Assessing Subjective Sleepiness During a Night of Sleep Deprivation: Examining the Internal State and Behavioral Dimensions of Sleepiness

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Abstract. Investigators in previous research have indicated that subjective measures of sleepiness may separate into state- and behavior-based dimensions; however, researchers have not examined this under sleep deprivation conditions. The authors’ purpose in this study was to examine several measures of subjective sleepiness under sleep deprivation conditions following completion of various tasks. Fourteen students participated in a 28-hour sleep deprivation study and completed vigilance and cognitive tasks 4 times during the night. The authors administered subjective measures of sleepiness after each task. Factor analyses indicated that when individuals were not excessively sleepy, subjective sleepiness measures separated into 2 dimensions: state and behavioral sleepiness. However, when individuals were more fatigued, there was no distinction between the state and behavior dimensions of sleepiness. The current results suggest that using measures that assess state and behavioral sleepiness separately could be useful in clinical and research settings when extreme levels of sleepiness are not expected.

Index terms: cognitive tasks, objective sleepiness, performance, subjective sleepiness, vigilance tasks

Many societies are moving toward 24-hour workdays, which often demand that employees work longer and irregular hours. Balkin et al.\textsuperscript{1} showed that as the job demands for longer working hours increase, the rate of sleepiness-related incidents at work also increases. These sleepiness-related incidents are usually associated with sleep deprivation or sleep disorders, which not only have a negative impact on safety, but also can cause performance decrements.\textsuperscript{2,3} Leger\textsuperscript{4} estimated that about 52.5% of all work-related accidents were related to sleepiness, with an estimated 5,565 fatalities, 945,000 disabling injuries, and an estimated cost of $24.7 billion. Webb,\textsuperscript{5} examining the same data, concluded that these numbers were an overestimation but still recognized the critical impact of sleepiness on both non-work-related and work-related accidents. Results of studies such as these indicate the need for measures that accurately assess sleepiness in an effort to help improve on-the-job performance and safety.

Although experts regularly assess sleepiness in clinical and research settings, there is some debate over the methods to best assess sleepiness. Researchers often use objective measures of sleepiness, such as the Multiple Sleep Latency Test, in clinical settings. Objective measures, however, have limited usability outside of a clinical or research setting.
because of the design of the measures (usually require a quiet, darkened room with a bed) and the cost of administration. In contrast, subjective sleepiness measures are low-cost and simple to administer. Researchers use several types of subjective sleepiness measures. Two well-established assessments are the Epworth Sleepiness Scale (ESS)\(^6\) and the Stanford Sleepiness Scale (SSS).\(^7\) The SSS has been widely used in a variety of clinical and research settings,\(^8,9\) whereas the ESS is a widely used measure in sleep medicine because of its brevity and simplicity.\(^10,11\) An additional sleepiness measure is a Visual Analogue Scale (VAS),\(^12\) which can also be used to measure subjective sleepiness. Experts frequently use the VAS measures in research settings.\(^13,14\) All 3 measures are quick and simple to administer, focusing on either the amount of sleepiness or alertness. As a result, these similarities contribute to an ongoing debate about the best subjective sleepiness measure to use, as none stands out as a gold standard.\(^6,12\) Thus, although different subjective sleepiness scales are in use, there is little agreement on how to best assess subjective sleepiness.

