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Sleepiness: Clinical Correlates, Association with Performance, and Effects of Performance Feedback

Spencer Nielson
Virginia Commonwealth University

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Spencer A. Nielson

Committee Chair: Joseph M. Dzierzewski, Ph.D.

Committee Members: Natalie Dautovich, Ph.D., Tushar Thakre, M.D., Ph.D.

Virginia Commonwealth University

Richmond, Virginia

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Abstract

Background: Daytime **s**leepiness is a common and debilitating phenomenon. Sleepiness is associated with increased symptoms of insomnia, depression, anxiety, and fatigue. Daytime sleepiness is commonly associated with cognitive performance, including performance on the Psychomotor Vigilance Test (PVT). The PVT includes performance feedback, and that feedback may influence an individual's report of their sleepiness. Whether the feedback on the PVT influences an individual's self-reported sleepiness is unknown. This study sought to investigate how sleepiness was associated with clinical symptoms and performance, whether there are sex differences in sleepiness, and whether manipulating feedback on the PVT influenced an individual's self-reported sleepiness.

Methods: Participants were 115 adults (*M*age = 20.8 years), mostly female (59%), and who had completed at least some college (75%) recruited from Brigham Young University and the surrounding community. Participants completed various questionnaires about sleep and mood before and after completing a 10-minute PVT. Before the PVT, participants were randomly assigned to one of four feedback conditions: (1) *PVT with reaction time shown*, (2) *PVT without reaction time shown*, (3) *PVT with 2 category descriptive feedback,* and (4) *PVT with 8 category descriptive feedback*. Sessions with participants were conducted over Zoom due to the COVID-19 pandemic. Pearson's correlations were conducted to investigate the associations of sleepiness, t-tests were conducted to investigate sex differences in sleepiness, linear regressions were used to investigate whether sleepiness predicted PVT performance and whether PVT performance predicted sleepiness after the PVT, and an Analysis of Covariance (ANCOVA) was conducted to investigate whether the four feedback conditions influenced an individual's self-reported sleepiness.

Results: Self-reported sleepiness was significantly correlated with symptoms of insomnia, depression, anxiety, and fatigue. Two t-tests were conducted to investigate sex differences in self-reported sleepiness assessed before the PVT and after the PVT. Women reported significantly higher sleepiness than men both before and after the PVT ($t(113) = 2.824$, $p = .006$; $t(113) = 2.846$, $p = 005$). None of the associations between sleepiness and clinical symptoms significantly differed between men and women. Self-reported sleepiness was not significantly correlated with PVT performance. Sleepiness did not predict PVT performance while PVT performance was partially moderated by group in predicting sleepiness after the PVT. Sleepiness after the PVT was not significantly different between groups when accounting for sleepiness before the PVT ($F\ (3,110) = 0.691$, $p = .560$).

Conclusion: Self-reported sleepiness was observed to be positively associated with various symptoms of clinical disorders including insomnia, depression, fatigue, and anxiety in line with previous findings. Women reported significantly higher sleepiness than men both before and after the PVT but the associations between sleepiness and the other clinical disorders were not significantly different between women and men, which may suggest differences in how women and men respond to sleepiness and report their difficulties with sleepiness. Surprisingly, no association between self-reported sleepiness and performance on the PVT was demonstrated in this study. Experimentally manipulating performance feedback on the PVT was not shown to influence sleepiness ratings reported after the PVT, which may suggest that manipulating performance feedback does not impact an individual’s self-reported sleepiness. Further research into how performance and sleepiness are associated and whether feedback, or the absence thereof, impacts self-reported sleepiness is needed. Such research could elucidate what

influences an individual's recognition and report of their sleepiness, which may have implications for sleep disorders and promoting sleep health among the population.

Keywords: Sleepiness, Psychomotor Vigilance, Insomnia

Statement of Problem: Daytime sleepiness is a common and debilitating phenomenon. Sleepiness is associated with increased symptoms of insomnia, depression, anxiety, and fatigue. Daytime sleepiness is commonly associated with tests of cognitive performance, such as the Psychomotor Vigilance Test (PVT), which includes feedback about performance. Whether the feedback on the PVT influences an individual's self-reported sleepiness is unknown. This study sought to investigate how sleepiness was associated with clinical symptoms and performance, whether there are sex differences in sleepiness, and whether manipulating feedback on the PVT influenced an individual’s self-reported sleepiness.

Introduction

Importance of sleepiness

Daytime sleepiness has been noted to be “one of the greatest challenges facing modern society” (Ohayon et al., 2012). It has been estimated that 27.8% of people suffer from excessive daytime sleepiness. The consequences of daytime sleepiness can be wide-ranged and varied. Daytime sleepiness is associated with impaired work performance, higher mortality, poorer mental and physical health, and increased motor vehicle accidents (Dean et al., 2010; Melamed & Oksenberg, 2002; Philip et al., 2010). Indeed, 60% of individuals reported feeling drowsy at the wheel and it has been estimated that 21% of accidents in which a person was killed involved a drowsy driver (Watson et al., 2015). Despite its enervating impact on individuals and society, daytime sleepiness remains a poorly understood problem.

Measurement and Definition of Sleepiness

One essential component to understanding daytime sleepiness is to understand what is meant when the term “daytime sleepiness” is used. Importantly, it has been recognized that there is no consensus definition of sleepiness, as most definitions of sleepiness have been argued to be operational definitions (Shahid et al., 2010; Shen et al., 2006). Most often daytime sleepiness has been operationally defined as “an individual’s readiness to fall asleep” (Carskadon & Dement, 1987, p. 307), or in other words, as the drive to fall asleep. This drive to fall asleep is primarily viewed as an individual’s propensity to fall asleep in a given moment, thereby reflecting the operational nature of this definition (Carskadon & Dement, 1987). Importantly, this definition of sleepiness conceptualizes sleepiness as a reflection of a biological drive or need for sleep, akin to hunger reflecting a physiological desire for food (Cluydts et al., 2002). This conceptualization of sleepiness is reflected in the 2-process model of sleep (Borbély, 1982). The 2-process model of sleep proposes that two homeostatic processes, the S and C processes, underlie sleep-wake states.

The S process is a process of sleep pressure that builds throughout wakefulness and then is ameliorated with sleep. The C process reflects an individual's circadian rhythm, which helps to regulate the timing of process S so that wakefulness occurs during the day and sleep occurs during the night (Borbély et al., 2016). Within this conceptualization, sleepiness would primarily be a function of process S, such that as process S builds sleepiness would increase, eventually reaching a point wherein an individual is compelled to fall asleep because of the intense sleep pressure. Process C would also interact with process S such that sleepiness would be less likely to occur during the day due to the arousing effects of the circadian rhythm. Moreover, within the 2-process model sleep pressure is alleviated through sleep and, by extension, sleepiness is alleviated as well. Importantly, this model fails to conceptualize sleepiness as more than a certain propensity to fall asleep at a given moment and fails to explain why individuals who feel sleepy would struggle to fall asleep (e.g., individuals with insomnia), why individuals who sleep for long periods of time would still feel sleepy (e.g., individuals with hypersomnolence), and why individuals who experience good sleep quality and duration would still feel sleepy upon waking up (e.g., sleep inertia).

Many forms of measurement have been proposed to measure sleepiness including pupillometry (Lowenstein et al., 1963), performance testing (Van Dongen et al., 2003), the Multiple Sleep Latency Test, which measures how quickly an individual falls asleep under soporific conditions (Carskadon & Dement, 1987), the Maintenance of Wakefulness Test (MWT), which measures how long an individual is able to stay awake in soporific conditions (Mitler et al., 1982), and self-report measures including the Epworth Sleepiness Scale (ESS; (Johns, 1991), which asks the individual to rate the likelihood of falling asleep in various hypothetical situations, and the Stanford Sleepiness Scale and the Karolinska Sleepiness Scale

(SSS and KSS; (Akerstedt & Gillberg, 1990), both of which ask the individual to rate their feeling of sleepiness within the current situation. However, even though these measures of sleepiness are all theoretically able to measure an individual's sleep propensity, it has often been observed that the association between so-called objective (MSLT, MWT) and subjective (ESS, KSS, SSS) measures of sleepiness is weak or lacking altogether (Alapin et al., 2000; Cluydts et al., 2002; Seidel et al., 1984). Some have argued that the weak association between objective and subjective measurements of sleepiness demonstrates that sleepiness is not a phenomenon that is simply a reflection of a biological drive to fall asleep, rather it is a phenomenon that includes other dimensions such as arousal and is affected by various circumstances and contextual factors such as performance, lighting, and position (Cluydts et al., 2002; Nielson et al., 2021; Shahid et al., 2010; Shen et al., 2006). Importantly, this demonstrates that further research into the nature of sleepiness is necessary in order to understand this ubiquitous phenomenon more fully.

An additional aspect of sleepiness that has been less noted in the literature is the phenomenological aspect of sleepiness. In currently accepted definitions of sleepiness, sleepiness is taken to be a direct reflection of a biological sleep need or of an interplay between a biological sleep need and an arousal drive (Cluydts et al., 2002). However, it is important to consider whether sleepiness would still be sleepiness if an individual's experience of their sleepiness was removed from consideration. Suppose, for example, that an individual was working diligently at their computer, feeling alert, focused, and driven with no immediate plans to take a break. Suddenly, the individual falls asleep without any prior indication. Did this individual experience sleepiness? Under a definition that only considers biological sleep need, the answer would be that this individual had to have experienced sleepiness of some sort as it would be seemingly impossible to sleep without experiencing some sort of sleepiness, at least at a biological level.

