SLEEP LOSS AND RISK-TAKING BEHAVIOR

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Thesis Prepared for the Degree of

MASTER OF SCIENCE

UNIVERSITY OF NORTH TEXAS

August 2012

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Womack, Stephanie D., *Sleep loss and risk-taking behavior*. Master of Science (Psychology), August 2012, 123 pp., 5 tables, 2 figures, references, 104 titles.

While sleep loss has been shown to have detrimental effects on cognitive, physiological, and psychological processes, it has only recently been investigated as a possible causal factor of risk-taking behavior (i.e., a conscious choice to engage in dangerous behavior despite knowledge of possible loss or harm). Among the few studies that have been conducted in this field, the majority found that as individuals become sleepier, their propensity to engage in risk-taking behavior increased. The results of the current study indicated a positive relationship between increased sleep loss and two measures of specific risk-taking behavior (i.e., substance use, sexual compulsivity), but no significant relationship between sleep loss and measures of general risk-taking behavior. There was some evidence for temporal stability of the Iowa Gambling Task (IGT), though scores on the IGT were not related to scores on other measures of risk-taking, nor to measures of sleep loss. Negative mood was found to partially mediate the relationship between sleep loss and substance use, as well as the relationship between sleep loss and sexual compulsivity.
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ACKNOWLEDGMENTS

I would like to thank Dr. Joshua Hook for his tireless support and dedication to seeing me succeed. This thesis would not have been possible without his help, encouragement, and myriad revisions. Thank you also to Dr. Watkins and Dr. Vosvick for their time, helpful comments, and assistance. Thank you Jen for saving my sanity and always being there for me during the ups and downs of graduate school. Finally, thank you to my family for their unfailing belief in me.
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Figure 1. Mediator effects of negative mood on the relationship between sleep loss (i.e., global sleep quality) and risk-taking behavior (i.e., total substance use). The number in parentheses is the effect of the independent variable on the dependent variable with the mediator in the model. *p < .01, **p < .001. ..................................................................................................................... 78

Figure 2. Mediator effects of negative mood on the relationship between sleep loss (i.e., global sleep quality) and risk-taking behavior (i.e., sexual compulsivity). The number in parentheses is the effect of the independent variable on the dependent variable with the mediator in the model. *p < .01, **p < .001. ..................................................................................................................... 78
CHAPTER 1
INTRODUCTION

Psychologists and economists have studied risk-taking behavior (RTB) for decades in an attempt to understand factors that motivate individuals to engage in, or refrain from engaging in, risky behaviors (Brown, 2008). Sleep loss, and its detrimental effect on cognitive, physiological, and emotional processes, has also been studied extensively (Dinges et al., 1997; Harrison & Horne, 2000). However, only recently has sleep loss been investigated as a possible causal factor in RTB.

Although only a few studies exist that investigate the relationship between sleep loss and RTB, the majority have found that as individuals are exposed to higher levels of sleep loss (i.e., become sleepier), their propensity to engage in RTB increases (i.e., they take more risks; Harrison & Horne, 2000). To date, no comprehensive, in-depth review of the literature exists that examines the direct link between sleep loss and risk-taking.

The purpose of this thesis is to conceptualize sleep loss and RTB, review the existing literature, and replicate and further investigate findings from previous studies. In Chapter 2, I organize and review the current empirical studies that examine the effects of sleep loss on RTB. In Chapters 3, 4, 5, and 6, I report the findings from an empirical study that examined the relationship between sleep loss and RTB using self-report and behavioral measures. Specifically, in Chapter 3, I detail a statement of the problem to introduce the topic I am addressing. In Chapter 4, I specify the methodology for my empirical study. In Chapter 5, I report the results, including (a) replication of previous studies that utilized the Iowa Gambling Task (IGT) to study sleep loss and RTB, (b) examination of the construct validity of the IGT in the context of sleep loss, (c) investigation of the temporal stability of the IGT in the context of
sleep loss, and (d) exploration of possible mediators of the relationship between sleep loss and RTB. In Chapter 6, I discuss the findings from my empirical study in the context of the extant literature.
CHAPTER 2
REVIEW OF THE LITERATURE

Risk-taking behavior (RTB) is defined as an action or decision that has both (a) the potential for danger, loss, or harm, as well as (b) the potential for gaining some form of reward (Leigh, 1999). The use of illegal drugs is an example of risk-taking behavior, because it involves making a choice to engage in the drug use, the potential for harm (e.g., overdose, going to jail, death), and the potential for a reward (e.g., euphoric feeling, escape from stressors).