Lang\(^5\) theory of multiple systems of emotional response could provide a theoretical structure to better understand the construct of sleepiness. Lang proposes that there are 3 emotional response systems: (1) physiological state changes, (2) subjective internal states, and (3) behavioral changes. Fear researchers have translated these response systems into increased sympathetic or physiological arousal, reports of feeling terrified or afraid, and avoidance or escape behaviors. Research indicates that these components of fear are related, but not identical to each other.\(^19\)

Pilcher, Pury, and Muth\(^20\) investigated the possibility of applying Lang’s theory to gain a better understanding of subjective sleepiness. They examined a number of subjective sleepiness measures during daytime hours, including the SSS, ESS, VAS, and the fatigue and vigor subscales on the Profile of Mood States (POMS). They found that the SSS, POMS, and 3 VAS measures were more strongly related to each other than with the ESS. Pilcher et al\(^15-17\) concluded that the ESS measures the behavioral aspect of sleepiness whereas the SSS, POMS, and VAS measure the internal state of sleepiness on the basis of Lang’s emotional response systems theory. This research indicated that sleepiness may not be a simple construct; instead, sleepiness seems to encompass several different subjective states.

An additional approach that researchers could use to better understand sleepiness is to examine how sleepiness may be affected when performing different types of tasks. For example, it is easy to imagine that long, boring tasks (e.g., vigilance tasks) would be associated with increased sleepiness, whereas more demanding or fun tasks (e.g., video games) would be associated with decreased sleepiness. Furthermore, the relationship between sleepiness and the type of task could be affected by degree of sleep loss such that under sleep deprivation conditions, sleepiness would likely increase regardless of the type of task.\(^21\) It is unclear, however, whether Lang’s theory could be applied to subjective measures of sleepiness following different types of tasks under sleep deprivation conditions.

Our purpose was to examine state and behavior measures of subjective sleepiness following the completion of vigilance tasks and a cognitively demanding task over a 28-hour sleep deprivation period. On the basis of the existing literature, we hypothesized that there would be a distinction between subjective state and behavior measures of sleepiness over the night of sleep deprivation following both tasks.

**METHODS**

Participants

Fourteen undergraduate students at a southeastern university (7 men, 7 women) completed this study. The mean age was 19.9 (standard deviation [SD] = 2.0). Potential volunteers completed a screening questionnaire to ensure that they were in good health, had no diagnosed sleep disorders, did not use tobacco or drugs, and did not excessively drink alcohol. The university’s institutional review board approved the study, and participants signed a consent form before beginning the study.

Procedures

We recruited volunteers with flyers advertising the study. If volunteers met the criteria for inclusion, they signed up for a time to participate. One week prior to the onset of the study, we gave participants actigraphs (Mini Mitter Company Inc, Bend, OR) to wear. Participants wore these on the nondominant arm and used them to record wrist accelerations to provide an objective measurement of sleep/wake activity. Participants also completed sleep logs during the week prior to sleep deprivation to record sleeping, waking, and napping activity as a subjective measure of sleep/wake activity. We then compared the sleep logs with the actigraph data to evaluate sleep episodes prior to sleep deprivation. We instructed participants to sleep approximately 8 hours the night prior to participation, not to nap on the day of sleep deprivation, not to consume alcohol the night prior to participation through the end of the study, and not to consume caffeine or large amounts of sugar on the day of the study.
We trained all participants on each of the tasks in the study on the day prior to sleep deprivation to help ensure a level of stable performance. Training lasted approximately 4 hours. After training was completed, we reminded participants to sleep approximately 8 hours that night and not to drink alcohol.

Participants reported to the lab at 5 PM on a Friday, and we tested them in groups of 4. The participants completed the study by about 11 AM the next day, and we compensated them $75 at that time. We also told participants that we would give incentive money to top scorers (ie, $100 to top scorer, $50 to second-top scorer, $25 to third- and fourth-top scorer) on the basis of completion of all the tasks throughout the night. We paid the incentive money at the completion of the study.

During the night of sleep deprivation, participants completed a variety of tasks across 4 testing sessions. We counterbalanced across all tasks across the testing sessions. The testing sessions lasted from approximately 5:30–9:30 PM, 9:45 PM–1:45 AM, 2:30–6:30 AM, and 6:45–10:45 AM. There were 10-minute breaks every hour, 15-minute breaks every 4 hours, and a 45-minute break halfway through the night. Participants received 2 boxed lunches during the night. Each lunch consisted of a sandwich, chips, apple, and a non-caffeinated beverage. Participants were also provided with ad lib water throughout the night.

