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How Sleep Deprivation Affects Psychological Variables Related to College Students' Cognitive Performance

June J. Pilcher, PhD, and Amy S. Walters, MA

Abstract. The effects of sleep deprivation on cognitive performance and on psychological variables related to cognitive performance were studied in 44 college students. Participants completed the Watson-Glaser Critical Thinking Appraisal after either 24 hours of sleep deprivation or approximately 8 hours of sleep. After completing the cognitive task, the participants completed 2 questionnaires, one assessing self-reported effort, concentration, and estimated performance, the other assessing off-task cognitions. As expected, sleep-deprived participants performed significantly worse than the nondeprived participants on the cognitive task. However, the sleep-deprived participants rated their concentration and effort higher than the nondeprived participants did. In addition, the sleep-deprived participants rated their estimated performance significantly higher than the nondeprived participants did. The findings indicate that college students are not aware of the extent to which sleep deprivation negatively affects their ability to complete cognitive tasks.

Key Words: cognitive performance, psychological variables, self-reports, sleep deprivation

Voluntary sleep deprivation is a common occurrence for many college students, who often partially deprive themselves of sleep during the week and compensate by increasing their sleep time over the weekend.[1] This pattern of sleep deprivation and rebound becomes more pronounced around examination periods, sometimes resulting in 24 to 48 hours of total sleep deprivation. By depriving themselves of sleep, college students are not only increasing their feelings of sleepiness during the day, thus decreasing their ability to pay attention in class, but are also negatively affecting their ability to perform on exams.

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It is well established that sleep deprivation of 24 hours or more leads to noticeable decrements in performance levels.[2,3] The psychological variables behind these decrements, however, are less clear. One theory states that decreases in performance are attributable to a decrease in the ability of the sleep-deprived person to focus the attention and effort necessary to complete the task successfully.[4,5] Similarly, a number of early sleep-deprivation studies concluded that the detrimental effects of sleep loss on performance result from periods of inattention called *lapses*.[6-8] Moreover, one early study specifically concluded that sleep loss leads to a decrease in attention to external stimuli.[9] None of the earlier studies, however, attempted to assess self-reported variables that reflect changes in psychological events or thoughts that may be associated with the observed decrements in performance.

The effect of sleep deprivation on psychological variables associated with performance, such as self-reported estimates of attention, effort, and performance, have not been thoroughly investigated. Few studies have examined perceived effort and performance,[11-15] and the results from those studies have often been contradictory. For example, some researchers have suggested that sleep deprivation may affect the willingness of the individual to put forth the effort to perform well on a task more than the actual ability of the individual to perform.[11,12]

By contrast, other researchers have concluded that participants may recognize their decreased performance levels following sleep deprivation and attempt to overcome this decrease by increasing their effort.[15] However, other studies have shown that a perceived increase in effort does not appear to overcome the detrimental effects of sleep deprivation. In one study,[13] the participants were given a reward for better performance, which resulted in an increase in perceived effort but no change in actual performance. In addi-

tion, studies have shown that increasing amounts of sleep loss do not have a detrimental effect on participants' self-reported motivation levels.[14,15] As these results show, the relationships between sleep deprivation and psychological variables associated with performance are not clearly understood.

Another method of examining psychological variables that may be associated with the decrease in performance following sleep deprivation is assessment of off-task cognitions. Off-task cognitions are thoughts that are not directed to the completion of the task at hand but that intrude upon concentration. These cognitions can include negative evaluations of one's performance on the task, such as "I don't know how to do this," or completely unrelated thoughts, such as "I wonder what I should have for lunch today." Only one study to date has investigated the effect of sleep deprivation on off-task cognitions,[10] but the participants in that study were specifically selected for their high baseline levels of off-task cognitions. Conclusions, therefore, could not be drawn about the effect of sleep deprivation on off-task cognitions independent of baseline levels.

