A Standard Procedure Enhances the Correlation Between Subjective and Objective Measures of Sleepiness

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Objective: The goal of this study was to assess whether instituting a standard procedure to minimize transient activation prior to the subjective rating of sleepiness can improve the predictive value of the rating process.

Methods: Thirty young adults, aged 19 to 26 years, participated in the study. Subsequent to sleeping at home with bedtime restricted to 5 hours, they came to the sleep laboratory. They were instructed to rate their level of sleepiness on the Stanford Sleepiness Scale (SSS) and visual analog scales (VAS). A “calm-down” procedure, sitting quietly with eyes closed for 1 minute, was instituted prior to sleepiness ratings for half of the subjects (experimental group) but not for the other half of the subjects (control group). A nap trial with polysomnographic recording was then conducted, followed by a vigilance test.

Results: For the experimental group, VAS results of “sleepiness” and “alertness” both correlated significantly with sleep-onset latency during the nap (SOL: \( r = -.62 \) and \( .64, \) respectively, \( P \) values < .05) and with reaction time (RT) on the vigilance test (\( r = .56 \) and -.54, \( P \) values < .05). The SSS ratings showed significant correlation with nap SOL (\( r = -.58 \), \( P < .05 \)) but not with RT on the vigilance test (\( r = .19, P = .52 \)). For the control group, none of the subjective ratings showed significant correlation with objective measures. The differences between the resultant correlations for the 2 groups were statistically significant for 2 sets of correlations: the correlation between VAS of “alertness” and nap SOL and the correlation between VAS of “sleepiness” and RT on the vigilance test.

Conclusion: The results indicate that the subjective ratings of the sleepiness state for individuals with mild sleep restriction more faithfully reflect a physiologic tendency to fall asleep as well as cognitive attentiveness when the ratings are conducted subsequent to sitting still with eyes closed for a sufficient time to minimize transient activation.

Key Words: Sleepiness, subjective sleepiness, Stanford Sleepiness Scale, sleep-onset latency

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INTRODUCTION

SLEEPINESS, DEFINED AS BOTH A FUNDAMENTAL FEELING STATE AND THE TENDENCY TO FALL ASLEEP, IS ONE OF THE MOST IMPORTANT CONCEPTS IN SLEEP MEDICINE. At a given moment, the manifest feeling of sleepiness may reflect basal physiologic sleepiness as well as factors such as context, activity, and motivation. When these activating influences are absent for an individual, latent or physiologic sleepiness is revealed. It has been suggested that subjective ratings of sleepiness reflect manifest sleepiness and objective measures such as sleep-onset latency (SOL) and behavioral measures reflect latent sleepiness.1 The significant but limited correlations between manifest and latent measures of sleepiness suggest that these different assessment techniques do not always measure similar aspects of sleepiness. The correlation between subjective sleepiness ratings and sleep latencies on the Multiple Sleep Latency Test (MSLT), for example, was initially found to be high in normal subjects2-3 but was subsequently found to be non-significant in both normal subjects4-7 and clinical populations.7,9

Similarly, the correlations between subjective ratings and objective behavioral measures of sleepiness have also been shown to have limited correspondence. For example, one study reported small to moderate correlations (\( r \) values = .25 to .42) between subjective sleepiness rating on visual analog scales (VAS) and performance on auditory vigilance tasks following sleep reduction, when data points collected repeatedly in 8 subjects were all included.10 Another study showed moderate to high correlations (\( r \) values = .49 to .71) between performance on a visual vigilance task and subjective sleepiness ratings on VAS and a 9-point rating scale (Karolinska Sleepiness Scale), when the 48 data points collected repeatedly from 6 subjects were included.11 Furthermore, the Stanford Sleepiness Scale (SSS) has been reported to have moderate to high correlations (\( r \) values = .47 to .70) with performance on different cognitive tasks. The correlations ranged from .18 to .95 for different subjects.12 A recent study demonstrated that mild physical activity could mask subjective sleepiness following total sleep deprivation. Subjects showed less decline of subjective sleepiness after walking, but their cognitive performance showed the same degree of impairment regardless of their having participated in exercise prior to subjective-sleepiness rating.13

As activating situational factors are minimized, manifest sleepiness should better correspond to measures of latent sleepiness. The current study was designed to minimize the situational factors that counter latent sleepiness and weaken the association between subjective and objective measures of sleepiness.

The present study was conducted to clarify the relationship between objective and subjective sleepiness measures. The goals of the study were (1) to evaluate the relationship between subjective sleepiness and physiologic tendency to fall asleep measured by polysomnographic SOL, (2) to evaluate the relationship between subjective sleepiness and vigilance measured by a continuous performance task, and (3) to determine if minimizing transient activation by instituting a procedure to calm the subject down prior to subjective-sleepiness ratings improves the predictive value of the rating process.