Tasks

Participants completed a battery of sleepiness measures after completing cognitive and vigilance tasks during the night of sleep deprivation. The results from the sleepiness measures completed after 1 complex cognitive task and 2 vigilance tasks will be used in the current analyses. The Wombat task (Aero Innovation Inc, Saint Laurent, Canada) was the complex cognitive task. It is a computerized task that was designed to assess situation awareness, stress tolerance, and attention management abilities. Training for this task followed the recommendations made by Aero Innovation and consisted of a 60-minute computerized instructional program, a 40-minute solitary practice session (solo Wombat), and a 10-minute practice session with a partner (duo Wombat). The Wombat was designed such that the participants were told to maximize their scores by switching between a tracking task and several bonus tasks. Real-time feedback on performance levels was provided on the computer screen to the participants as they completed the task. When starting the task, participants used 2 joysticks to track objects on the computer screen. When the objects were lined up correctly, the participants could engage the autopilot, which would then automate the tracking task for them. The participants could then choose and complete a bonus task to increase their performance scores. Different weights were assigned to the bonus tasks at different times. Thus, to maximize their performance scores, the participants had to keep track of the current weight assigned to each bonus task and select a bonus task that they felt confident in completing as well as one that had a high assigned weight. However, the weights assigned to the bonus tasks would change as the participants were completing the tasks. The participants could choose to switch from one bonus task to a higher weighted bonus task to improve their performance score.

The bonus tasks consisted of a 3-D figure-rotation task, a quadrant location task, and a digit-canceling task. Figure rotation showed participants pairs of objects with different spatial orientations on a computer screen. Participants could use joysticks to rotate the objects to decide whether the 2 objects were the same. The quadrant location task required participants to choose numbers in ascending order by pushing a button that corresponded with the quadrant in which each number was located on the computer screen. The digit-canceling task (a 2-back task) showed participants a single digit from 1 to 8. After the third digit was displayed, participants pressed the key corresponding to the digit that was displayed 2 back in the sequence.

As an additional attention management assessment, the autopilot on the tracking portion of the Wombat was programmed to randomly fail. Thus, in addition to keeping track of the changing weights assigned to the different bonus tasks, the participants also had to monitor the effectiveness of the autopilot on the tracking task. When the autopilot failed, to keep their score up, participants had to exit the bonus task to manually track the objects again until autopilot could be reengaged. Once reengaged, the participants could again perform a bonus task.

For testing, participants worked solo for part of the time and with another participant for the remainder of the time. Each participant completed the solo Wombat for the first 12 minutes. After a 2-minute break, the participants completed 24 minutes on the duo Wombat where 2 participants worked together on the task. Once autopilot was engaged, they decided together which bonus tasks to perform to maximize their overall performance. After the duo Wombat, participants completed another 10 minutes of the solo Wombat.

The 2 vigilance tasks were the Psychomotor Vigilance Task (PVT) and a computerized vigilance task. For training on the PVT, we gave participants the handheld device and told them to push a button (corresponding to handedness), as soon as numbers counting up in milliseconds appeared in a small window on the box. The participants were then
allowed to practice for a couple of minutes. During testing, we administered the PVT for 10 minutes. Training on the longer computerized vigilance task consisted of showing participants how the task worked and allowing them to practice for a minute. Letters randomly flashed on a computer screen every 2 to 10 seconds. We told participants to press the space bar only when the letter H appeared and to ignore the random distracter letters (ie, Z, K, F, T, U, R, Q). Stimuli were displayed for 0.5 seconds, with a 1 in 5 chance of the target stimuli being presented. During testing, we administered this vigilance task for 38 minutes.