Sleep-deprived participants' current mood state may provide additional information about the ability of the individual to perform following sleep deprivation. One of the best documented effects of sleep deprivation and one that would be expected to decrease complex task-solving ability is an increase in self-reported sleepiness and fatigue.[14,16,17]

Other specific mood states could also influence successful task completion. For example, if sleep deprivation has a consistent negative effect on tension or anxiety, sleep-deprived participants would be expected to have more difficulty than nondeprived participants in maintaining the necessary attention and effort to complete a complex cognitive task. Although several studies have reported that sleep deprivation decreases positive mood states and increases negative mood states,[3,14,18,19] relatively few studies have examined the effect of sleep deprivation on specific mood states.

Another important consideration is the effect of sleep deprivation on an individual's ability to accurately assess psychological variables, such as concentration, effort, and estimated performance. Research findings have shown that the accuracy of self-reports varies, depending upon experimental characteristics surrounding the task. For example, Johnson and colleagues[20] found that participants' self-reports of the amount of effort they put into a task corresponded better with performance on a difficult task than on a very easy task. The researchers also found that the amount of reported effort, but not necessarily actual performance, could be increased by giving an external incentive.

In addition, Beyer[21] noted that self-evaluations of performance on longer tasks are more accurate than self-evaluations of performance on shorter tasks. Self-report estimates of performance have also been shown to be altered by feedback on the accuracy of actual performance as the person completes the task.[22] These findings indicate that self-report data on psychological variables can be manipulated by a variety of experimental conditions. One experimental condition that has not been thoroughly investigated is sleep deprivation.

In sum, our current study addressed three specific issues. First, does sleep loss lead to changes in self-reported levels of psychological variables related to actual performance? As measures of psychological variables, we examined self-reported levels of concentration, effort, and estimated performance and self-reported off-task cognitions while the participant completed a complex cognitive task. Because sleep deprivation increases feelings of sleepiness and fatigue, we expected the sleep-deprived individuals to report lower levels of concentration, effort, and estimated performance and higher levels of off-task cognitions if they were capable of accurately assessing these psychological variables.

The second aim of our study was to determine whether sleep deprivation significantly alters mood states that may be related to performance. As specific measures of mood, we assessed feelings of tension, depression, anger, vigor, fatigue, and confusion. On the basis of a previous study that used the same mood measures,[23] we expected sleep-deprived participants to report increased fatigue, confusion, and tension and decreased vigor.

The final purpose of our current study was to determine whether sleep deprivation alters peoples' ability to make an accurate assessment of their concentration, effort, and estimated performance. To investigate this aspect of sleep deprivation, we compared self-reported assessments with actual performance levels.

METHOD

Participants

We solicited study participants from five psychology classes, two 100-level courses, one 200-level course, and two 400-level courses. Of the original 65 volunteers, 44 (26 women and 18 men) completed the study. The mean age of the respondents, who were given extra credit points as an incentive to participate, was 20.5 years (SD = 4.37).

Materials

We used the Watson-Glaser Critical Thinking Appraisal (WG; The Psychological Corporation, San Antonio, TX) to measure cognitive performance. We chose the WG because it would be cognitively challenging and similar to normal testing conditions for college students in that it is a linguistic task that requires mental but no physical effort. The WG contains three portions: inference, recognition of assumptions, and deduction. To increase the similarity of the task to normal testing conditions for college students, we administered the test with a 40-minute time limit.

We used self-report scales to measure mood, off-task cognitions, effort, concentration, and estimated performance. To assess current mood, we used the Profile of Mood States (POMS; Educational and Industrial Testing Service, San Diego, CA). The POMS scale provides a list of 65 words describing current mood states (see Table 1). The

student participants rated each word based on their current mood.

We assessed the number of off-task cognitions while the participant completed the WG task, using the Cognitive Interference Questionnaire (CIQ).[24] The CIQ provides a list of types of thoughts. The participants respond by stating how often they experienced those thoughts while completing the WG task. We developed a short psychological variables questionnaire, using Likert-type scales (1 to 7), to measure self-reported estimates of effort, concentration, and estimated performance. In the written instructions for the questionnaire, participants were told to respond to the questions in relation to the WG task. A complete copy of the psychological variables questionnaire is available from the author on request. Higher numbers on each of the self-report variables represent a greater frequency of that variable. For example, higher numbers on the estimated performance scale indicate a higher level of estimated performance.

