Self-Imposed Sleep Loss, Sleepiness, Effort and Performance

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The study had three goals. The first was to compare self-reported sleep before exams with sleep before lectures. The second was to determine whether self-imposed sleep loss results in impaired exam performance. The third goal was to evaluate whether sleepiness, non-academic task preference and subjective effort were affected by self-imposed sleep loss. A questionnaire, completed on three occasions, once following a lecture and twice following exams, included a sleep and activities diary, subjective effort and concentration questions, the Stanford Sleepiness Scale, and a non-academic task-choice question. Students slept less prior to exams than before the lecture. Sleepiness following exams was greater than following the lecture. Exam performance was not related to total sleep time or sleepiness. However, lower total sleep time and increased study time on nights before exams were followed by increased feelings of sleepiness, increased subjective effort, and increased concentration. Sleepiness predicted the choice of lower difficulty non-academic tasks on Exam 1 and Lecture while feeling refreshed predicted the choice of higher difficulty non-academic tasks on Exam 2. Under self-imposed sleep loss, sleepiness or the lack of feeling refreshed influences the selection of tasks of minimal difficulty. The need to efficiently use available resources when sleepy may reflect changes in energy or neurochemistry. Future research will determine the impact of this effect on the workplace. **(Sleep and Hypnosis 2004;6(4):155-162)**

Key words: *sleepiness, choice, effort, performance, college students*

INTRODUCTION

College students often deprive themselves of sleep so they may satisfy their academic, occupational, and social obligations. However, sleep loss causes impairments in reaction time and vigilance as well as increases in sleepiness, fatigue, and negative mood states (1-3). Sleep deprivation of one day, as compared with non-sleep-deprived conditions, also results in preferences for tasks requiring less effort (4).

Human attention capacity is finite and tasks are selectively chosen depending on the amount of mental effort required (5,6). Stressors, such as sleep loss, impose limitations on the amount of mental effort that can be applied to tasks. This reduction in resources results in a prioritization of actions (7) and effort is mobilized to meet the demands necessitated by the primary or most pressing task. Remaining attention is then divided among other secondary or less pressing

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tasks (5).

Under sleep loss conditions, performance on tasks identified as secondary may suffer because of the preferential status of the primary task and the resources applied to it. For example, Hockey and his colleagues show that under sleep deprivation conditions, performance on a task identified as primary is maintained, while performance on secondary tasks are subject to decreased monitoring, decreased response time, and response omissions (7). When a single task is the focus, components of that task are prioritized into primary and secondary components. In the case of performance on individual tasks, task elements considered essential may receive greatest attention while task elements of lesser importance may be relatively neglected. This occurs in the speed-accuracy trade-off. When sleep-deprived participants are requested to maintain or improve accuracy of performance on a task, the speed of response is sacrificed (1,8,9).

A focus on the primary task or task components, with reduced attention to secondary tasks, or secondary task components, occurs when no choices are offered regarding the tasks to be performed. However, Engle-Friedman et al. found that when sleep-deprived participants are offered choices of tasks to perform, they select less demanding courses of action (4). In that study, sleep-deprived participants chose less difficult math problems to perform, while maintaining speed and accuracy levels equivalent to that of the non-deprived participants. Only on the math task's highest level of difficulty did the non-deprived group out-perform the sleep-deprived group. In addition, the more participants felt sleepy or fatigued, the simpler the tasks chosen on a non-academic task-choice measure. Consistent with this pattern, the sleep-deprived group selected less demanding non-academic tasks than the control group. There were no differences between the two groups in terms of subjective effort expended.

The purpose of the current study was to expand our understanding of the impact of sleep loss by examining self-imposed sleep restriction in a college environment, performance on exams, and preference for tasks that range in difficulty. The study, therefore, had three goals. The first was to compare self-reported sleep before exams with sleep before lectures. The second was to determine whether self-imposed sleep loss results in impaired exam performance. The third goal was to evaluate whether sleepiness, task preference and subjective effort were affected by self-imposed sleep loss.