**Subjective Measures**

The participants completed a computerized subjective survey at the completion of the Wombat and both vigilance tasks. This survey consisted of 3 sections. The first section contained 12 VAS questions to assess subjective concepts, such as sleepiness, performance, and stress. For example, participants were asked, “How sleepy do you feel right now?” Using a mouse, participants moved a vertical line on a 100-mm horizontal line indicating not at all on the left end and very sleepy on the right end to indicate how sleepy they felt at that time. We assessed sleepiness 2 ways within the VAS questions. Three of the VAS questions were state measures of sleepiness, asking how alert (VAS alert), sleepy (VAS sleepy), and tired (VAS tired) participants felt at that moment. Two of the VAS questions were behavioral measures of sleepiness asking participants how likely it would be for them to fall asleep at that moment if reading a book (VAS reading book) or if they put their head down on a desk (VAS head on desk). The second section of the survey was the SSS. On the SSS, participants indicated how likely it would be for them to doze off or fall asleep in various situations and thus provided a measure of behavioral sleepiness. Example situations were sitting and reading, watching TV, or as a passenger in a car for an hour without a break. The rating scale for the ESS ranged from 0 (would never doze) to 3 (high chance of dozing). The third section of the survey was the SSS. For the SSS, participants rated their current level of sleepiness from 1 (feeling active and vital; alert; wide awake) to 7 (almost in a reverie; sleep onset soon; lost struggle to remain awake). Although some of the descriptors associated with the SSS had behavioral components, most of the descriptors reflected a subjective state of sleepiness and, as such, provided a subjective state measure of sleepiness.

**Data Analysis**

We scored each VAS by measuring the distance (in millimeters) between the left edge of each line and the participant’s mark on each line. We reverse-scored the VAS indicating alertness so that all subjective sleepiness measures were indicating a level of sleepiness. We scored the ESS by following the directions provided by Johns.6 This provided an overall behavioral measure of sleepiness ranging from 0 to 3. The SSS provided a subjective state measure of sleepiness ranging from 1 to 7. We entered all data into SPSS (SPSS Inc, Chicago, IL) for analysis. We calculated means and standard deviations for each measure of sleepiness during each session for both the Wombat and vigilance tasks. We conducted repeated-measures ANOVAs using testing session as a factor on all sleepiness tasks to examine changes in sleepiness across the night. We reported Wilk’s Lambda multivariate results.

We conducted 4 principal components factor analyses on the sleepiness data using a Promax rotation with an unspecified number of factors to see whether the state and behavioral measures of sleepiness would fall into separate factors. Each factor analysis used the 3 state VAS measures, 2 behavior VAS measures, the ESS (behavior measure), and the SSS (state measure) of sleepiness. We conducted 2 factor analyses (one for the Wombat and one for the vigilance tasks) for each of the 4 testing sessions completed during the night of sleep deprivation.

As an additional means of examining which sleepiness measure best assessed subjective sleepiness, we conducted reliability analyses for the Wombat and vigilance tasks for each session of the night. We calculated reliabilities for the state measures of sleepiness by comparing the SSS reliability with the reliability of VAS alert, VAS sleepy, and VAS tired. We also calculated reliabilities for the behavior measures of sleepiness by comparing the ESS reliability with the reliability of VAS reading book and VAS head on desk.

**RESULTS**

**Descriptive Analysis**

The participants were well rested when reporting to the sleep laboratory for the night of sleep deprivation as indicated by both subjective and objective estimates of sleep. For the 3 nights prior to sleep deprivation, all participants reported sleeping an average of 7 hours, 28 minutes (SD = 1 hour, 36 minutes) each night on their sleep logs, whereas their actigraph data indicated that participants slept an average of 7 hours 2 minutes (SD = 1 hour, 24 minutes).

Researchers22 in a previous report from our lab concluded that there was a significant performance increase on the Wombat task during the night in spite of the prolonged training completed on the task. In contrast, performance decreased on both the PVT and computerized vigilance
tasks during the night, such that reaction time on both vigilance tasks increased significantly across the night.