Procedures

The experiment began at 10 PM on a Friday night and concluded at 11 AM the next morning. Approximately 8 participants were tested each Friday night. All participants were requested in advance not to drink alcoholic beverages or take nonprescription drugs from 10 PM on Thursday night until the conclusion of the experiment. In addition, we asked all participants to get out of bed between 7 AM and 9 AM on Friday morning and not to nap during the day.

The experiment commenced with all participants reporting to the sleep laboratory at 10 PM on Friday night. At that time, the students were randomly assigned in a block fashion to either a sleep-deprived (n = 23) or a nondeprived group (n = 21), were given the final set of instructions for the experiment, and signed consent forms. In an effort to create realistic sleep loss and nonsleep loss conditions for college students, we chose to limit the length of sleep deprivation to 24 hours for the sleep-deprived group and to allow the nondeprived group to sleep in their own beds under normal sleeping conditions for approximately 8 hours.

After the meeting at the sleep laboratory on the Friday night of the experiment, the members of the nondeprived group were told to go home and sleep approximately 8 hours. They were instructed to go to bed between 11 PM and 1 AM and to get out of bed between 7 AM and 9 AM on Saturday morning. The nondeprived participants were called at 9 AM on Saturday morning to ensure that they were awake, and they were encouraged to eat breakfast before reporting to the testing site at 10 AM.

The sleep-deprived group remained awake under the supervision of two research assistants in the sleep laboratory. Participants interacted with each other and with the research assistants, watched movies, played video and board games, or worked on personal projects during the night. They were allowed to bring food to eat during the night, but were asked to limit caffeinated beverages and sugary snacks to two of each. Sleep-deprived participants were escorted to a restaurant for breakfast at about 8 AM on Saturday morning. After breakfast, they were escorted to the testing area at 10:00 AM.

Testing took place at the university library in an isolated room of study cubicles, with one person per cubicle. To as-

TABLE 1
Examples of Self-Report Scale Used in Study of Sleep Deprivation

Test/question	Responses/scale
Profile of Mood Status	
1. Friendly	*Not at all* (0) to *extemely* (4)
2. Tense	*Not at all* (0) to *extemely* (4)
3. Angry	*Not at all* (0) to *extemely* (4)
Cognitive Interference Questionnaire	
1. I thought about how poorly I was doing	*Never* (1) to *very often* (5)
2. I thought about what the experiementer would think of me.	*Never* (1) to *very often* (5)
3. I thought about other activities (eg, assignments, work).	*Never* (1) to *very often* (5)
Psychological Variables Questionnaire	
1. How well were you able to concentrate on the task?	*Not at all* (1) to *extemely well* (7)
2. How well do you think you performed on this task?	*Poorly* (1) to *extemely well* (7)
3. How much effort did this task take?	*Very little* (1) to *very much* (7)

Note. These are examples of the types of questions to which participants were asked to respond.

sess their compliance with instructions, we asked the participants to complete a short questionnaire that included questions on sleep times and items consumed since Thursday night. All participants then completed the POMS scale, followed by the WG. After finishing the WG, all of the participants completed the questionnaire assessing self-reported effort, concentration, and estimated performance in relation to the WG. The last 18 participants in each of the groups also filled out the CIQ. The entire testing period took less than 1 hour.

Data Analyses

The data from the POMS, WG, and CIQ were initially scored according to the directions given for each measure. We calculated six POMS scores (tension–anxiety, depression–dejection, anger–hostility, vigor, fatigue, and confusion–bewilderment), one WG score representing the performance percentile of the individual in relation to other college students, and three CIQ scores (off-task cognitions relevant to task, off-task cognitions irrelevant to task, and general mind wandering). We derived self-reported effort, concentration, and estimated performance from the questions on the psychological variables questionnaire. We averaged self-reported sleep data for the sleep-deprived and the nondeprived groups separately, by group, for Thursday and Friday nights.