It was hypothesized that prior to exam days, when compared to a lecture day, students would sleep less and spend more time studying. It was anticipated that exam grades would not suffer since performance on the exam was of primary concern and attention. It was expected, however, that reduced sleep would induce participants to select non-academic tasks of minimal difficulty on exam days. It was also expected that participants would be unaware of this reduction in effort.

METHOD

Participants

Students were recruited from Introductory Psychology courses at Baruch College, City University of New York, during the spring 2002 semester. In exchange for their participation, students received credit toward the fulfillment of their Introductory Psychology research requirement. Of the original 270 volunteers, 82 undergraduate students completed the entire study. Participants included 29 males and 53 females with a mean age of 19.51 years (SD=3.25, Range=18-39). Seventeen White (non-Hispanic), 14 Hispanic, 7 Black (non-Hispanic), 36 Asian, and 8 other students comprised the sample.

Procedure

All sessions were conducted in the lecture

hall after class had been completed and the professors had left the premises.

Introduction. During the introductory meeting, the procedure, approved by the Baruch College Institutional Review Board, was described to students. Those students who wished to participate were asked to provide signed informed consent for (a) their participation in the experiment, and (b) the release of their exam grades. All students were informed of the right to withdraw their participation at any time without penalty or prejudice.

Questionnaire. The questionnaire was completed on four occasions, twice following lectures and twice following exams. Each administration of the questionnaire was separated by approximately two weeks. The questionnaire included a sleep and activities diary, effort and concentration questions, the Stanford Sleepiness Scale, and a non-academic task-choice question.

The sleep and activities diary included questions regarding the previous night's sleep, including sleep onset latency, number of awakenings, time spent awake at night (during the awakenings), and total sleep time. Other questions inquired about sleep quality, how refreshed a person felt, and activities engaged in after 9pm. Activities after 9pm included studying for psychology, studying for other subjects, watching TV, and using the computer for fun.

The Stanford Sleepiness Scale (10) requested that participants describe their current state of alertness, awareness, and sleepiness by endorsing one of seven statements. The statements ranged from 1 (most alert) to 7 (most sleepy).

The effort question asked: "How much effort do you feel you put into listening in class (or your psychology exam) today?" Similarly, the concentration question asked: "How well were you able to concentrate in class (or on your exam) today?" Effort and concentration were assessed using a Likert-type scale, ranging from 1 (no effort/concentration) to 5 (extreme effort/concentration).

The non-academic task-choice question was used as an objective measure of effort (4). It asked participants to select one task, from a list of five tasks, they would willingly perform for the next 20 minutes. Previous normative studies, conducted in our laboratory, evaluated the perceived difficulty of the tasks and found that the tasks were significantly different from one another. The tasks are arranged from those perceived to require the least effort to those requiring the most: (a) retrieving messages from an answering machine, (b) entering data into a computer, (c) scheduling next week's meetings for the chairman of the department, (d) composing exam questions for a Psychology 1001 final exam, and (e) helping to design a research study to evaluate and reduce teenage and college alcohol abuse.

Exam grades. Participants' exam grades were collected for the two exam days on which questionnaire data was obtained. After all questionnaires were completed, the exam grades were received from a designated teaching assistant who was not involved in student grade determination. Exam grades were obtained for 53 of the 82 participants.

RESULTS

Data from the first lecture was eliminated due to procedural difficulties. Table 1 provides the means and standard deviations as a function of type of day, with the overall ranges, for the variables under consideration.