**Sleepiness Ratings**

As shown in the top portion of Figure 1, subjective sleepiness assessed by the SSS, the ESS, and the VAS measures at the conclusion of the Wombat increased during the night. Repeated-measures ANOVAs revealed significant increases in sleepiness for all state measures of sleepiness across the testing sessions: VAS alert, $F(3, 11) = 9.38, p = .002$, partial $\eta^2 = 0.72$; VAS sleepy, $F(3, 11) = 9.26, p = .002$, partial $\eta^2 = 0.72$; VAS tired, $F(3, 11) = 6.04, p = .011$, partial $\eta^2 = 0.62$; and the SSS, $F(3, 11) = 7.66, p = .005$, partial $\eta^2 = 0.68$). There were also significant increases in subjective ratings of sleepiness for all behavior measures of sleepiness: VAS reading book $F(3, 11) = 5.38, p = .016$, partial $\eta^2 = 0.60$; VAS head on desk, $F(3, 11) = 5.02, p = .02$, partial $\eta^2 = 0.58$; and the ESS, $F(3, 11) = 4.33, p = .03$, partial $\eta^2 = 0.54$. These results indicate that regardless of whether subjective sleepiness was measured as a state or as a behavior, sleepiness increased significantly following a complex and engaging task during a night of sleep deprivation.

**FIGURE 1.** Participant state and behavior sleepiness ratings for the Wombat and vigilance tasks. VAS = Visual Analogue Scale. SSS = Stanford Sleepiness Scale. ESS = Epworth Sleepiness Scale.
The lower portion of Figure 1 shows increases in average mean ratings of sleepiness assessed after the vigilance tasks throughout the night. These increases were significant for all 4 state measures of sleepiness: VAS alert, $F(3, 10) = 11.32, p = .001$, partial $\eta^2 = 0.77$; VAS sleepy, $F(3, 10) = 9.52, p = .003$, partial $\eta^2 = 0.74$; VAS tired, $F(3, 10) = 3.78, p = .048$, partial $\eta^2 = 0.53$; and the SSS, $F(3, 8) = 6.50, p = .015$, partial $\eta^2 = 0.71$. The increases during the night for the 3 behavior measures of sleepiness were also significant: VAS reading book, $F(3, 10) = 5.28, p = .019$, partial $\eta^2 = 0.61$; VAS head on desk, $F(3, 10) = 8.31, p = .005$, partial $\eta^2 = 0.71$; and the ESS, $F(3, 10) = 4.78, p = .026$, partial $\eta^2 = 0.59$. Similar to that seen with the complex cognitive task, the results indicate that regardless of whether subjective sleepiness was measured as a state or as a behavior, sleepiness increased significantly following simple vigilance tasks across a night of sleep deprivation.

**Factor Analyses**

Table 1 shows results from the factor analyses. The results for the Wombat revealed that there were 2 distinct factors of sleepiness during the first session of the night. The state measures of sleepiness (VAS alert, VAS sleepy, VAS tired, SSS) loaded onto Factor 1 and accounted for the majority of the variance (61.8%); the behavior measures of sleepiness (VAS reading book, VAS head on desk, ESS) loaded onto Factor 2, accounting for 23.3% of the variance. During the second session of the night, all measures of sleepiness, with the exception of VAS alert and the SSS, loaded highly onto Factor 1, accounting for the majority of variance (68.8%). VAS alert and SSS loaded more highly onto Factor 2 and accounted for 17.4% of the total variance. During sessions 3 and 4, only one factor was extracted. For the third session, the loadings of the 7 sleepiness measures accounted for 76.1% of the variance. For the fourth session, the loadings accounted for 83.1% of the variance.