However, given that the individual did not have any prior indication of their sleep attack, it would seem that they did not experience sleepiness. Thus, this example illustrates that sleepiness involves not only an interplay between a biological sleep need and an arousal drive, as reflected in the 2-process model, but also involves an individual's experience of desiring sleep in any given moment. Taken together, it may be best to conceptualize sleepiness as a reflection of heightened sleep drive where an individual experiences a heightened sleep need biologically and phenomenologically such that the individual may experience feelings of lethargy, drowsiness, desire to fall asleep, or general slowness. This conceptualization makes sleepiness distinct from a simple biological drive to fall asleep because it includes the individual's experience within the phenomenon and involves more than just a pure likelihood of falling asleep. Importantly, this transitions sleepiness from being a purely biological phenomenon to one that is both biological and phenomenological. Thus, because sleepiness is now being conceptualized as more than just a biological sleep propensity, it then becomes important to measure an individual's experience of sleepiness. Self-report is an indirect measure of an individual's experience of sleepiness as it requires an individual to introspect on their level of sleepiness at a given moment and reflects their self-awareness of the phenomenon (Akerstedt et al., 2014). Although many have argued that self-report is a flawed measurement that is prone to bias and falsification (Shen et al., 2006), self-report provides the only access to an individual's experience of their sleepiness through the use of interviews and questionnaires. Thus, investigating factors that influence an individual's self-reported sleepiness gives access to an individual's experience of their sleepiness that is not possible through physiological or behavioral measurements.

Factors associated with self-reported sleepiness

While in many studies self-reported sleepiness is thought to be a measure of an individual's awareness of their biological sleepiness, contextual factors may influence an individual's self-reported sleepiness ratings. In general, the self-report unit of analysis has been noted to be influenced by various contextual factors such as affect, cognitions, and situational factors (Pavot, 1993). In regard to contextual factors affecting self-reported sleepiness specifically, an individual's position, location, and interest in the activity have been shown to directly influence an individual's rating of their sleepiness (Sharafkhaneh & Hirshkowitz, 2003). Åkerstedt and colleagues (2008) asked participants to rate their sleepiness in three different contexts: (1) after 30 minutes of resting, (2) after performing a 6-minute reaction time test, and (3) after doing 30 minutes of normal activities. They found that these contexts significantly impacted participants' self-reported sleepiness, with the reaction time test leading to the greatest amount of increase in sleepiness and the normal activities leading to the least amount of increase in sleepiness (Åkerstedt et al., 2008). Some have argued that these contextual influences, and other inconsistencies in self-report, show that self-report data of sleepiness is inaccurate, biased, or flawed (Shen et al., 2006). However, self-report is one of the most common ways of measuring sleepiness and is commonly used in other areas of sleep (Ohayon et al., 2012). For example, a diagnosis for insomnia disorder does not require objective data about an individual's sleep and instead relies on self-report. Moreover, self-report is the only way to have direct access to an individual's experience of sleepiness and investigating contextual factors may lead to a greater understanding of how an individual experiences their levels of sleepiness and how they respond to that experience (e.g., resting when sleepy vs. continuing with task at hand). Thus, further research is needed to examine how contextual factors influence an individual's self-reported sleepiness and whether contextual factors can be manipulated to influence an individual's self-reported sleepiness rating.

Clinical Correlates of Sleepiness

Sleepiness and anxiety and depression

An important way of increasing understanding about sleepiness is to investigate its clinical correlates. One of the most consistent clinical correlates of daytime sleepiness is depression. Indeed, excessive daytime sleepiness (EDS) is prevalent in up to 57% of individuals with major depression (Chellappa & Araújo, 2006; Hein et al., 2019). A significant association between daytime sleepiness and depressive symptoms has been observed in multiple samples such as older women, Hispanic/latinx, individuals with psychiatric conditions, adolescents, and pregnant women (Aukia et al., 2020; Chellappa & Araújo, 2006; Maglione et al., 2012; Nuyen et al., 2016; Shen et al., 2011; Yang et al., 2019). Moreover, daytime sleepiness has been observed to be a better predictor of major depression when compared to other sleep disturbances, and as such, has been recommended as a marker of major depressive disorder (Ando & Kawakami, 2012).

Anxiety shares significant comorbidity with depression, and as such, it might be expected that daytime sleepiness would be significantly associated with anxiety symptoms. Daytime sleepiness and anxiety have been observed to have a significant association, with several studies demonstrating that anxiety symptoms were a significant predictor of EDS (Chen et al., 2019; Hasler et al., 2005; Pereira-Morales et al., 2018; Theorell-Haglöw et al., 2015). However, many of these studies also found that depression was a significant predictor of EDS, demonstrating that there may have been comorbidity between depression and anxiety within these samples. Moreover, one study observed that daytime sleepiness was associated with diagnoses of depressive disorders but not with anxiety disorders (Hayley et al., 2013). Thus, while the association between daytime sleepiness and depression has been well-established, more research is needed to investigate the association between daytime sleepiness and anxiety.

Sleepiness and fatigue

Fatigue is a phenomenon that is common in various psychiatric and psychological phenomena (Shen et al., 2006). Despite its prevalence, fatigue remains a poorly defined and understood phenomenon. Indeed, there is currently no accepted definition of fatigue nor is there a commonly accepted objective measurement of fatigue (Shahid et al., 2010). One definition of fatigue derived from qualitative interviews with multiple sclerosis patients stated that fatigue is a “reversible, motor, and cognitive impairment with reduced motivation and desire to rest, either appearing spontaneously or brought on by mental or physical activity, humidity, acute infection, and food ingestion. It is relieved by daytime sleep or rest without sleep.” (Mills & Young, 2008), p. 57). Importantly, it can be observed from this definition that fatigue and sleepiness share quite a bit of overlap in the minds of patients. Indeed, fatigue and sleepiness are commonly grouped together under the umbrella term “tired” by many clients, thereby showing that for many people these two concepts are almost identical (Shen et al., 2006). As such, distinguishing fatigue from sleepiness, and vice versa, has proven to be a difficult challenge in the field. Multiple studies have demonstrated that fatigue and sleepiness are distinct from one another because they are uniquely associated with other constructs (Matsangas & Shattuck, 2018; Merkelbach & Schulz, 2006). On the other hand, moderate to strong associations between fatigue and sleepiness have been observed and the overlap between these two constructs has been demonstrated as well (Åkerstedt et al., 2002; Alapin et al., 2000; Bailes et al., 2006). These mixed results demonstrate that further research is needed to investigate further how fatigue and sleepiness relate to each other and to other clinical phenomena.

Sleepiness and insomnia

Insomnia is a disorder that is characterized by difficulty falling asleep or staying asleep. Because of the lack of sleep that is characteristic of insomnia, one might expect that daytime sleepiness would be a common symptom in insomnia. Indeed, many studies have demonstrated an association between self-reported insomnia symptoms and daytime sleepiness within various populations including individuals with Parkinson's disease, adolescents, women, including pregnant women, nurses, and young adults (Aukia et al., 2020; Chan et al., 2020; Chen et al., 2019; Chung et al., 2013; Fava, 2004; Theorell-Haglöw et al., 2015). However, even though individuals with insomnia often complain of daytime sleepiness, many studies fail to find expected impairments in cognitive performance (Fortier-Brochu et al., 2012; Shekleton et al., 2010). Moreover, many studies have failed to find abnormal scores on the MSLT, the gold standard of sleepiness measurement, for individuals with insomnia (Liu et al., 2014). However, this may be due to the fact that even though individuals with insomnia report daytime sleepiness, the disorder is characterized by difficulty falling asleep, which directly impacts the operationalization of sleepiness reflected in the MSLT. There is growing evidence that individuals with insomnia maintain an intact sleep drive despite their difficulty falling asleep, thereby demonstrating a capacity to feel sleepiness (Kay et al., 2019; Stepanski et al., 2000). The hyperarousal model of insomnia may explain the lack of association between the difficulty falling asleep and the increased sleepiness an individual with insomnia reports. The hyperarousal model posits that individuals with insomnia experience a heightened state of arousal, especially around bedtime which prevents them from falling asleep. Importantly, it is unclear how an individual can experience both a heightened sense of arousal and excessive sleepiness as these phenomena may be mutually exclusive in important aspects. Thus, more research into the association between insomnia and sleepiness may elucidate how to help these individuals who struggle to fall asleep despite feeling sleepy.

Sleepiness and sex differences

An individual's demographic features might affect their daytime sleepiness as well (Gander et al., 2005). Indeed, several studies have demonstrated sex differences in daytime sleepiness within patients with epilepsy (Jo et al., 2020; Lee et al., 2019). Within older adults there have been mixed results with some studies demonstrating increased sleepiness in older men compared to women while other studies found no such difference (Broström et al., 2018; Sanford et al., 2006; Unruh et al., 2008). Within obstructive sleep apnea (OSA), there is a growing literature on sex differences. Many studies have observed increased sleepiness in men with OSA when compared to women with OSA (Baldwin et al., 2004; Eliasson et al., 2015; Wang et al., 2021; Yukawa et al., 2009). However, these results are not ubiquitous as some have found increased sleepiness in women with OSA, while others have found that this distinction may be due to differences in perceptions of symptoms as women reported greater fatigue rather than sleepiness (Eliasson et al., 2015; Larsson et al., 2003). Importantly, few studies have examined sex differences in non-clinical populations. Akerstedt and colleagues (2017) found sex differences in self-reported sleepiness in working individuals during the workday such that women reported significantly higher sleepiness than men. Moreover, these authors argued that future research about sex differences in sleepiness, especially in non-clinical populations, is needed and may elucidate underlying associations about sleepiness (Åkerstedt et al., 2017).