It is important to differentiate RTB from risk. Risk is defined as “the possibility of loss or injury” (“Risk,” 2011), whereas RTB is defined as the conscious choice to engage in a dangerous behavior despite knowledge of possible loss or harm (West, 1991). This dimension of personal decision is an important facet of RTB. An individual may have an increased risk for heart disease due to genetics, which they have no control or choice over. However, that same individual may also choose to eat a high-fat diet and rarely exercise, which also puts them at risk for heart disease. These behaviors are engaged in despite the knowledge that such decisions might lead to health problems, and thus are classified as RTB.

An individual’s notion of “danger or harm” can be subjective. In other words, individuals may differ in their judgments of whether a specific behavior has potential for danger (Leigh, 1999). These negative outcomes can take various forms, including physical danger (e.g., broken bones), psychological distress (e.g., depressed mood), monetary loss, a combination of the three, or anything that an individual perceives to be a negative outcome. Similarly, individual definitions of “reward” might differ depending on the context. A reward might take the form of money, positive emotions (e.g., happiness), improvement to a personal situation
(e.g., improved health following surgery), or anything that an individual deems to be a positive or favorable outcome.

Theories of RTB

There is a large amount of literature in the field of psychology examining RTB, and there are multiple theories to explain the mechanisms of risk-taking (Brown, 2008). Most theories posit that personality traits account for part of the variability in RTB (Unger & Stahlberg, 2011). Sensation seeking and impulsivity are the two most widely studied personality constructs within the context of risk-taking (Zuckerman & Kuhlman, 2000). Though several other variables explaining the mechanisms of RTB have been proposed, sensation-seeking and impulsivity are among the factors consistently measured and accounted for in research, and are thus of interest for the purposes of this literature review.

Marvin Zuckerman (1994), who is among the most widely known researchers in the field of risk-taking (Trimpop, Kerr, & Kirkcaldy, 1997), defines sensation-seeking as a preference to seek out novel and thrilling experiences, and a willingness to take risks for the sake of these experiences. He developed the Sensation-Seeking Scale, from which a 4-factor model of sensation seeking (i.e., thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility) was derived (Zuckerman, 1974).

Impulsivity can be defined as the tendency to enter into situations without planning or thought for potential negative outcomes, as well as a lack of inhibition in seeking rewards despite dangerous situations (Zuckerman & Kuhlman, 2000). Eysenck and Eysenck (1977) found that impulsivity has four factors: narrow impulsiveness, risk-taking, non-planning, and liveliness.
In addition to personality traits, reflection effects and framing effects have been identified as important influences on risk-taking behavior (Kahneman & Tversky, 1979; Tversky & Kahneman, 1981; Xie & Wang, 2003). Reflection effects refer to an individual’s tendency to make less risky decisions when the outcome of that decision involves gaining something, and to make riskier decisions when the outcome involves losing something (Tversky & Kahneman, 1981). Risk preference for gains and losses are mirror images, or reflections, of one another; an individual will prefer low risks for gains and high risks for losses. Thus, RTB changes depending on the situation (i.e., whether the task involves gaining something or losing something).