The factor analyses results for the vigilance tasks were similar to those from the Wombat (see Table 1). During the first session of the night, the factor analyses revealed 2 distinct factors of sleepiness. The state measures of sleepiness (VAS alert, VAS sleepy, VAS tired, SSS) loaded onto Factor 1 and accounted for the majority of the variance (78.1%). The behavior measures of sleepiness (VAS reading book, VAS head on desk, ESS) loaded onto Factor 2 and accounted for 14.6% of the total variance. During sessions 2, 3, and 4, only one factor was extracted. For the second session of the night, the loadings of the 7 measures of sleepiness accounted for 66.8% of the variance. The subjective measures of sleepiness accounted for 83.5% of the variance during the third session of the night and

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<th>TABLE 1. Factor Loadings of State and Behavior Sleepiness Measures for the Wombat and Vigilance Tasks</th>
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<td>VAS alert</td>
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<td>VAS sleepy</td>
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<td>VAS tired</td>
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<td>SSS</td>
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<td>VAS reading book</td>
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<td>VAS head on desk</td>
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<td>ESS</td>
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Note. VAS = Visual Analogue Scale; SSS = Stanford Sleepiness Scale; ESS = Epworth Sleepiness Scale. For the Wombat task, one factor was extracted for sessions 3 and 4, accounting for 76.1% and 83.1% of the variance, respectively. For the vigilance tasks, one factor was extracted for sessions 2, 3, and 4, accounting for 66.8%, 83.5%, and 72.7% of the variance, respectively. Accounted for 61.8% of variance. Accounted for 23.3% of variance. Accounted for 68.8% of variance. Accounted for 78.1% of variance. Accounted for 14.6% of variance.
72.7% of the variance during the fourth session of the night. These results for the Wombat and vigilance tasks show that state and behavior measures of sleepiness lose their distinction from one another over a period of sleep deprivation.

Reliability Analyses

As shown in Table 2, the reliability of the more commonly used subjective measures of sleepiness (ie, SSS, ESS) was consistently lower than was the reliability of the corresponding cluster of state or behavior VAS. This was true following both the Wombat and vigilance tasks during the night. Moreover, the reliability of the cluster of 3 state VAS measures was higher than 0.8 for each session for both the Wombat and vigilance tasks and was consistently higher than the SSS reliability. This was also true for the behavior measures, where the reliability of the cluster of the 2 behavior VAS measures was higher than 0.8 for each session. For every session of the Wombat and vigilance tasks, the VAS behavior cluster reliability was consistently higher than the SSS reliability. Overall, results showed that the reliability of each VAS cluster was generally higher than 0.8 and that the state and behavior VAS clusters had consistently higher reliabilities than the single state SSS or behavior ESS across both types of tasks.

COMMENT

As expected, subjective sleepiness assessments separated into 2 factors, one measuring an internal state of sleepiness and the other a behavioral dimension of sleepiness at the beginning of the sleep deprivation period when the participants would have been naturally awake. However, in contrast to our expectations, sleepiness did not separate into the state and behavioral dimensions as the night progressed. For the Wombat task, factor analysis results for the first session of the night showed 2 dimensions of sleepiness, with the state VAS measures and SSS loading onto one factor whereas the behavior VAS measures and ESS loaded onto a second factor. As participants became sleepier throughout the night, the 2-factor model was less distinct for session 2 and there was no differentiation between the different subjective sleep assessments for sessions 3 and 4. For the vigilance tasks, factor analysis results for the first session of the night showed similar results to the Wombat task, with the state VAS measures and SSS highly loaded onto one factor whereas the behavior VAS measures and ESS highly loaded onto a second factor. The two-factor distinction was not present during sessions 2, 3, or 4 for the vigilance tasks. These findings suggest that at the beginning of the night of sleep deprivation, the participants reported 2 dimensions of subjective sleepiness, state and behavior; however, as the night progressed, the participants reported only one dimension of sleepiness.