Performance and Sleepiness

It is widely known that performance deficits are associated with sleepiness (Lim & Dinges, 2008). One of the most widely recognized performance deficits associated with sleepiness is a deficit in attention. The Psychomotor Vigilance Test (PVT) is a simple reaction time test wherein a participant responds as quickly as possible to the stimuli through pressing a button and is particularly sensitive to increased sleepiness (Basner & Dinges, 2011; Van Dongen et al., 2003). Indeed, the association between sleepiness and deficits on the PVT is of such strength that some have suggested that the PVT could serve as a biomarker of sleepiness (Balkin, 2011). Various reaction time metrics derived from PVT performance have been demonstrated to be associated with increased sleepiness including mean reciprocal reaction time (Basner & Dinges, 2011), standard deviation of reaction time (Nielson, 2021), and lapses in reaction time (Van Dongen et al., 2003). Although the association between increased sleepiness and PVT performance deficits is widely acknowledged, the degree to which self-reported ratings, including self-reported sleepiness ratings, are associated with performance metrics and under what conditions these associations occur is still unknown.

Several studies have shown that level of performance on the PVT may be closely associated with self-reported ratings generally, and especially those of alertness and sleepiness. For example, Dorrian and colleagues (2003) found that when individuals rated the level of their performance after taking a PVT, ratings were closely associated with actual level of performance. Moreover, before taking a PVT, individuals' self-reported levels of alertness were closely associated with their predictions of their performance on the PVT, suggesting that an individual's expected performance was closely tied to their experience of alertness (Dorrian et al., 2003). Horne and Burley (2010) had participants self-report their sleepiness every two minutes while doing a PVT and found that self-reported sleepiness ratings were closely associated with levels of performance such that as reaction times got slower during the task, self-reported sleepiness ratings increased accordingly (Horne & Burley, 2010).

Performance Feedback and Sleepiness

The PVT includes an aspect of performance feedback by showing the individual their reaction time after every trial. Importantly, the PVT generally does not describe this feedback as being fast or slow and simply reports the number of milliseconds it took for the individual to respond. This trial-to-trial feedback may be a contextual factor that influences an individual's self-reported sleepiness (Nielson et al., 2021). For example, during sleep deprivation individuals were better able to monitor performance deficits on the PVT than on tasks that did not include performance feedback, and this monitoring of performance was associated with an individual's self-reported sleepiness, suggesting that performance feedback may be an important factor that individuals use to determine the impact of sleepiness on performance (Boardman et al., 2018). In a previous study where individuals rated their sleepiness directly before and after a PVT, it was reported that an individual's level of performance on the PVT was able to reliably predict changes in sleepiness ratings directly following the PVT (Nielson et al., 2021). Specifically, individuals with more variable PVT performance, but not worse overall PVT performance, demonstrated a decline in sleepiness ratings. Because individuals were likely able to detect variability in their performance due to performance feedback, the authors concluded that the performance feedback during the PVT may have been a contextual factor influencing participant self-reported sleepiness ratings. However, due to methodological limitations, it is still unknown whether and how performance feedback on the PVT influences an individual's sleepiness ratings. One way that performance feedback may influence an individual's sleepiness ratings may be explained by cognitive dissonance theory.

Cognitive Dissonance Theory introduction

Cognitive Dissonance Theory (CDT) has been termed the most important theory within social psychology, due to its importance in advancing a cognitive perspective and for its capacity to generate a multiplicity of research hypotheses (Aronson, 1992). Shortly after Festinger originally proposed his theory of cognitive dissonance, an explosion of research occurred as researchers investigated the wide range of hypotheses that could be generated from CDT (Aronson, 1992). While the popularity of CDT in the research field waned, it recently has started to resurge in importance within the field (Aronson, 1992; Joule & Touati Azdia, 2003). In short, CDT posits that an individual will experience dissonance, or discomfort, when their cognitions, attitudes, or values do not match their behavior (Festinger, 1957). Thus, the primary hypothesis of CDT is that an individual will change their cognitions, attitudes, or values to align more closely with their performed behaviors as a result of the dissonance that the individual experiences (Festinger, 1957). Less commonly, an individual may also change their behavior to align with their cognitions, attitudes, or values more closely (Aronson, 1992; Stalder & Baron, 1998). Once a change has been made, the individual will presumably stop experiencing the uncomfortable feeling of dissonance which will further motivate the individual to avoid dissonance, or stop it when it happens, in the future.

While CDT may be applicable to any set of two cognitions, Aronson (1992) argued that dissonance occurs most potently when an individual has a cognition about their "self" and then performs a behavior which violates that self-concept. Aronson (1992) further elaborated that most individuals strive for three things: "(1) to preserve a consistent, stable predictable sense of self, (2) to preserve a competent sense of self, and (3) to preserve a morally good sense of self". Importantly, it may be possible that an individual experiences dissonance when just one of these cognitions about the self is challenged, when a combination of some of them are challenged, or when all three of these cognitions are challenged. Moreover, an individual may reduce this dissonance by changing their cognitions about themselves or by changing their behavior. For example, suppose there exists a student who has performed well on every test they have encountered throughout their academic career. Suppose the student has a psychology exam that they expect to perform well on but, upon taking the exam and receiving feedback about their scores, they find that they failed the exam. The student will then most likely experience significant dissonance over whether they are as competent as they thought they were. In response to this dissonance, CDT posits that the student will most likely change their self-concept. Perhaps the student will start to think that they are not as competent as they thought or that they must not be as good at psychology as they thought. Alternatively, the student may reduce this dissonance by changing their subsequent behavior. For example, perhaps they will study intently for the next exam and obtain an “A” as a result. Lastly, the student might also seek justification for their behavior that is either external or internal without actually changing their cognitions or behavior (Joule & Touati Azdia, 2003). For example, the individual might reduce their dissonance by rationalizing that their performance was a result of their poor sleep the night before and subsequent sleepiness they experienced during the exam. Thus, within CDT, an individual may reduce dissonance through changing their self-concept, changing their behavior, or finding a way to justify their behavior through both external and internal means.

Cognitive dissonance and self-report ratings

One of the main hypotheses of CDT is that an individual will change their cognitions in order to align more closely with their behavior (Aronson & Mills, 1959). One popular research paradigm used to investigate this phenomenon is to have participants do a rating of their self or of another person, induce dissonance by performing some tasks, and then ask the participant to do another rating. One of the first studies to use this paradigm asked participants to rate another individual, whom they watched on a video screen, on a series of adjectives, induce dissonance by having the participants read a negative evaluation about the other individual before they were expected to either meet the other individual or not, and then had the participants rate the individual again (Davis & Jones, 1960). The researchers observed that the participants changed their rating to be less favorable of the other individual, which was consistent with the hypothesis that participants would change their ratings of another individual to reduce dissonance (Davis & Jones, 1960). Importantly, the researchers argued that the change in ratings reflected a change in the participants' cognitions about the other individual (Davis & Jones, 1960). Subsequent studies also demonstrated that an individual will not only change their cognitions in relation to others but may also change their cognitions about themselves as well. For example, one study demonstrated that teachers who indicated that administrators should receive evaluations then changed their attitudes about their own evaluations (Gehlbach et al., 2018). Other studies have demonstrated that individuals will change their self-concept when their self-concept is challenged (Aronson, 1992). Thus, cognitive dissonance theory predicts that an individual whose self-concept is challenged, potentially through a discrepancy between their performance and their expectations of performance, would potentially then change their self-concept.

Another important implication of CDT is that dissonance resulting from unexpected performance may induce an individual to not only change their expectations about their performance but may also induce them to change their performance itself. For example, one of the first studies conducted to investigate this phenomenon had participants perform a task with immediate feedback to provide baseline expectations, then had them perform the task some more and provided feedback about their performance that was either dissonant or congruent with previous feedback, then had the individuals perform the task once more, and then had the participants repeat this part of the task with the ability to change their answers under the pretenses that the experimenter had made an error and the task needed to be repeated (Aronson & Mills, 1959). Thus, participants had the ability to change their actual behavior to reduce dissonance in order to make their behavior more in accordance with their expectations of their performance. The researchers observed that participants changed their responses the most both when they had high expectations and low performance and when they had low expectations and high performance (Aronson & Mills, 1959). This result is consistent with the hypothesis that an individual who is experiencing dissonance in either direction would then change their performance.

Importantly, this study also demonstrates that feedback about an individual's performance can induce dissonance. Moreover, several studies have demonstrated that performance feedback can influence an individual's ratings of their expectations for their performance (Cottrell, 1967; Hammen & Krantz, 1976; Wallace, 1966). Indeed, one study demonstrated that individuals who received feedback that disagreed with their expectations of their performance either lowered their expectations or increased their expectations, depending on the feedback, to minimize the discrepancy between their actual performance and their cognitive expectations (Fishbein et al., 1963). Importantly, this also demonstrates that individuals who are undergoing cognitive tests most likely have expectations for their performance level which may or may not be met during testing. Moreover, it has also been demonstrated that performance feedback can influence how an individual expects to feel in the future, such that individuals who performed more poorly expected to feel less happy in the future, and that this expectation is often unmet as both groups of individuals demonstrated similar happiness levels (Sjåstad et al., 2020).