METHOD

Subjects

Subjects were 30 young adults (10 men and 20 women) recruited from a college campus. Their ages ranged from 19 to 26 years, with a mean age of 22 years and SD of 1.36 years. Their habitual bedtime ranged from 11:00 PM to 2:00 AM, and habitual arising time from 7:30 AM to 11:30 AM. Their habitual total time in bed ranged from about 6 hours to 8 hours, and their total sleep time was not less than 600 minutes. Two sleep lab technicians performed the behavioral tasks and polysomnography. Subjects were told to avoid caffeine and alcohol for 24 hours prior to the study. All subjects were volunteers and gave informed consent to participate. Inclusion criteria included no ongoing sleep disturbance, no axis I psychiatric disorder, no sleep-related medication, no history of major illness, and no history of any medication use that might impact subjective sleepiness ratings. The subjects were scheduled to arrive at the sleep laboratory at 3 PM and were then permitted to rest in a 2-bed room for a 2-hour period to achieve baseline subjective sleepiness levels. At 3:30 PM, the experiment began with the Stanford Sleepiness Scale (SSS) and Visual Analog Scale (VAS). A “calm-down” procedure, sitting quietly with eyes closed for 1 minute, was instituted prior to subjective sleepiness rating. This was followed by a vigilance test.

For the experimental group, polysomnographic recording was then conducted, followed by another SSS rating. Subjects were instructed to rate their level of sleepiness on the Stanford Sleepiness Scale (SSS) and visual analog scales (VAS). A “calm-down” procedure, sitting quietly with eyes closed for 1 minute, was instituted prior to sleepiness ratings for half of the subjects (experimental group) but not for the other half of the subjects (control group). This was followed by a vigilance test.
9 hours. After passing a screening interview for psychiatric disorders, neurologic disorders, and major medical conditions, the subjects were randomly assigned to either the experimental group or the control group.

PROCEDURE

The day before coming to the laboratory, the subjects were instructed to refrain from consuming caffeinated drinks. Their sleep was restricted to 5 hours (from 3:00 AM to 8:00 AM) to induce mild sleepiness. They were instructed to call a time-stamping answering machine in the laboratory immediately prior to their going to bed and immediately subsequent to their having woken up. The subjects were scheduled to come to the sleep laboratory at 9:00 AM, 2:00 PM, or 6:00 PM, at the subjects’ convenience. Eight subjects were scheduled for the morning session (3 in control group, 5 in experimental group); 8 for the afternoon session (6 in control group, 2 in experimental group); 14 for the evening session (6 in control group, 8 in experimental group). The habitual bedtime and rising time did not differ significantly among the subjects in the morning, afternoon, and evening groups (bedtime: F = .01, NS; arising time: F = 2.0, NS).

The laboratory was sound attenuated and air-conditioned. Indoor fluorescent lights were on throughout the experimental procedures except for the nap test. During the nap test, all lights were turned off. After the subjects arrived in the laboratory, electrodes were applied for standard polysomnographic recording. The recording montage included electroencephalography (C3, C4, O1, and O2 referred to A1 and A2), electrocerebrography, and chin electromyography. Two sessions of sleepiness measures were conducted. The first was an adaptation session. Only data from the second session were included for analysis. During each session, the subjects’ subjective sleepiness was measured with the SSS and VAS. The SSS is a 7-point scale ranging from 1 (“Feeling active and vital; alert; wide awake.”) to 7 (“Almost in reverie; sleepy/onset soon; lost struggle to remain awake.”). The VAS contained 2 items (“sleepiness” and “alertness”), each consisting of a 10-cm line, with “not sleepy/not alert at all” on the left end of the line and “extremely sleepy/extremely alert” on the right end of the line. Subjects were asked to view the line as representing their personal range of feelings and to place a mark on the line indicating their feeling at that moment. Similar scales have been used in many of the previously mentioned studies. Subjects in the experimental group were instructed to sit quietly with their eyes closed for 1 minute before the ratings. No specific instruction was given to subjects in the control group. After the ratings, subjects were instructed to lie down in bed and try to fall asleep. As soon as their polysomnogram showed 3 consecutive pages of sleep following the standard scoring criteria, they were awakened and the recording terminated. If sleep onset was not achieved, the recording was terminated in 25 minutes. A continuous performance test (CPT) measuring vigilance and alertness was conducted prior to subjective ratings of sleepiness. The standard procedure obtained a mean RT of 1.74 seconds, which is more than 10 SD above the mean RT of the rest of the subjects (mean = 62, SD = .11 second). Her data on the CPT were therefore excluded from data analysis. For the experimental group, RTs correlated significantly with VAS sleepiness and alertness ratings but not with SSS ratings (see Table 1). Figure 2 shows the scatter plots of the correlations. The differences between the respective correlations for the 2 groups were also compared by computing the confidence interval corresponding to the z-score differences. The results revealed that only the correlation between VAS alertness rating and SOL was significantly higher for the experimental group than the control group (P < .05). The remainder of the correlations revealed no statistical differences between the 2 groups.