Researchers examining the possible distinction between state and behavior subjective measures of sleepiness conducted testing during the morning and afternoon and showed similar results to those found in the first session of the night in our study. Researchers in the earlier study found that the SSS and state VAS measures loaded onto a separate factor than did the ESS when subjective daytime sleepiness was assessed. Thus, it seems that when people complete subjective measures of sleepiness at times when they would not be expected to experience excessive levels of sleepiness, that their assessment of sleepiness is composed of at least a state sleepiness component and a behavior sleepiness component. However, our results indicate that as participants become progressively more fatigued over a night of sleep deprivation, the distinction between the state and behavioral dimensions of subjective sleepiness fades away.

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<tr>
<th>Measure</th>
<th>Wombat</th>
<th>Vigilance</th>
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<tr>
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<td>Session 1</td>
<td>Session 2</td>
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<td>State</td>
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<td>SSS</td>
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<td>VAS alert, sleepy, tired</td>
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<td>ESS</td>
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<tr>
<td>VAS reading book, head on desk</td>
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Note. VAS = Visual Analogue Scale; SSS = Stanford Sleepiness Scale; ESS = Epworth Sleepiness Scale.
Note that the Wombat task resulted in a more gradual change from a 2-factor model to a 1-factor model than did the vigilance tasks. This may be because of the intrinsic differences between the 2 types of tasks. The Wombat was complex and highly engaging, requiring the participants to constantly interact with the computer to complete the task. In contrast, the vigilance tasks required attention but little interaction or engagement on the part of the participants; they simply had to wait for a stimulus and quickly respond. As such, although sleepiness increased during the second session following the Wombat task, it is conceivable that the interactive nature of the task provided a short-term counteraction to sleepiness while the participants were completing the task but that the counteractive effect was not strong enough to overcome the increasing levels of sleepiness later in the night.

The general conclusion that a highly interactive or engaging task may actually have a short-term counteractive effect on sleepiness is also supported by the performance results from the Wombat and vigilance tasks. Performance on the Wombat increased significantly during the night, indicating that the participants were quite capable of successfully completing this demanding cognitive task even while experiencing increasing levels of sleepiness. In contrast, performance on the vigilance tasks decreased across the night as levels of sleepiness increased. These results support previous research in which investigators found that performance on vigilance tasks is affected more quickly than are the state and behavior subjective sleepiness assessments separate from each other.23,24

The reliability results showed that the 3 state VAS measures had higher reliability than did the SSS for both the Wombat and vigilance tasks. The 2 behavior VAS measures had higher reliability than did the ESS for both the Wombat and vigilance tasks. Although it makes sense that 2 or 3 measures will have greater reliability together than will a single measure of the same construct, these results have important implications in both research and clinical sleep settings. First, VAS measures are easy to administer and score, making them appealing from an administration as well as data analysis viewpoint. Although both the ESS and SSS are easy to administer and score, both are more complex and take longer than do VAS measures. In addition, the VAS measures need not be combined to obtain a composite score, but they do provide the option of combining into a composite sleepiness score that is more reliable than is a single score from either the SSS or ESS. Second, the SSS appears to contain state-based sleepiness ratings as well as some behavior-based sleepiness ratings, thus merging what appear to be 2 different dimensions of subjective sleepiness. In contrast, the VAS can be worded to focus on either an internal state of sleepiness or a behavioral component of sleepiness. Third, there may be a benefit in keeping state and behavior subjective sleepiness assessments separate when both can be administered and scored in a timely manner. This separation would give researchers and clinicians an opportunity to choose whether to measure both dimensions of sleepiness or whether to focus only on one. Furthermore, if researchers or clinicians want to measure both the state and behavior dimensions, they can easily accomplish this with as few as 5 VAS questions, which would take no longer to administer than either the SSS or ESS alone. Last, when assessing sleepiness during the day or early evening when humans would be expected to be relatively awake because of our endogenous circadian rhythms, using VAS measures to assess both state-based and behavior-based sleepiness would result in a more complete measurement of subjective sleepiness. Thus, the VAS measures may be a better approach to assessing subjective sleepiness than the more commonly used SSS and ESS.