This demonstrates that one way individuals may reduce dissonance is to lower their expectations for the future and rate their subjective state differently depending on the dissonance. Indeed, changes in self-report ratings following dissonance induced from performance feedback has been observed (Cisek, 2006; Cottrell, 1967; Hammen & Krantz, 1976). Although none of these studies investigated how cognitive dissonance due to performance feedback influences an individual's self-reported sleepiness, it may be that individuals change their self-reported sleepiness ratings due to some dissonance felt as a result of a perceived discrepancy between their expectations for their level of performance and their actual performance. Within this conceptualization sleepiness could be considered as a justification for an individual's perceived incompetence in the task. For example, an individual who is performing more variably on the PVT might interpret their performance as being particularly poor and this may induce feelings of dissonance. As such, the individual may justify their performance by changing their previous cognition about the state of their sleepiness so as to protect their belief about their competence. Said more simply, the individual may justify their performance as being a result of sleepiness (which would involve changing a cognition about their state of sleepiness) rather than changing a belief about their competence thereby reducing the dissonance between their belief about their competence and their poor performance without having to change their belief or their performance.

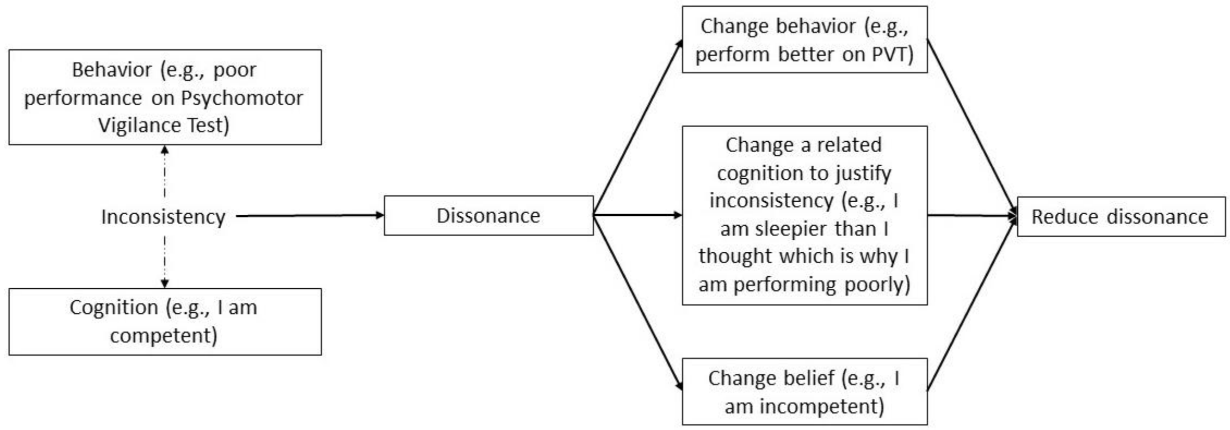

Figure 1. Diagram showing how Cognitive Dissonance Theory may lead to an individual changing their self-reported sleepiness. Adapted from Gaya, 2017.

Aims and Hypotheses:

The current study had three aims: (1) investigate the clinical correlates of sleepiness, (2) investigate the relationship between PVT performance and sleepiness, and (3) determine whether sleepiness can be manipulated through performance feedback. Self-reported sleepiness was measured before and after PVT. Performance feedback on the PVT was experimentally manipulated, with participants randomized to one of four possible feedback conditions: (1) PVT with reaction time shown after each trial, (2) PVT without reaction time shown, (3) PVT with 2 category descriptive feedback, and (4) PVT with 8 category descriptive feedback.

Aim 1: Investigate clinical correlates and sex differences of sleepiness

Hypothesis: Sleepiness will be associated with various clinical correlates including depression, insomnia, anxiety, and fatigue. Sleepiness will be significantly higher in males than females.

Aim 2: Investigate associations between sleepiness and performance

Hypothesis: Self-reported sleepiness measured before and after the PVT will be associated with performance metrics. Moreover, self-reported sleepiness will be able to predict performance metrics while controlling for clinical correlates and performance metrics will be able to predict self-reported sleepiness assessed after the PVT while controlling for clinical correlates.

Aim 3: Investigate whether sleepiness can be manipulated through performance feedback

Hypothesis: Changes in self-reported sleepiness will be influenced by the manipulation of performance feedback. More specifically, it is hypothesized that individuals who receive feedback will increase their sleepiness significantly more than individuals who did not receive feedback. Moreover, it is hypothesized that individuals who received descriptive feedback that is more variable (i.e., has more descriptors) will increase their sleepiness more than individuals who did not receive descriptive feedback or more variable descriptive feedback.

Methods:

Participants:

The total sample includes 129 participants. 9 participants were excluded for indicating an ADD/ADHD diagnosis after signing the informed consent document or for not completing the PVT. Thus, the sample that will be used for analyses includes 120 participants. An a priori power analysis demonstrated that 30 participants per group would have enough power to detect medium to large effect sizes. Participants are mostly female (59.2%), white (86.7%), emerging adults less than 26 years old (M = 20.86, SD = 2.16), with some level of college education (75.8%). Participants reported sub-threshold insomnia symptoms (M = 8.52, SD = 4.34), mild levels of depressive symptoms (M = 5.87, SD = 3.92), moderate levels of anxiety (M = 35.91, SD = 9.20), mild levels of fatigue (*M* = 3.63, *SD* = 1.15), and moderate levels of sleep valuation (*M* = 1996.33, *SD* = 449.08).

Protocol:

The current study was conducted online through Zoom appointments that lasted approximately one hour. Virtual appointments were utilized due to safety protocols during the COVID-19 pandemic. The study was advertised through flyers posted on BYU campus, emails sent out by BYU's psychology department and by various student organizations, and through the SONA system. Participants first indicated their desire to join the study by emailing the BYU Sleep lab or by signing up for a study appointment directly through the SONA website. A research assistant would send the participant a Zoom link the day before the appointment and then conduct the study protocol virtually via Zoom. All participants were scheduled to have appointments before 12pm to limit heterogeneity in sleepiness. When the participant joined the Zoom call, the research assistant would send the participant a link to the baseline assessment which was administered through Qualtrics, a survey software platform. When the participant opened the link, the research assistant would review the informed consent document. After the research assistant ensured that the participant had no questions and understood the study, the participant gave their informed consent by selecting the choice that indicated that they consented to participate in this study. After participants gave their informed consent, they completed the rest of the baseline assessment which included the following: a questionnaire to obtain demographic information (age, biological sex, race, marital status, education level, employment status, caffeine consumption, etc.), the Post Sleep Questionnaire (PSQ), which is a general sleep diary that asked about their sleep the previous night and their usual sleep along with other questions about sleep quality, alertness, and mood, the State-Trait Anxiety Inventory-State form

(STAI-State), the Patient Health Questionnaire-9 (PHQ-9), the Fatigue Severity Scale (FSS), the Insomnia Severity Index (ISI), the Sleep Valuation Questionnaire (SVQ), and the Karolinska Sleepiness Scale (KSS). The research assistant muted their microphone and turned off the video while the participant completed the Baseline assessment to reduce potential distractions.

After the participant finished the baseline assessment, the research assistant would ask the participant to wait a few moments to ensure that the questionnaire was received. Then the research assistant would check the questionnaire to make sure it was received and would also check whether the participant had indicated that they had previously received an ADHD diagnosis (exclusion criteria) or whether they had indicated active suicidality through the last question on the PHQ-9 (i.e., have you had thoughts of hurting yourself). If the participant indicated active suicidality, the research assistant would ask the participant whether they were experiencing those thoughts in the current moment. If no, the participant was allowed to progress through the rest of the study and the research assistant would email the participant resources (e.g., number for suicide hotline, website for BYU counseling services) at the end of the study. If yes, then the research assistant would call the lab director and Primary Investigator, a licensed clinical psychologist, who would assess the risk of the participant and whether they needed immediate medical attention.

After the participant completed the baseline assessment, they were emailed a link to a folder where they would download the psychomotor vigilance task (PVT) which was administered through E-Prime Go. After the participant downloaded the task to their computer, they opened the task and filled out a one-item sleepiness scale that asked them to rate their sleepiness on a scale from 1-10. After they filled out the sleepiness scale, they had a brief practice trial, which included 5 stimuli and lasted about one minute, and then they completed the

10-minute PVT. During the PVT the research assistant muted their microphone and turned off their video, again to reduce potential distractions.

After the PVT, participants filled out the one-item sleepiness question again. After that, they emailed the PVT data to the Sleep Lab email. Once the research assistant saw that the participant had emailed the data, they sent the participant the link to the Posttest assessment. The Posttest assessment included questionnaires that asked participants about their sleepiness (KSS), general sleep features and sleep quality (PSQ), sleep valuation (SVQ), fatigue (FSS), anxiety (STAI-State), and how they felt they did on the PVT. During the Posttest assessment the research assistant again muted their microphone and turned off their video to reduce potential distractions. After the participants finished the Posttest assessment, the research assistant read a brief description of the study to debrief the participant, answered any final questions, and then compensated the participant with either 6 SONA credits or a $10 Amazon gift card.