Paired t-tests: Sleep Measures

Total sleep time varied depending on whether it preceded an exam day or a lecture day. Students' total sleep time was decreased prior to the exams in comparison to their total sleep time prior to the lecture [Exam 1 vs. Lecture: $t\ (81)=-1.948$, $p=.055$; Exam 2 vs. Lecture: $t\ (81)=-2.055$, $p=.043$]. No differences

Table 1. Ranges, with Means and Standard Deviations as a Function of Type of Day, for the Variables

Variables	Range	Type of Day		
		Exam 1	Lecture	Exam 2
Activities after 9pm (hrs)				
Psychology study time	0-6.00	2.09 (1.51)	0.16 (0.58)	2.35 (1.59)
Other study time	0-5.00	0.42 (1.01)	0.27 (0.73)	0.07 (0.26)
Watching TV	0-5.00	0.65 (0.88)	1.23 (1.18)	0.66 (0.92)
On the computer for fun	0-4.75	0.28 (0.53)	0.92 (1.22)	0.32 (0.68)
Total sleep time (hrs)	0-11.00	6.85 (1.61)	7.23 (1.59)	6.82 (1.88)
Sleep latency (min)	0-120.00	18.74 (17.94)	17.24 (16.12)	16.92 (20.40)
Number of awakenings	0-15	0.48 (0.77)	0.72 (1.80)	0.47 (0.90)
Time spent awake at night (min)	0-60.00	3.34 (6.99)	4.29 (9.50)	2.61 (6.14)
Sleepiness	1-7	2.87 (1.27)	2.52 (1.27)	2.98 (1.30)
Feeling refreshed	1-5	2.98 (1.04)	2.95 (1.10)	3.00 (1.07)
Task choice	1-5	2.10 (1.17)	2.20 (1.19)	2.11 (1.00)
Concentration	1-5	4.05 (0.86)	3.30 (1.06)	4.01 (0.84)
Effort	1-5	3.94 (0.83)	3.26 (1.05)	3.96 (0.89)
Exam grade	38-94	72.13 (12.43)		76.15 (12.73)

Note. Standard deviations are provided in parentheses.

in total sleep time were found between the two exam days. Students felt sleepier on exam days when compared to the lecture day [Exam 1 vs. Lecture: t (81)=2.072, p=.041; Exam 2 vs. Lecture: t (81)=2.434, p=.017]. There were no significant differences in sleepiness between the exam days. Other sleep variables, including sleep latency, number of awakenings, time spent awake at night, and feeling refreshed, did not differ significantly across exam and lecture days.

Paired t-tests: Exam 1 vs. Exam 2

The data obtained on the two exam days differed, such that study time focused on courses other than psychology, decreased from Exam 1 to Exam 2 [t (81)=2.958, p=.004], and higher grades were achieved on Exam 2 as compared with Exam 1 [t (52)=2.648, p=.011].

Paired t-tests: Exams 1 and 2 vs. Lecture

Significant differences were found when the lecture day was compared with the exam days. An evaluation of student activities found that prior to exams, students increased the amount of time engaged in studying and decreased time engaged in relaxation. Specifically, they spent more time studying for psychology after 9pm [Exam 1 vs. Lecture: t (81)=11.071, p<.001; Exam 2 vs. Lecture: t (81)=12.238, p<.001], less time watching TV [Exam 1 vs. Lecture: t (81)=-4.338, p<.001; Exam 2 vs. Lecture: t (81)=-4.238, p<.001], and less time on the computer for fun [Exam 1 vs. Lecture: t (80)=-5.264, p<.001; Exam 2 vs. Lecture: t (80)=-5.056, p<.001]. Students also reduced the time spent studying for other subjects after 9pm, from the Lecture to Exam 2 [t (80)=-2.295, p=.024].

Students reported applying more effort [Exam 1 vs. Lecture: t (80)=4.693, p<.001; Exam 2 vs. Lecture: t (80)=5.379, p<.001] and concentration [Exam 1 vs. Lecture: t (81)=5.590, p<.001; Exam 2 vs. Lecture: t (80)=5.069, p<.001] on the exam days. There was no difference in tasks selected on the task-choice measure when the lecture and exam days were compared.