Limitations

There are several limitations in our study. One limitation is the low number of participants; however, note that the factor analysis results in the first testing session of the study, when participants were well rested, parallels the findings of previous researchers. This finding indicates that the current sample resulted in useful and reliable data. Another limitation is that we did not allow participants to nap or consume caffeine or sugar during the study. This is something that many individuals would do if they stayed awake at night and felt fatigued. As such, the sleepiness ratings reported here may be exaggerated in comparison with what one could expect in nonlaboratory settings. This indicates, however, that if sleepiness were assessed during a night shift when workers may be taking measures to counteract fatigue (eg, drinking coffee), that subjective sleepiness would more closely reflect what occurs when assessed during nonfatigued states and divide into the state and behavior components. Experts could design future studies in which researchers assess state-based and behavior-based sleepiness during a night of sleep deprivation when participants are allowed to counteract fatigue through behaviors like consuming caffeinated drinks. The final limitation of this study is that college students served as participants. College students typically report more variability in their sleep patterns than do other adults. This expected increase in sleepiness would have conceivably increased the levels of sleepiness, thus decreasing the likelihood that sleepiness would successfully separate into the two factors as expect-
ed. Researchers could complete future studies using nonstudent populations to examine whether the 2-factor model of sleepiness holds true across different populations.

Conclusion

In conclusion, our results provide additional evidence that Lang’s15-17 theory of multiple systems of emotional response can be used to help understand sleepiness. The results indicate that there are 2 dimensions of sleepiness within typically used subjective sleepiness assessments when an individual is not excessively sleepy. The SSS and state-based VAS measures appear to be measuring an internal state of sleepiness whereas the ESS and behavior-based VAS measures appear to be measuring a behavioral likelihood of falling asleep. As a person becomes sleepy, however, this individual no longer seems to separate state from behavior sleepiness and simply reports being very sleepy. This finding could be useful in clinical settings where clinicians frequently assess subjective sleepiness in individuals who have sleep complaints. Researchers could explore the possibility of using the different dimensions of sleepiness as a means to assess subjective sleepiness in clinical patients. In addition, the VAS measures appear to provide a more reliable and flexible way of assessing subjective sleepiness than do the single SSS or ESS measures. These are important findings for sleep clinicians or researchers measuring sleepiness. Those individuals who assess sleepiness during the hours when humans would be expected to be less fatigued due to endogenous circadian rhythms may want to consider assessing both state and behavior dimensions of subjective sleepiness as well as consider using VAS measures for such assessments.

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REFERENCES


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Call For Papers

Behavioral Medicine

Behavioral Medicine welcomes all submissions of pertinent manuscripts.

Behavioral Medicine is an interdisciplinary journal of research and practice that deals with psychosocial influences on health and behavior. It publishes original research studies, both experimental and clinical; evaluation studies; review articles; case reports; and book reviews.

In addition, the journal welcomes three-part coordinated submissions on a theme topic that deal in depth with (a) a review of the literature on a health problem that can be treated through the use of psychological or behavioral intervention, (b) the evidence from research for the value of the behavioral intervention, and (c) an analysis of the policy implications of the therapy and means of introducing it into mainstream training and health practice. The economic impact of new or evolving therapies may be included in the discussion.

Manuscripts must include an abstract, index terms, and a brief biographical statement about the author. All manuscripts should adhere to the style and conventions of the American Medical Association Manual of Style, 9th edition. Manuscripts should be double-spaced in MS Word files with 8.5 x 11 in. (22 x 28 cm) page setup and 1 in. (2.5 cm) margins. Use 10-point Times or New York font. Use separate files for the main text, any tables, any figures, and any appendixes.

Thank you for your interest in Behavioral Medicine.

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