Experimental Conditions and Randomization

The PVT is a simple reaction time task where participants are asked to pay attention to a blank screen and press the mouse button as quickly as possible when they see a red dot appear on the screen. During a normal PVT, once a participant clicks the mouse they will briefly see their reaction time appear on the screen. However, for this experiment participants were randomly assigned to one of four conditions, relating to the type of feedback they received. This randomization was done by using Microsoft Excel's random number generator that generated a random number between 1-4 for each participant. Condition 1 (*PVT with reaction time shown*) received feedback as usual, where they experienced a red dot as a stimulus and, upon clicking the mouse in response to the stimulus, saw their reaction time appear on the screen in milliseconds. Condition 2 (*PVT without reaction time shown*) did not receive any feedback upon clicking the mouse button in response to the red dot. Condition 3 (*PVT with 2 categories descriptive feedback*) received two categories of descriptive feedback in words instead of seeing their reaction time in milliseconds. In this condition, participants received the feedback of "average" if they reacted quicker than 500ms (which is where many responses lie) and they received the feedback of "slow" if they reacted slower than 500ms. Condition 4 (*PVT with 8 categories descriptive feedback*) received 8 categories of descriptive feedback in words instead of seeing their reaction time in milliseconds. In this condition, participants received certain descriptive feedback depending on their reaction time. If the participant’s reaction time was faster than 200ms they received the feedback of "Exceptionally fast", between 200-250ms they received "Very Fast", between 250-300ms they received "Fast", between 300-350ms they received "Somewhat fast", between 350-400ms they received "Somewhat slow", between 400-450 they received "Slow", between 450-500ms they received "Very Slow", and any reaction time that was slower than 500ms received feedback of "Exceptionally slow."

Inclusion/Exclusion Criteria:

Inclusion Criteria:

1. At least 18 years of age

Exclusion Criteria:

1. ADHD diagnosis or significant ADHD symptoms. ADHD is a disorder of attention and, as such, has a significant impact on a test of sustained attention such as the PVT (Hervey, 2006).
2. Active suicidal ideation.

Measures:

Demographic Questionnaire - This questionnaire asks the participants to provide the following demographic information: age, biological sex, race, previous diagnosis of ADHD or ADD, education level, employment status, marital status, how many people live with them, if they are the head of the household, how many dependents they have, age of dependents (if applicable), general health estimate, general mental health estimate, caffeine consumption, alcohol consumption, cigarette consumption, and medications currently being taken.

Mental Health Measures:

The State-Trait Anxiety Inventory-State (STAI-State; (Spielberger et al., 1983)**)** – The STAI-State scale is a 20-item measure used to assess state (i.e., in the moment) anxiety symptoms. The STAI-State asks participants to indicate how a variety of descriptive statements, such as “I feel calm”, best describe how they are feeling right now in the moment. Answer choices are on a 4-point scale and range from “almost never” to “almost always”. This scale was administered before and after the PVT. Cronbach’s alpha for this scale in the current sample was 0.904.

Patient Health Questionnaire-9 (PHQ-9; (Kroenke et al., 2001) – The PHQ-9 is a 9-item measure of depressive symptomology. This scale was administered before the PVT. This scale asks participants to indicate how often over the past two weeks they have been bothered by the following problems and includes various depressive symptomatology such as “little interest or pleasure in doing things”. Answer choices are on a 4-point range, with 0 being “not at all” and 3 being “nearly every day”. Cronbach’s alpha for this scale in the current sample was 0.754.

Fatigue Severity Scale (FSS;(Krupp et al., 1989) – The FSS is a 9-item measure of fatigue severity. The scale’s directions were slightly altered to ask the participant to reflect on their fatigue in the past five minutes to make this scale more sensitive to temporal changes in fatigue within the time of the experiment. Example items from this scale include “fatigue interferes with my physical functioning” and “fatigue interferes with my work, family, or social life” and answer choices range from 1 to 7 with 1 being “strongly disagree with the statement” and 7 being “strongly agree with the statement”. This scale was administered before and after the PVT. Cronbach’s alpha for this scale in the current sample was 0.855.

Sleep Measures:

Insomnia Severity Index (ISI; (Bastien et al., 2001) – The ISI is a 7-item measure of insomnia symptoms over the past two weeks. This scale asks participants to reflect on their sleep problems they have experienced over the past two weeks and includes items such as “please rate the severity of your difficulty falling asleep” and “to what extent do you consider your sleep problem to interfere with your daily functioning”. Answers all range from 0-4, although the descriptors for the items change as appropriate. This scale was administered before the PVT. Cronbach’s alpha for this scale in the current sample was 0.777.

Sleep Valuation Item Bank (SVQ; Nielson et al., 2021) - This is an item-bank that was developed by Daniel Kay, Ph.D. to measure how much an individual values their sleep. Items 17, 30, and 32 were removed for poor face validity as it was determined that these items were measuring depression rather than sleep valuation (Nielson, 2021). Items 3, 14, 16, 21, 22, 29, 31, 33, 34, and 42 were reverse scored (Nielson, 2021). This scale asks participants to indicate their agreement on a scale from 0 (strongly disagree) to 100 (strongly agree) with statements about how much they value sleep such as “I avoid doing things that disrupt my sleep” or “I plan my day around my sleep”. This item bank was administered before and after the PVT. Cronbach’s alpha for this scale, excluding the removed items and including the reverse scored items, in the current sample was 0.876.

Karolinska Sleepiness Scale (KSS; Akerstedt & Gillberg, 1990) – The KSS is a one-item scale used to assess sleepiness by having the individual report how sleepy they are feeling in that moment on a scale from 1-9 with 1 being "extremely alert" and 9 being "extremely sleepy, can't keep awake". There are descriptors for each response option. This scale was administered before and after the PVT. Cronbach's alpha was not calculated for this scale because it only has one item.

Self-report sleepiness scale included in the PVT (PVT-Sleepiness) - As part of the PVT there is a self-report sleepiness scale that asks how sleepy participants are feeling in the moment on a scale of 1-10, thereby making it a proxy visual analog scale. The only descriptors on this scale were at 1 (not at all sleepy) and at 10 (very sleepy). This question was administered before and after the PVT as part of the standard PVT administration. Cronbach's alpha was not calculated for this scale because it only has one item.

Post Sleep Questionnaire (PSQ; Kay et al., 2019)– The PSQ is a morning sleep diary that asks about sleep features of the previous night as compared to a usual night's sleep. The PSQ also measures feelings of alertness, anxiety, depression, and the perceived quality of one's sleep on a visual analog scale from 1-10. Because this questionnaire is not a homogeneous questionnaire (i.e., there is a sleep diary section and a daily functioning section) Cronbach's alpha was not calculated.

Analysis Plan:

Aim 1: Investigate clinical correlates and sex differences of sleepiness

To investigate and predict the clinical correlates of sleepiness, correlational analyses will first be conducted to determine any associations between sleepiness (KSS and PVT-Sleepiness) and insomnia symptoms (ISI), anxiety symptoms (STAI-State), depression symptoms (PHQ-9), and fatigue symptoms (FSS). To investigate sex differences of sleepiness, a t-test will be conducted to determine if there are significant differences between men and women in sleepiness. Moreover, Fisher's r to z transformation will be conducted to compare whether any of the correlations are significantly stronger in men or women.

Aim 2: Investigate associations between sleepiness and performance

To investigate associations between sleepiness and performance, correlational analyses will be conducted to investigate specific associations between aspects of performance (e.g., mean reciprocal reaction time, standard deviation of reciprocal reaction time) and self-reported sleepiness. We will first focus on sleepiness rating obtained before the PVT performance. If associations are found, a regression analysis will be conducted to determine if self-reported sleepiness is able to predict performance after controlling for clinical correlates identified in Aim 1. To further investigate these associations, we will conduct a similar set of analyses focusing on sleepiness rating obtained after completion of the PVT performance task. Again, the analytic plan will be to first examine basic associations via Pearson correlations, followed by linear regressions (as appropriate) while controlling for clinical correlates in Aim 1.

Aim 3: Investigate whether sleepiness can be manipulated through performance feedback

To investigate whether sleepiness can be manipulated through performance feedback, an ANCOVA (analysis of covariance) will be conducted with post PVT sleepiness as the DV, condition (i.e., group assignment) as the IV, and pre-PVT sleepiness as the covariate. If condition is significant within the statistical model, then we can conclude that the feedback conditions significantly impacted an individual's self-reported sleepiness rating.

Results

Participant characteristics are reported in Table 1. Five participants' data were excluded from all analyses for univariate outliers, making the analysis sample 115 individuals. In brief, participants were mostly young adults (*M*age = 20.8 years), female (59%), who had completed at least some college (75%). The four conditions did not differ in any demographic variable or in any clinical variable. However, the four conditions were significantly different in the mean reciprocal reaction time and the standard deviation of the reciprocal reaction time (F (3,111) = 4.261, p = .007; F(3,111) = 3.318, p = .023, respectively).