All statistical analyses were completed on SAS (SAS Institute, Cary, NC). To assess whether sleep deprivation had an effect on actual performance and self-reported estimates of psychological variables and mood states, we performed multiple analysis of variance (MANOVA), by sleep condition, on all variables.

RESULTS

All of the student participants reported that they slept approximately 8 hours on Thursday night. The sleep-deprived participants reported sleeping an average of 7.91 hours (SD = 1.26), whereas nondeprived participants reported sleeping an average of 7.79 hours (SD = 0.69). The wake-up times on Friday morning were very similar for both groups. The deprived group reported a mean time of getting out of bed of 8:55 AM (SD = 1.22 hours), and the nondeprived group reported a mean time of getting out of bed time of 8:30 AM. (SD = 1.10 hours).

On Friday night, nondeprived participants reported sleeping an average of 7.92 hours (SD = 0.51 hours) and a mean time of getting out of bed on Saturday morning of 8:40 AM (SD = 0.73 hours). Two participants, one in each sleep condition, reported taking a nap of less than 30 minutes on Friday. We analyzed the data both with and without the two napping participants included. Because the results from the two analyses were very similar, we report the results from all participants. None of the participants reported using alcohol or nonprescription drugs (except for acetaminophen) between 10 PM on Thursday and 10 AM on Saturday.

For means and standard deviations on the WG and the self-report tasks, see Table 2. As expected, the sleep-deprived participants performed significantly worse on the WG than the nondeprived participants did, $F(1, 42) = 4.02$, $p < .05$.

TABLE 2
Means and Standard Deviations of Sleep and Nondeprived Participant Groups

	Sleep deprived		Nondeprived	
Variables	*M*	*SD*	*M*	*SD*
Watson-Glaser	24.52	21.29	38.71	25.63*
Cognitive Interference Questionnnaire				
Distracting task-relevant thoughts	2.36	0.62	2.22	0.53
Distracting task-irrelevant thoughts	1.59	0.70	1.58	0.58
General mind wandering	4.17	1.92	3.72	1.60
Estimated effort	4.03	1.00	3.41	0.70*
Estimated concentration	4.30	1.66	3.28	1.31*
Estimated performance	4.54	1.36	3.36	0.84***
Profile of Mood States				
Tension/anxiety	14.22	7.30	11.19	8.05
Depression/dejection	11.96	12.08	9.86	10.22
Anger/hostility	11.65	9.00	8.00	7.46
Vigor	16.87	6.90	17.86	6.06
Fatigue	12.35	6.80	7.95	5.88*
Confusion/bewilderment	10.65	5.22	5.95	4.10**

Note. Significant differences between groups: *$p < .05$; **$p < .01$; ***$p < .001$.

Although we expected that sleep-deprived participants would have more difficulty concentrating on the task and, thus, would show an increase in off-task cognitions, none of the CIQ scales was significantly increased in the sleep-deprived group. Furthermore, instead of the expected decrease in self-reported concentration, as measured by the psychological variables questionnaire, the sleep-deprived participants reported higher subjective levels of concentration while completing the task than the nondeprived participants did, $F(1, 42) = 5.03$, $p < .05$.

The sleep-deprived participants also estimated that they expended significantly more effort to complete the task than did the nondeprived participants, $F(1, 42) = 5.49$, $p < .05$. Interestingly, although sleep-deprived participants actually performed worse on the WG than the nondeprived participants, the students deprived of sleep reported significantly higher levels of estimated performance than the nondeprived participants did, $F(1, 42) = 11.79$, $p < .001$.

The sleep-deprived participants reported higher levels on five of the six POMS scales, but only the increases in the fatigue and confusion scales were significant: fatigue, $F(1, 42) = 5.21$, $p < .05$; confusion, $F(1, 42) = 10.88$, $p < .01$.

