and feelings, increased Pathognomonic Verbalization, less Form Appropriateness and decreased movement during RD than during NRD.

DISCUSSION

This is the first controlled study to demonstrate psychological test changes under RD. Two previous studies using psychological tests (9, 12) reported no significant changes under RD. However, neither of these studies controlled, as we did, for the biasing effects of fatigue, for order of experimental conditions, and for examiner's preconceived expectations.

Kales et al. (9) studied only two subjects under both NRD and RD conditions. Besides the obvious statistical limitations imposed by using only two subjects, the study did not control for order effects. Certain of the tests used in the Kales study were found to be insensitive to RD effects among our subjects.

The investigation by Sampson (12) used six subjects, but did not control for effects of sleep loss or for possible examiner bias. Moreover, the tests used, such as digits forward and digits backward, a paper and pencil word association procedure, and a complex serial subtraction test, are probably strongly influenced by practice. Such tasks depend upon well practiced habits

TABLE 4
Variables Significantly Affected by RD

Variables	Source	F	,	Direction of Diff.
es	02 ta6+W 02		29.9 (1909)	
tensity of need	RD order	59.84 9.61	< .001	RD > NRD
tensity of feeling	RD order	17.43 1.55	< .05 nsd	RD > NRD
zman Inkblot Tech. Pathognomonic		1		Control for Control Control
Verbalization	RD order	67.42 67.46	< .001	RD > NRD
Appropriateness	RD order	8.10 1.41	<.05	RD < NRD
ement	RD order	6.28 2.10	<.06 nsd	RD < NRD

of memory and arithmetic thinking. Such highly structured and well learned skills might not reflect subtle losses of ego control produced by RD. It is important to note that the present results were obtained exclusively on projective tests which reduce the subjects' sets for careful, controlled thinking; neither Kales et al. nor Sampson used such measuring procedures.

Despite the controls used in the present study, generalization from the results should await verification with a larger sample. However, projective tests appear to hold promise for clarifying psychological effects of selective REM sleep deprivation.

The test results indicating higher intensity of feeling and need under REM deprivation are congruent with previous animal research studies showing heightened drive under similar deprivation conditions (3, 4). Under heightened drive, subjects' perceptions, particularly in ambiguous situations, should be influenced more by internal clues than by situational demands. Results from the Holtzman Test are consistent with this expectation, for under RD, subjects showed increased Pathognomonic Verbalization, but decreased Form Appropriateness.

Pathognomonic Verbalization is scored when subjects show deviant or autistic thinking. However, deviant thinking of this kind is not necessarily pathological (8). The subjects in this study showed an increase primarily in terms of "Fabulation." This category was scored when the subject ascribed affective characteristics to the concept in an unusual manner, e.g., a "kind monster." Usually, this represents increased sensitivity to internal feelings and the freedom to let such feelings determine perception, a style of behavior which is not necessarily pathological. However, there were times when subjects described highly improbable combinations, "a pig with horns and with a bat on top of his head," responses which are more

pathological than "Fabulation." These results do indicate a drop in reality testing.

Other results also suggested that as intensity of needs and feelings increased. there was a reduction in critical facility under RD. The decrease in Form Appropriateness indicates that subjects were less attentive to blot configurations and either less able or less concerned about matching their concepts to physical outlines. The decrement in Movement is also suggestive of reduced ability to control. Holtzman points out (8) that a subject needs good "ego control" functions to perceive movement in the designs. However, since this latter result is of borderline significance, it should not be weighed as heavily as the others.

The decrease of reality testing and the push of needs was most dramatically presented by one subject who, after RD, saw a woman's reproductive organs and genitalia on ten of the inkblot cards. He expressed helplessness and confusion over such perceptions and felt that he had no control over his thoughts. It should be made clear that all of the other subjects were able to show more appropriate control, so that the differences in sexual and hostile content on the Holtzman were not significantly related to RD. Nor were there additional observations or reports of grossly deviant behavior. Thus, it appears that the effects of RD under the experimental conditions are subtle. They appear most readily in fantasy productions in which social pressures for control are reduced. Whether longer periods of RD would hinder and obstruct cognitive functions enough to be measured by highly structured intelligence tests awaits further study.

There is one other important experimental condition which could affect the results the social context of the experiment. In this study, subjects were given a great deal of attention, were well paid, and in general experienced a "supportive" atmosphere. These environmental factors could assist he subject in coping with feelings of stress. f this were the case, the effect of RD on ontrolling functions would be attenuated. future studies in this area should carefully onsider possible effects which the social ontext of the experiment may exert on the irection of the results.

SUMMARY

Six male subjects, serving as their own ontrols, experienced six nights of REM eprivation and six nights of NREM eprivation. A battery of psychological sts was given after each of the experiental conditions. Evidence from proctive tests showed an elevation in innsity of need and feeling and a depression certain ego-controls as a result of REM privation.

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