Table 1. Demographic characteristics by condition and of the total sample

Characteristic (*M(SD)* or *n(%)*)	Total Sample (*N* = 115)	Condition 1 (*n* = 32)	Condition 2 (*n* = 26)	Condition 3 (*n* = 29)	Condition 4 (*n* = 28)	χ^2, *t*, *F*	*df*	*p*
Age	20.8 (1.9)	21 (2)	21 (2)	20.5 (1.6)	20.8 (1.9)	0.381	3,111	0.767
Sex, female	68 (59%)	19 (59%)	19 (73%)	17 (59%)	13 (46%)	3.97	-	0.265
Sex, male	47 (41%)	13 (41%)	7 (27%)	12 (41%)	15 (54%)			
Race, white	100 (87%)	29 (91%)	22 (85%)	24 (83%)	25 (89%)	5.683	-	0.771
Race, Asian	2 (2%)	1 (3%)	0	1 (3%)	0			
Race, Hispanic/Latinx	6 (5%)	2 (6%)	1 (4%)	2 (7%)	1 (4%)			
Race, Mixed	7 (6%)	0	3 (11%)	2 (7%)	2 (7%)			
Graduated high school or equivalent	21 (18%)	4 (13%)	5 (19%)	7 (24%)	5 (18%)	19.812	-	0.179
Part college or trade school	87 (75%)	25 (78%)	17 (65%)	22 (76%)	23 (82%)			
Graduated 2-year college or trade school	3 (3%)	1 (3%)	2 (8%)	0	0			
Graduated 4-year college	1 (1%)	1 (3%)	0	0	0			
Part graduate or professional degree	3 (3%)	1 (3%)	2 (8%)	0	0			
KSS, Pre	4.65 (2)	5 (2)	4.28 (2)	4.96 (2)	4.15 (1.9)	1.482	3, 111	0.223
KSS, Post	5.14 (2)	5.69 (2)	4.76 (1.9)	5.21 (2.1)	4.77 (1.9)	1.676	3, 111	0.176
PVT-Sleepiness, Pre	5.13 (2.1)	4.94 (2.3)	5.48 (2.2)	5.04 (2)	5.15 (2.1)	0.306	3, 108	0.821
PVT-Sleepiness, Post	5.96 (2.1)	6.09 (2.2)	6.08 (2.1)	5.93 (2)	5.65 (2.3)	0.242	3, 109	0.867
ISI	8.43 (0.7)	8.97 (4.6)	8.52 (3.6)	8.68 (4.7)	7.85 (4.0)	0.697	3, 111	0.556
PHQ-9	5.78 (3.7)	5.53 (3.5)	6.96 (3.9)	5.71 (3.4)	5.46 (3.8)	0.783	3, 111	0.506
STAI-State, pre	35.76 (9.1)	36.13 (9.6)	34.96 (9.1)	35.64 (8.2)	36.19 (10)	0.141	3, 111	0.935
STAI-State, post	34.88 (8.7)	34.69 (8.9)	34.32 (9.3)	35.29 (8.7)	35.69 (8.6)	0.193	3, 111	0.901
FSS, pre	3.6 (1.1)	3.64 (1.3)	3.57 (1)	3.83 (1.1)	3.34 (1.1)	0.967	3, 111	0.411
FSS, post	3.6 (1.2)	3.63 (1.4)	3.61 (1.1)	3.64 (1.1)	3.60 (1.1)	0.047	3, 111	0.986

Mean reciprocal reaction time	3.44 (0.4)	3.41 (0.48)	3.23 (0.42)	3.48 (0.33)	3.65 (0.38)	4.261	3, 111	0.007**
Standard deviation of reciprocal reaction time	0.64 (0.1)	0.65 (0.13)	0.61 (0.1)	0.70 (0.13)	0.61 (0.13)	3.318	3, 111	0.023*

Notes: Statistical tests were done to compare the four conditions. $^{**}p < .01$, $^{*}p < .05$, Pre = before the PVT, Post = After the PVT, PVT = Psychomotor Vigilance Test, ISI = Insomnia Severity Index, PHQ-9 = Patient Health Questionnaire-9, STAI-State = State Trait Anxiety Inventory-State, FSS = Fatigue Severity Scale, KSS = Karolinska Sleepiness Scale. Condition 1 = PVT with normal reaction time feedback, Condition 2 = PVT with no feedback, Condition 3 = PVT with 2 categories descriptive feedback, Condition 4 = PVT with 8 categories descriptive feedback

Aim 1: Investigate clinical correlates and sex differences of sleepiness

Pearson's bivariate correlations were conducted to investigate associations between Sleepiness (KSS and PVT-Sleepiness, pre- and post-PVT), insomnia (ISI), anxiety (STAI-State, pre- and post-PVT), depression (PHQ-9), and fatigue (FSS, pre- and post-PVT) in the total sample. Results are reported in Table 2. Self-reported sleepiness was significantly correlated with all other clinical variables. Two t-tests were conducted to investigate sex differences in self-reported sleepiness assessed before the PVT and after the PVT. Women reported significantly higher sleepiness than men both before and after the PVT ($t(113) = 2.824$, $p = .006$; $t(113) = 2.846$, $p = 005$). Fisher's r to z transformations were used to investigate whether the strength of the associations between self-reported sleepiness (KSS pre-PVT) and each clinical correlate (i.e., ISI, STAI-State, PHQ-9, FSS, all assessed before the PVT) significantly differed between men and women. Results are reported in Table 3. No correlations were significantly stronger in either men or women (all p's >.05).

Table 2. Correlations between self-reported sleepiness and clinical measures and performance.

		Pre-PVT Sleepiness	Post PVT KSS	Post-PVT Sleepiness	Pre PVT STAI	Post PVT STAI	Pre PVT FSS	Post PVT FSS	ISI	PHQ-9	Mean reciprocal reaction time	Standard deviation of reciprocal reaction time
Pre PVT KSS	*r*	.558**	.743**	.579**	.218*	.192*	.495**	.440**	.511**	.283**	-0.158	0.140
	N	112	115	113	115	115	115	115	115	115	115	115
Pre-PVT Sleepiness	*r*	-	.509**	.688**	.316**	.330**	.402**	.342**	.288**	.327**	-0.102	0.104
	N	-	112	111	112	112	112	112	112	112	112	112
Post PVT KSS	*r*	-	-	.737**	.198*	.210*	.459**	.482**	.524**	.321**	-0.112	0.082
	N	-	-	113	115	115	115	115	115	115	115	115
Post-PVT Sleepiness	*r*	-	-	-	.256**	.218*	.445**	.428**	.379**	.360**	-0.146	0.107
	N	-	-	-	113	113	113	113	113	113	113	113
Pre PVT STAI	*r*	-	-	-	-	.740**	.329**	.213*	.391**	.441**	-0.031	0.210*
	N	-	-	-	-	115	115	115	115	115	115	115
Post PVT STAI	*r*	-	-	-	-	-	.287**	.286**	.285**	.390**	-0.027	0.179
	N	-	-	-	-	-	115	115	115	115	115	115
Pre PVT FSS	*r*	-	-	-	-	-	-	.804**	.392**	.537**	0.019	0.152
	N	-	-	-	-	-	-	115	115	115	115	115
Post PVT FSS	*r*	-	-	-	-	-	-	-	.349**	.456**	0.059	0.147
	N	-	-	-	-	-	-	-	115	115	115	115
ISI	*r*	-	-	-	-	-	-	-	-	.511**	-0.135	0.109
	N	-	-	-	-	-	-	-	-	115	115	115
PHQ-9	*r*	-	-	-	-	-	-	-	-	-	-.184*	0.075
	N	-	-	-	-	-	-	-	-	-	115	115
Mean reciprocal reaction time	*r*	-	-	-	-	-	-	-	-	-	-	0.187*
	N	-	-	-	-	-	-	-	-	-	-	115

Note. **p* <.05, ** *p* <.01. KSS = Karolinska Sleepiness Scale, PVT = Psychomotor Vigilance Test, STAI = State-Trait Anxiety Inventory-State, FSS = Fatigue Severity Scale, ISI = Insomnia Severity Index, PHQ-9 = Patient Health Questionnaire-9

Table 3. Sex group comparisons of the strength of the associations between sleepiness before the psychomotor vigilance test and various clinical measures

Clinical Measures	r_{women}	r_{men}	Z	p
Insomnia Severity Index	0.447**	0.532**	-0.574	0.283
State-Trait Anxiety Inventory - State	0.151	0.220	0.366	0.357
Patient Health Questionnaire-9	0.206	0.329*	-0.680	0.248
Fatigue Severity Scale	0.494**	0.391*	0.657	0.255

Notes: All correlations were between the clinical measures and the Karolinska Sleepiness Scale, measured before the PVT. *p <.05, **p <.01

Aim 2: Investigate associations between sleepiness and performance

Pearson's bivariate correlations were conducted to investigate associations between reciprocal mean reaction time, the standard deviation of reciprocal reaction time and self-reported sleepiness. The reaction time metrics were not significantly correlated with any self-reported sleepiness measure (all p's > .05, results shown in Table 2 correlations). Multivariate linear regressions were conducted to further investigate these associations. Results are included in Tables 4 and 5. Because performance differed significantly by group (see Table 1), group was included as a moderator variable in each model. Hayes' (2022) PROCESS macro version 4 (Model 1) was used to run each moderated regression model and generate 5,000 bootstrapped confidence intervals of the moderation effect. All continuous independent variables (i.e., pre-PVT KSS and mean reciprocal reaction time) were centered prior to inclusion in the model where they were the independent variable to limit multicollinearity. In the first model mean reciprocal reaction time was included as the dependent variable with pre-PVT KSS as the independent variable, and STAI-State, FSS, ISI, and PHQ-9 (all assessed before the PVT) included as covariates. Group was included as the moderator variable. The overall model was significant (F (11,103) = 2.04, p = .032), with FSS being the only significant predictor of PVT performance within the model (*b* = 0.093, *t* = 2.1, *p* = .042). None of the interaction terms were significant, thereby indicating no evidence for moderation. In a following model, self-reported sleepiness (KSS post-PVT) was included as the dependent variable, with mean reciprocal reaction time (as a centered variable) included as the independent variables and KSS (pre-PVT), STAI-State, FSS, ISI, and PHQ-9 as covariates. Group was included as the moderator variable. Overall, the model was significant (F (12,102) = 14.25, p <.001) with KSS (pre-PVT) being a significant predictor (*b* = 0.611, *t* = 7.6, *p* < .001). Two of the three moderation interaction terms were significant (*b* = -2.02, *t* = -2.27, *p* = .025; *b* = -1.94, *t* = -2.29, *p* = .024). Specifically, condition 3 (PVT with 2 category descriptive feedback) and condition 4 (PVT with 8 category descriptive feedback) significantly differed from condition 1 in the association between mean reciprocal reaction time and post-PVT KSS. The change in R^2 was not significant (ΔR^2 = .03, F(3,102) = 2.64, p = .054) and simple slope analyses indicated that mean reciprocal reaction time was unrelated to post-PVT KSS at each group level (all *p*'s > .05). Taken together, these results indicate that there may be partial moderation from conditions 3 and 4, but there is no evidence for higher-order moderation at the whole group level.