Correlations

Pearson product-moment correlations were computed for each session in an attempt to explore the relationship among the variables. Total sleep time was positively correlated with

feeling refreshed on Exam 1 [r (81)=.521, p<.001], Lecture [r (82)=.451, p<.001], and Exam 2 [r (82)=.314, p=.004]. Feeling refreshed was negatively correlated with sleepiness on Exam 1 [r (81)=-.348, p=.001] and Exam 2 [r (82)=-.295, p=.007]. Total sleep time, feeling refreshed, and sleepiness ratings were not correlated with exam grades.

Increased study time was related to decreases in total sleep time. Psychology study time negatively correlated with total sleep time on Exam 1 [r (82)=-.305, p=.005] and Exam 2 [r (82)=-.333, p=.002], but not for the Lecture. Time spent studying for other subjects correlated negatively with total sleep time on Exam 1 [r (82)=-.391, p<.001] and Lecture [r (81)=-.319, p=.004], but not for Exam 2.

While the comparison of task choice on lecture and exam days did not reveal significant differences, sleepiness was negatively correlated with task-choice, the objective measure of effort, on Exam 1 [r (82)=-.314, p=.004] and Lecture [r (82)=-.322, p=.003]. Feeling refreshed was positively correlated with task-choice on Exam 2 [r (82)=.315, p=.004]. On the lecture day, the selection of more difficult tasks was related to higher levels of perceived concentration [r (82)=.333, p=.002] and perceived effort [r (82)=.354, p=.001]. Although subjective reports of concentration and effort were positively correlated with one another across sessions [e.g., Exam 1: r (81)=.553, p<.001; Lecture: r (82)=.581, p<.001; Exam 2: r (81)=.652, p<.001], they seldom correlated with the other measures of interest.

Regression analyses of Task-choice

Linear regression and stepwise multiple regression analyses were conducted to test the contribution of several measures in the prediction of task-choice. The aforementioned correlations determined which variables, other than total sleep time, would be included as predictors for a given session. All percentages reported are based on R^2. For Exam 1, the predictors of task-choice were total sleep time and sleepiness. Sleepiness predicted 9.8% of the variance [F (1,80)=8.725, p=.004], and when combined with total sleep time, 14.3% of task-choice variance could be accounted for [F (2,79)=6.567, p=.002] (Figure 1). For Exam 2, the predictors were total sleep time and feeling refreshed. Feeling refreshed explained 9.9% of task-choice variance [F (1, 80)=8.794, p=.004]; total sleep time was not instrumental in this instance (Figure 2).

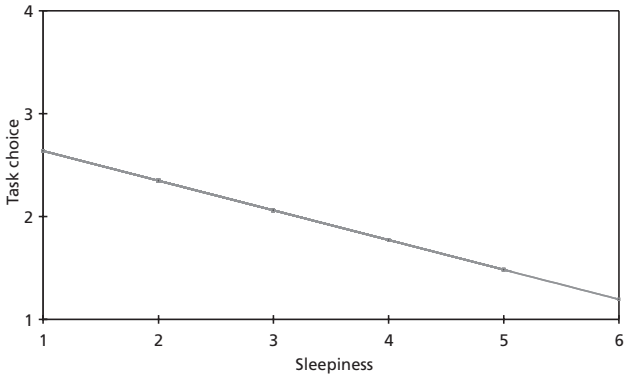

Figure 1. Regression line of sleepiness, as measured by the Stanford Sleepiness Scale, predicting task-choice following Exam 1.