DISCUSSION

The present study revealed that a simple “calm-down” procedure conducted prior to subjective ratings of sleepiness could enhance the correlation between an individual’s subjective sleepiness and that individual’s SOL and performance on a vigilance task. The standard procedure increased the predictive value of the subjective ratings of sleepiness from a nonsignificant correlation to a moderately high correlation with objective measures of sleepiness. When comparing the correlations obtained with and without the standard procedure, two of the comparisons reached significance as regards difference.

Table 1—Correlations between subjective ratings of sleepiness states and sleep-onset latency and performance on continuous performance test

<table>
<thead>
<tr>
<th></th>
<th>SOL</th>
<th>RT</th>
<th>Hit</th>
<th>CE</th>
<th>Lapse</th>
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</thead>
<tbody>
<tr>
<td><strong>Experimental Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SSS</td>
<td>.578*</td>
<td>-.130</td>
<td>.123</td>
<td>.225</td>
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<tr>
<td>VAS-Sleepiness</td>
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<td>-.114</td>
<td>.171</td>
<td>.179</td>
<td></td>
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<tr>
<td>VAS-Alertness</td>
<td>.640*</td>
<td>-.077</td>
<td>.071</td>
<td>.194</td>
<td></td>
</tr>
<tr>
<td><strong>Control Group</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSS</td>
<td>-.353</td>
<td>-.397</td>
<td>.313</td>
<td>.383</td>
<td></td>
</tr>
<tr>
<td>VAS-Sleepiness</td>
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<td>-.462</td>
<td>-.046</td>
<td>.192</td>
<td></td>
</tr>
<tr>
<td>VAS-Alertness</td>
<td>.049</td>
<td>.273</td>
<td>-.093</td>
<td>.430</td>
<td></td>
</tr>
</tbody>
</table>

*P < .05
SOL refers to sleep-onset latency; RT, reaction time; Hit, hit rate; CE, commission errors; Lapse, number of lapses; SSS, Stanford Sleepiness Scale; VAS, visual-analog scale.
One possible explanation for our finding that the experimental group’s ratings of subjective sleepiness corresponded more satisfactorily to SOL and cognitive attentiveness is that sitting quietly for 1 minute with eyes closed reduces situational factors that produce activation and therefore unmasks sleepiness and sleep tendency. By reducing activation due to motivation and sensory and motor stimulation, the experience of sleepiness is more in accord with behavioral and physiologic indexes of sleepiness.

From a different vantage point, the current results may be understood as being due to reducing the method variance between our sleepiness measures. Testing theory has long held that different procedures used to measure a construct will produce different results in part due to differ-
ences in the methods themselves. This principle was supported by the results of the present study, which demonstrated that when the procedure prior to ratings of subjective sleepiness was standardized so that it resembled the procedure prior to a nap, subjective sleepiness more closely reflected the physiologic tendency to fall asleep. The standard instructions to the experimental group—sit quietly for 1 minute with eyes closed—is similar to the procedure prior to the nap. We speculate that if the procedures prior to rating subjective sleepiness were even more similar to the prenap procedure, for example, lying down in the dark with eyes closed, the correspondence between these two measures would be even stronger. We decided that subjects would sit up rather than lie down so that this standard procedure could be widely applicable in other settings when a bedroom is not available. If the investigator or clinician is interested in the subjective experience of sleepiness that is less related to momentary activating factors and more related to behavioral and physiologic sleepiness, we suggest that the current procedures become a standard.

This study was conducted in individuals with mild restriction of sleep the night before the testing. Future studies will be needed to determine if the standard procedures for subjective rating of sleepiness we recommend improve predictions of objective measures of sleepiness in more sleep-deprived (eg, total sleep-deprived), non–sleep-deprived, and sleep-disordered individuals. In addition, the procedure may be modified for different conditions. For example, eyes being held closed for a period of 1 minute may be too long for totally sleep-deprived individuals because they may actually fall asleep during this procedure. On the other hand, 1 minute may not be sufficiently long subsequent to active physical activity. Also, it has been shown that subjective rating of sleepiness following the completion of a performance task yields better predictive value of cognitive performance than was the case if the rating process was completed prior to the performance task. The performance task itself might serve as a standard procedure to minimize the transient activation. Therefore, the necessity for the standard procedure prior to subjective rating of sleepiness may also depend upon the activity conducted immediately prior to the rating process.

REFERENCES