Table 4. Moderated multiple regression predicting mean reciprocal reaction time.

Variable	*β*	*SE(B)*	*t*
Constant	3.20	0.22	14.76***
Karolinska Sleepiness Scale (pre-PVT) centered	-0.04	0.04	-1.06
KSS centered x Condition 2	-0.001	0.06	-0.02
KSS centered x Condition 3	-0.03	0.05	-0.49
KSS centered x Condition 4	0.003	0.06	0.05
Insomnia Severity Index	0.003	0.01	0.25

STAI-State	0.0003	0.005	0.05
Patient Health Questionnaire-9	-0.03	0.01	-1.81
Fatigue Severity Scale	0.09	0.05	2.06*

Notes. **p*<0.05 ***p*<0.01 ****p*<0.001. Group was included as a moderator variable. PVT = psychomotor vigilance task, KSS = Karolinska Sleepiness Scale

Table 5. Moderated multiple regression predicting self-reported sleepiness assessed after the psychomotor vigilance task.

Variable	*β*	*SE(B)*	*t*
Constant	1.69	0.63	2.68**
Mean reciprocal reaction time centered	0.95	0.0.49	0.1.93
Mean reciprocal reaction time x Condition 2	-0.91	0.80	-1.14
Mean reciprocal reaction time x Condition 3	-2.02	0.89	-2.27*
Mean reciprocal reaction time x Condition 4	-1.94	0.85	-2.29*
Insomnia Severity Index	0.07	0.04	1.68
STAI-State	-0.01	0.02	-0.64
Patient Health Questionnaire-9	0.02	0.05	0.48
Fatigue Severity Scale	0.17	0.15	1.16
Karolinska Sleepiness Scale (pre-PVT)	0.61	0.08	7.58***

Notes. **p*<0.05 ***p*<0.01 ****p*<0.001. Group was included as a moderator variable. PVT = psychomotor vigilance task, KSS = Karolinska Sleepiness Scale

Aim 3: Investigate whether sleepiness can be manipulated through performance feedback

An analysis of covariance (ANCOVA) was conducted to investigate whether feedback conditions (i.e., group) influenced post-PVT sleepiness while adjusting for pre-PVT sleepiness. Post-PVT sleepiness, as measured by the KSS, was the dependent variable, feedback condition was the independent variable, and pre-PVT sleepiness, as measured by the KSS, was the covariate. In this model, group was not significant (F (3,110) = 0.691, p = .560) while pre-PVT sleepiness was significant (F(1,110) = 129.104, p < .001). This indicates that there were no significant differences in post-PVT sleepiness between all four feedback conditions while controlling for pre-PVT sleepiness levels.

Discussion

This study had three aims: (1) to investigate the clinical correlates of self-reported sleepiness, (2) to investigate the relationship between performance on the psychomotor vigilance task (PVT) and self-reported sleepiness, and (3) to determine whether self-reported sleepiness can be manipulated through performance feedback. Self-reported sleepiness was observed to be significantly and positively associated with self-reported clinical variables including insomnia severity, depression symptoms, fatigue symptoms, and anxiety symptoms. Women reported significantly higher sleepiness than men both before and after the PVT. However, none of the associations between self-reported sleepiness and other clinical variables were significantly different between women and men. No association between self-reported sleepiness and performance on the PVT was demonstrated in this study. Experimentally manipulating performance feedback on the PVT was not shown to influence sleepiness ratings reported after the PVT. Overall, this study was not able to replicate previous findings concerning the sleepiness—performance association, nor was it able to provide evidence in support of previous suggestions that performance feedback may influence self-reported sleepiness ratings (Nielson, 2021; Boardman, 2018).

The present study observed positive associations between self-reported sleepiness and other measures of clinically important variables including insomnia severity, anxiety, depression, and fatigue. These findings are consistent with what has been reported in the literature. Sleepiness has been shown to be a common and debilitating phenomenon in insomnia disorder and, is most likely a result of the disturbed sleep that is common in insomnia disorder (Hein, 2017). Sleepiness is commonly associated with depression with up to 57% of individuals with depression reporting excessive daytime sleepiness. Sleep disturbance is a common feature of depression, such that insomnia and hypersomnia are included as part of a criterion for the diagnosis of depression. Since sleepiness is a common phenomenon of both insomnia and hypersomnia, it is expected that sleepiness is associated with depression. However, because insomnia and hypersomnia are currently recognized as being separate disorders from depression, rather than as features of major depressive disorder, it is unclear if sleepiness can be considered a result of depressive symptoms or a result of the sleep disturbance common in insomnia and hypersomnia. The lack of motivation and lethargy that are commonly seen in depression may be interpreted by the individual as sleepiness even though the individual may not have an increased drive to sleep. However, it could be possible that the individual desires increased sleep, due to preferring sleep over experiencing their waking conditions, and that this desire coincides with increased lethargy, lack of motivation, depressed mood, to come together to result in an increased drive to sleep. There is a high rate of comorbidity between depression and anxiety and sleep disturbance is common in both. However, the association between sleepiness and anxiety symptoms has generated mixed results. Several studies have failed to find associations between sleepiness and anxiety, including in community-based samples of children and women (Hayley, 2013; Turcio, 2022; Calhoun, 2011). However, other studies have demonstrated a significant association between anxiety and sleepiness including in samples of healthy young adults, pregnant women, and in a representative sample of the US population (Pereira-Morales, 2018; Perotta, 2021; Aukia, 2020; Ohayon, 2012). This study found that sleepiness was associated with both anxiety and depression symptoms. Whether the association between sleepiness and anxiety is due to anxiety's high comorbidity rate with depression is unclear and further research is necessary. Sleepiness and fatigue are conceptually similar and often have overlapping operational definitions, which may account for why sleepiness and fatigue are often associated (Shen, 2006; Shahid, 2010). Indeed, there is currently no consensus definition in the field for either sleepiness or fatigue, which limits the ability of the field to distinctly study these phenomena (Shen, 2006). Moreover, fatigue and sleepiness often share important overlap in the minds of patients (Shen, 2006; Mills-young, 2008). Thus, more theoretical work in the areas of sleepiness and fatigue is needed to distinguish these two phenomena from each other so that research results can be better interpreted.

The present study observed that women reported higher sleepiness than men before and after the PVT. While women have been shown to report moderate levels of sleepiness in comparable rates to men in the U.S. population, women have also been observed to have increased levels of excessive daytime sleepiness (Hayley et al., 2013; Ohayon et al., 2012). Moreover, women have higher rates of sleep complaints when compared with men, even though several studies have demonstrated that women have better sleep and better sleep quality than men (Bixler et al., 2009; Krishnan & Collop, 2006; Roehrs et al., 2006; Ulander et al., 2021). This discrepancy between the rate of sleep complaints and actual quality of sleep may be due to several factors such as women potentially having increased sensitivity to sleep difficulties, women and men potentially having differences in their sleep needs, and/or cultural, societal, or individual factors potentially influencing whether, and how much, men and women report their sleep difficulties. The associations between sleepiness and the other clinical variables were not significantly different between men and women. These findings (or lack thereof) may suggest that these groups experience a similar clustering of symptoms associated with their level of sleepiness in terms of directionality and strength. Future research is necessary to replicate these findings and elucidate factors underlying them.

Surprisingly, this study failed to replicate previous findings demonstrating a significant association between self-reported sleepiness and PVT performance (Lim & Dinges, 2008). This lack of association was surprising given the historical link between the PVT and self-reported sleepiness (Lim & Dinges, 2008; Nielson et al., 2021; Van Dongen et al., 2003). Sleepiness was assessed using the well-validated Karolinska Sleepiness Scale and was the last variable assessed before the PVT began and the first variable assessed after the PVT ended, which meant it had the most proximity to the testing. Moreover, participants were all scheduled to participate before 12pm to limit fluctuations in sleepiness which naturally occur throughout the day. As such, it seems unlikely that this pattern of results could be due to a measurement error or methodological inconsistencies. This null finding may have occurred in part because performance significantly differed across groups. There was some evidence for partial moderation from condition 3, where individuals received feedback in the form of two descriptive words (i.e., average or slow) and condition 4, where individuals received feedback in the form of 8 descriptive words (i.e., extremely fast, very fast, fast, somewhat fast, somewhat slow, slow, very slow, extremely slow) in the association between performance and sleepiness assessed after the PVT. This partial moderation may indicate that the experimental feedback within conditions 3 and 4 may have impacted the association between performance and sleepiness. However, because there was no evidence for moderation at the whole group level and because there was no significant association between performance and sleepiness at each group level within this analysis, there is limited evidence to suggest that this partial moderation had a significant effect. The partial moderation from conditions 3 and 4 may have increased heterogeneity within the total sample such that for some groups self-reported sleepiness and performance were associated in one particular way while for others the association may have been in reverse, without delineating such differences to the level required for full moderation. In other words, this may be a case where the systematic variation between groups did not go far enough to become full moderation but increased the variability within the data enough to obscure any associations between self-reported sleepiness and performance. Because of this, associations between performance and sleepiness may have been too varied at the whole sample level while not being systematically varied enough at the group level to be detected by the analyses that were conducted.