DISCUSSION

As we expected, the results from our current study indicated that participants who were deprived of sleep for 24 hours performed significantly worse on a complex cognitive task than nondeprived participants. Although they actually performed worse, the sleep-deprived participants reported significantly higher levels of estimated performance, as well as more effort expended on the cognitive task, than the nondeprived participants did. In addition, sleep-deprived participants reported a significantly higher level of self-rated concentration than nondeprived participants did. We found no significant differences in levels of off-task cognitions between the sleep-deprived and nondeprived groups.

The apparent contradiction between the self-reported data on effort, concentration, and estimated performance and the actual performance level of sleep-deprived participants is somewhat surprising. It is unlikely that the disagreement between the self-reported variables and actual performance was a result of the type of task used. The Watson-Glaser task should have provided a suitable scenario for accurately assessing psychological variables because more difficult and longer tasks have been shown to result in more accurate self-estimates of both effort and performance.[20,21]

Several explanations for the disagreement between the self-report data and the actual performance levels are possible. Sleep-deprived participants may have expended more effort to complete the task, but the effort was not sufficient to overcome the performance decrements caused by being deprived of sleep. Furthermore, the increase in effort could have led the sleep-deprived participants to believe that they were performing better and concentrating more than they actually were.

An alternative explanation is that sleep deprivation may have negatively affected the degree to which participants recognized internal effort. In turn, this could have led the sleep-deprived participants to believe that they were expending more effort than they actually were, which may also have led to increases in estimated performance and self-rated concentration. Regardless of the mechanism behind the self-report data, the results indicated that our sleep-deprived participants did not realize the extent to which their own performances were affected by sleep loss, and they appeared to be making incorrect assumptions about their ability to concentrate and to provide the necessary effort to complete the task.

Interestingly, sleep deprivation did not result in the expected change in reporting off-task cognitions. Although a previous study[10] found that participants who habitually reported distracting thoughts were more likely to do so when deprived of sleep, it appears that the effect of sleep deprivation on off-task cognitions depends on whether the sleep-deprived person regularly experiences high levels of off-task cognitions. Therefore, reporting off-task cognitions does not appear to be specifically affected by sleep deprivation, independent of baseline levels.

A second major finding of this research is that sleep deprivation differentially affected mood states in these college students. The current findings indicate that sleep deprivation significantly affected only the fatigue and confusion subscales on the POMS. The reported increase in fatigue and confusion could have contributed to the significant decrease in actual performance that we observed in the sleep-deprived student participants. It is interesting to note that none of the remaining POMS subscales changed significantly in the sleep-deprived participants, indicating that some mood changes commonly ascribed to sleep deprivation, such as anger, irritability, and anxiety, were not necessarily products of 24 hours of sleep loss.

The current findings on mood states are very similar to those reported by Dinges and colleagues.[23] Sleep-deprived participants in both studies reported significantly more fatigue and confusion than nondeprived participants. Dinges and colleagues reported significantly more tension and significantly less vigor in sleep-deprived participants.

Similarly, we noted a trend for more tension and less vigor in the sleep-deprived participants in our study. The most likely reason for the small differences between the two studies is that Dinges and colleagues collected mood data every 2 hours for a 64-hour sleep-deprivation period, whereas we collected mood data only once—immediately before the students' completion of the cognitive task. Furthermore, neither study reported a significant increase in angry or depressed feelings following sleep deprivation, indicating that sleep deprivation does not necessarily increase reports of anger and depression, as is commonly believed.

In sum, our findings suggest that college students are not aware of the extent to which sleep deprivation impairs their ability to complete cognitive tasks successfully because they consistently overrate their concentration and effort, as well as their estimated performance. In addition, the current data suggest that 24 hours of sleep deprivation significantly

affects only fatigue and confusion and does not have a more general effect on positive or negative mood states. The practical implication of these findings is that many college students are unknowingly sabotaging their own performance by choosing to deprive themselves of sleep before they complete complex cognitive tasks.

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