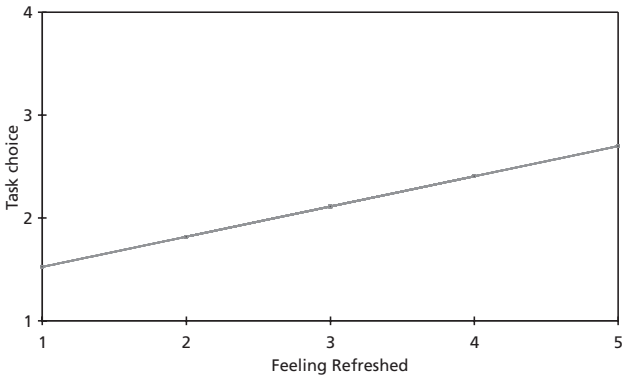

Figure 2. Regression line of feeling refreshed predicting task-choice following Exam 2.

For Lecture, the predictors of task-choice were total sleep time, sleepiness, subjective effort, and subjective concentration. Subjective effort alone predicted 12.5% of task-choice variance [F (1,80)=11.449, p=.001]. The combination of subjective effort and sleepiness accounted for 23.3% of task-choice variance [F (2, 79)=11.999, p<.001](Figure 3).

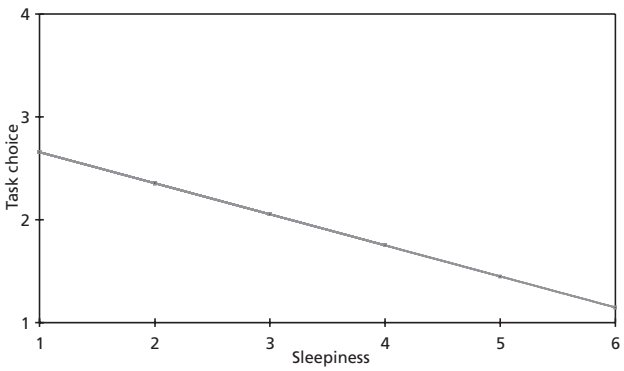

Figure 3. Regression line of sleepiness, as measured by the Stanford Sleepiness Scale, predicting task-choice following Lecture.

DISCUSSION

Our study had three goals. The first was to compare self-reported sleep before exams with sleep before lectures. The present study found that self-reported total sleep time was significantly reduced prior to exams relative to sleep before the lecture and sleepiness was significantly increased on exam days as compared with the lecture day.

The second goal was to determine whether self-imposed sleep loss results in impaired exam performance. Prior sleep loss and sleepiness did not influence grades on two exam administrations. During the nights prior to exams, students increased study time after 9pm and decreased pleasurable activities such as television watching and using the computer for fun. The increase in time spent studying may have resulted in sleep loss and sleepiness but likely helped actual exam performance.

The third goal was to evaluate whether sleepiness, task preference, and subjective effort were affected by self-imposed sleep loss. The present study found that total sleep time did not consistently predict sleepiness, task preference, and subjective effort. However, sleepiness was correlated with the choice of simpler tasks, corroborating previous findings (4). Sleepiness and total sleep time accounted for 14.3% of task-choice variance following Exam 1, feeling refreshed explained 9.9% of the variance following Exam 2, and sleepiness accounted for 10.4% of the variance in responding to the task-choice measure following the Lecture.

That sleepiness and lack of feeling refreshed did not predict grades achieved on exams, but did predict the choice of low difficulty tasks, may be understood from an energy conservation perspective in which limited resources are allocated to the high priority task (5,7). In sleep deprivation studies, participants who are directed to complete a specific task, prioritize intra-task elements, such that accuracy of performance is maintained while speed of performance suffers (1,8,9). In the present study, performance accuracy seems to have been maintained, though it is unknown whether other elements of the exam-taking process were neglected. For example, speed data was not available and whether students who were the most sleep-deprived or most sleepy took longer to complete the exam was not explored.

When the opportunity was available to make a choice between tasks that ranged in difficulty, sleepy participants chose tasks of lower difficulty. Is sleep loss a necessary contributor to sleepiness or can other energy-depleting experiences generate sleepiness? In the current study, sleepiness may have been caused by energy expended from studying, self-imposed sleep loss, or the process of taking the exam. Future studies may clarify the relationship between sleepiness and objective effort by inducing sleepiness through a number of strategies and assessing their influence on effort.