An alternative explanation for this null result could be that there was a reduced range in PVT performance because the sample largely consisted of healthy, emerging adult, college students, a group which is known for having strong cognitive performance (Lim & Dinges, 2008). The lack of variability in performance may have reduced any associations between PVT performance and self-reported sleepiness. Moreover, with 30 participants per group, this study was powered to detect medium to large effect sizes. As such, it may be possible that the study was simply not powered enough to detect the associations between performance and sleepiness. Lastly, this null result may have been due to some third variable which systematically covaried between self-reported sleepiness and PVT performance such as participant environment, or conditions associated with the COVID-19 pandemic. Due to the restrictions associated with COVID-19, we were unable to control the participant's location or computer equipment. As such, there was significant heterogeneity in both location and equipment as some participants performed the experiment in areas where they were more likely to be disturbed (e.g., living room, common room of dorm etc.) while others were in a quiet bedroom. Moreover, there was significant heterogeneity in whether the participants performed the PVT on a laptop or a desktop computer. While all participants performed the experiment using a computer mouse (rather than a laptop trackpad or other device), there may have been variability associated with whether a laptop or desktop was used or due to the kind of mouse the participants used. We were unable to measure these sources of heterogeneity and, as such, cannot account for whether they systematically varied with the results. Importantly, due to the randomization process, these sources of heterogeneity should have been randomly distributed throughout the groups, which would make such heterogeneity less of an influence (Kazdin, 2016; Hsu, 2016). However, because we were unable to measure these factors, we cannot be sure that this heterogeneity was not significantly different between the groups.

This study did not find any evidence to suggest that experimentally manipulating the kind of performance feedback received during a PVT influenced an individual’s self-reported sleepiness. One previous study observed that individuals who were sleep deprived were better able to monitor their performance deficits on the PVT than on other tasks which did not provide feedback (Boardman et al., 2018). Moreover, another study observed significant associations between an individual’s variability in their performance and their self-reported sleepiness and suggested that performance feedback may influence an individual's sleepiness (Nielson et al., 2021). This study sought to expand upon these previous results and examine whether experimentally manipulating the type of performance feedback an individual received during the PVT influenced their sleepiness ratings. Because no differences in self-reported sleepiness ratings assessed after the PVT were observed between groups, this study does not provide evidence that manipulating the type of performance feedback received during the PVT influences an individual’s self-reported sleepiness. Thus, it might be the case that manipulating performance feedback does not influence an individual’s self-reported sleepiness. As discussed above, this null finding could also be due to a variety of factors including: a potential lack of power to detect small effects, the restricted range of PVT performance, or it could be due to the inability to control the participants’ environments.

This study has several limitations. First, this study was conducted entirely online through Zoom sessions which meant that the research staff were unable to control participants' environment. Thus, there may have been unique distractions in the participants' environments that may have affected their responses and PVT performance. However, because of the randomization process inherent in this experimental design, such differences may have been resolved through randomizing the participants to each condition. Unfortunately, there are no statistical tests that we can run to determine if such heterogeneity between the groups relating to distractions exists because these potential nuisance variables went unmeasured. Relatedly, because the PVT was performed on each participant's personal device there may have been heterogeneity in reaction time measurement. However, because of the randomization process, it could be that the heterogeneity of the computers was randomized across the groups, thereby negating such heterogeneity as a confounding variable. Because no information about the participants' computers was collected, we are unable to run any statistical tests to determine if such heterogeneity between the groups exists. Moreover, this study's sample was largely limited to undergraduates at Brigham Young University. Because of this university's demographic makeup, our sample mostly consisted of individuals who identified as white, meaning that the results of this study may not be generalizable to individuals of other races. This study mostly utilized self-report methods of measurement. As such, this method of measurement may have introduced biases and measurement error.

Further research is necessary to investigate whether performance feedback influences an individual's self-reported sleepiness and under what conditions this effect occurs. A more powerful intervention such as providing no feedback vs normal feedback or providing fake feedback vs correct feedback, may help elucidate if manipulating feedback influences an individual's self-reported sleepiness. Moreover, conditions of sleep restriction or sleep deprivation, which frequently increase an individual's variability in their PVT performance (Van Dongen et al., 2003) may also provide suitable conditions to observe whether feedback influences sleepiness. This line of investigation could lead to important discoveries regarding how an individual determines their sleepiness levels and what affects an individual's sleepiness.

In conclusion, this study sought to examine the clinical correlates of sleepiness, how PVT performance relates to sleepiness, and whether systematically manipulating the type of performance feedback an individual receives on the PVT influences their self-reported sleepiness. This study observed significant associations between sleepiness and various clinical variables including insomnia severity, depression, anxiety, and fatigue. No associations between sleepiness and PVT performance were observed. Moreover, there was no evidence to suggest that systematically manipulating the type of feedback an individual receives on the PVT influences their self-reported sleepiness. Such research could have potential implications for helping individuals who struggle with excessive daytime sleepiness and sleepiness caused by sleep disturbances or disorders such as insomnia.

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Appendix A. Measures

State-Trait Anxiety Inventory-State (STAI-State)

SELF-EVALUATION QUESTIONNAIRE STAI Form Y-1

Please provide the following information:

Name______________________________ Date______________ S_____

Age______________ Gender (*Circle*) **M** **F** T_____

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

STAIP-AD Test Form Y
www.mindgarden.com

Patient Health Questionnaire-9 (PHQ-9)

PATIENT HEALTH QUESTIONNAIRE-9 (PHQ-9)

Over the last 2 weeks, how often have you been bothered by any of the following problems? *(Use "✔" to indicate your answer)*	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

FOR OFFICE CODING __0__ + ______ + ______ + ______

=Total Score: ______

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	**Somewhat difficult**	**Very difficult**	**Extremely difficult**
☐	☐	☐	☐

Fatigue Severity Scale (FSS)

FATIGUE SEVERITY SCALE (FSS)

Date ______________________________ Name __________________________________

Please circle the number between 1 and 7 which you feel best fits the following statements. This refers to your usual way of life within the last week. 1 indicates "strongly disagree" and 7 indicates "strongly agree."

Read and circle a number.	Strongly Disagree → Strongly Agree						
1. My motivation is lower when I am fatigued.	1	2	3	4	5	6	7
2. Exercise brings on my fatigue.	1	2	3	4	5	6	7
3. I am easily fatigued.	1	2	3	4	5	6	7
4. Fatigue interferes with my physical functioning.	1	2	3	4	5	6	7
5. Fatigue causes frequent problems for me.	1	2	3	4	5	6	7
6. My fatigue prevents sustained physical functioning.	1	2	3	4	5	6	7
7. Fatigue interferes with carrying out certain duties and responsibilities.	1	2	3	4	5	6	7
8. Fatigue is among my most disabling symptoms.	1	2	3	4	5	6	7
9. Fatigue interferes with my work, family, or social life.	1	2	3	4	5	6	7

VISUAL ANALOGUE FATIGUE SCALE (VAFS)

Please mark an "X" on the number line which describes your global fatigue with 0 being worst and 10 being normal.

0	1	2	3	4	5	6	7	8	9	10

Insomnia Severity Index (ISI)

Insomnia Severity Index

The Insomnia Severity Index has seven questions. The seven answers are added up to get a total score. When you have your total score, look at the 'Guidelines for Scoring/Interpretation' below to see where your sleep difficulty fits.

For each question, please CIRCLE the number that best describes your answer.

Please rate the CURRENT (i.e. LAST 2 WEEKS) SEVERITY of your insomnia problem(s).

Insomnia Problem	**None**	**Mild**	**Moderate**	**Severe**	**Very Severe**
1. Difficulty falling asleep	0	1	2	3	4
2. Difficulty staying asleep	0	1	2	3	4
3. Problems waking up too early	0	1	2	3	4

4. How SATISFIED/DISSATISFIED are you with your CURRENT sleep pattern?

Very Satisfied	Satisfied	Moderately Satisfied	Dissatisfied	Very Dissatisfied
0	1	2	3	4

5. How NOTICEABLE to others do you think your sleep problem is in terms of impairing the quality of your life?

Not at all Noticeable	A Little	Somewhat	Much	Very Much Noticeable
0	1	2	3	4

6. How WORRIED/DISTRESSED are you about your current sleep problem?

Not at all Worried	A Little	Somewhat	Much	Very Much Worried
0	1	2	3	4

7. To what extent do you consider your sleep problem to INTERFERE with your daily functioning (e.g. daytime fatigue, mood, ability to function at work/daily chores, concentration, memory, mood, etc.) CURRENTLY?

Not at all Interfering	A Little	Somewhat	Much	Very Much Interfering
0	1	2	3	4

Guidelines for Scoring/Interpretation:

Add the scores for all seven items (questions 1 + 2 + 3 + 4 + 5 +6 + 7) = _______ your total score

Total score categories:
0–7 = No clinically significant insomnia
8–14 = Subthreshold insomnia
15–21 = Clinical insomnia (moderate severity)
22–28 = Clinical insomnia (severe)

Karolinska Sleepiness Scale (KSS)

KAROLINSKA SLEEPINESS SCALE

Please, indicate your sleepiness during the five minutes before this rating through circling the appropriate description

1=extremely alert
2=very alert
3=alert
4=rather alert
5=neither alert nor sleepy
6=some signs of sleepiness
7=sleepy, but no effort to keep awake
8=sleepy, some effort to keep awake
9=very sleepy, great effort to keep awake, fighting sleep

References

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