Subjective reports of effort differed on the lecture and exam days. The participants reported applying more effort and concentration on exams than on lectures. Perceived effort expended on exams did not predict subsequent task selection, however, the perception of effort expended in the lecture, predicted approximately 12.5% of the task-choice variance.

Several explanations may account for the difference in the experience of expended effort during the lecture and the exams with regard to task-choice. First, students may have felt depleted following the exam. Listening to a lecture may require less energy than taking an exam and participants may have experienced an availability of energy for use on the task-choice measure on the lecture day, that they did not feel on either exam day. Alternatively, the lecture experience may have required that students actively apply effort in order to stay attentive and engaged in the lecture. Once the energy was mobilized during the lecture, students faced with the task-choice question may have had energy at their disposal.

It is not certain how participants determine the effort they expend. Perceived effort was not dependent on exam performance. Pilcher and Walters found, too, that performance and subjective effort were unrelated (11). In their study, the sleep-deprived group performed worse than a control group on a critical-thinking cognitive task requiring mental effort. The sleep-deprived participants did not perceive the performance deficit. Instead, they reported more effort, more concentration, and better performance than their non-deprived counterparts. How participants judge effort expended requires further exploration.

Research examining brain neurochemistry and choice behavior may help to elucidate the relationship between sleep loss, sleepiness, and effort. Dopamine, in particular, appears to play a role in effortful choices. Injections of dopamine antagonists directly into the nucleus accumbens, or depletions of dopamine resulting from injections of 6-hydroxydopamine, results in a shift from high-effort lever pressing to low-effort chow-feeding (12) and a shift from high-effort barrier crossings to low effort, unobstructed movement through a T-maze (13). These researchers demonstrated that less difficult operant choices were made when animals experienced dopamine depletion. The relationship between dopamine depletion, sleepiness, and effort also requires further research.

A number of limitations affect the generalizability of the study. First, the investigation was conducted over the course of one semester and participants who completed the study may have had more intrinsic motivation than individuals who did not participate or dropped out. Second, data following only one lecture was available. Frequent data collections within a semester and across several semesters would increase both the size of the sample and the number of lecture and exam sessions evaluated. Finally, no consistent relationship was found between exam grades and psychology study time, or exam grades and internal states (e.g., sleepiness, feeling refreshed, concentration, and effort). This implies that other variables, not heretofore examined, must mediate these relationships. Trockel et al., similarly, was unable to identify a direct relationship between academic grade point average (GPA) and total sleep time, or between GPA and internal states (14).

The effects of sleepiness on effortful behavior are far-reaching. A poll by the National Sleep Foundation (15) revealed that 58% of respondents reported having at least one symptom of insomnia at least a few nights per week and 37% reported feeling so sleepy that it interfered with daily activities a few days per month or more. Ninety-three percent of the respondents either completely or mostly agreed that inadequate sleep impaired work performance. Similarly, 63% of respondents thought it would be somewhat or much more difficult to engage in careful, thoughtful decision-making and 65% thought mistakes or errors were somewhat or much more likely following sleep loss.

It is unknown whether simpler choices are being made on a regular basis among those who regularly experience too little sleep or who are sleepy. This is of particular concern within industries that expect employees, when given choices, to select the most difficult tasks under

all requisite circumstances. Employees may instead select tasks they can tolerate. If the effortful performance of employees in industries concerned with safety issues (e.g., nuclear power plant operation, air traffic control, and surgery) are affected by sleep loss or sleepiness, serious consequences may result.

In conclusion, when choices are offered, sleepy participants select tasks of lower difficulty, which may reflect changes in energy or neurochemistry. Research can further elucidate the relationship between sleepiness and effortful behavior and may determine the impact of this effect on the workplace.

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