Framing effects, however, involve the way that an individual thinks about a problem (Tversky & Kahneman, 1981). For example, a decision-making task might involve choosing either option A or B, and each option could result in either gain or loss of money. If the participant were instructed to make choices that would ensure they won as much money as possible, the task would be framed in terms of gains. If the participant were instructed to make choices that would ensure they lost as little money as possible, the task would be framed in terms of losses. Individuals tend to make less risky decisions when the outcomes are framed as a gain, and riskier decisions when the outcomes are framed as a loss (Kahneman & Tversky, 1979). In this instance, risk preference changes depending on how an individual conceptualizes or thinks about the task, not whether the task actually involves gains or losses. Individuals will show different risk preference for two choices with identical outcomes depending on how the choices are framed.

Though reflection effects and framing effects seem to be similar, it is important to note the distinction between them (Fagley, 1993; Kuhberger, Schulte-Mecklenbeck, & Perner, 1999).
Both framing and reflection involve losses and gains, and both elicit similar RTB (i.e., avoid risk for gains, seek risk for losses), but the two concepts are fundamentally different. With reflection, the outcomes of the two decisions are different (i.e., one involves gains, one involves losses), but with framing, the outcomes are identical, but the individual’s perception of the choices is different. In this way, framing effects are similar to optical illusions, whereas reflection effects are not (Fagley, 1993). Thus, when deciding to incorporate either type of effect into a study, the distinction between framing and reflection is important because it directly affects the design of the experiment.

Researchers have begun to study RTB within different contexts to identify other variables that might influence risk-taking, including changes in mood (Bruyneel, Dewitte, Franses, & Dekimpe, 2009; Grable & Roszkowski, 2008; Hockey, Maule, Clough, & Bdzola, 2000; Yuen & Lee, 2003), the introduction of a cognitively demanding task or changes in cognitive processes (Morrongiello & Matheis, 2007; Romer, Betancourt, Giannetta, Brodsky, Farah, & Hurt, 2009), and disturbances in sleep (Catrett & Gaultney, 2009; Killgore, Lipizzi, Kamimori, & Balkin, 2007; McKenna, Dickinson, Orff, & Drummond, 2007). Of these, the effects of sleep disturbances are of particular interest because of the prevalence of sleep problems and potential consequences of sleepiness.

Sleep and Sleep Loss

The National Sleep Foundation recommends that adults sleep between 7 and 9 hours per night (Bonnet & Arand, 2011). The 2004-2006 National Health Interview Survey (NHIS), however, found that only 63% of adults report sleeping the recommended amount per night, and that 29% of adults report sleeping 6 hours or less per night (Schoenborn & Adams, 2008). The
NHIS also found that the number of individuals who report inadequate (6 hours or less per night) sleep has increased 6% in the past 20 years, indicating a growing trend for adults to fail to sleep enough each night (Luckhaupt, SangWoo, & Calvert, 2010). Several theories explaining why adults’ sleep duration has steadily decreased have been proposed, including increased demand for longer work days and technological advances such as laptops and cell phones (Luckhaupt et al., 2010), as well as increased prevalence of sleep disorders such as sleep apnea and insomnia (Catrett & Gaultney, 2009).

Sleep loss is most commonly studied in one of three contexts: sleep deprivation, sleep restriction, and sleep fragmentation (Brown, 2008). Sleep deprivation, sometimes referred to as total sleep deprivation (TSD), is a complete lack of sleep for a specified period of time. Sleep restriction involves a decrease in the total amount of sleep time (e.g., staying up late to complete a presentation). Sleep fragmentation occurs when sleep is disrupted (e.g., waking in the middle of the night; Brown, 2008). Experimental studies that investigate the effects of sleep loss often employ TSD, because it is easier to achieve experimental control—each participant is kept awake the same amount of time and thus individual differences in subjective feelings of sleepiness are somewhat uniform. Sleep restriction and sleep fragmentation are more commonly observed outside a laboratory, and are often measured using self-report questionnaires, sleep diaries, and measures of activity such as actigraphy (Brown, 2008).

Sleep loss has been linked not only to health problems such as heart disease and hypertension (Gottlieb et al., 2006; Luckhaupt et al., 2010; Vgontzas et al., 2010), but also to deficits in basic cognitive processes, including concentration, attention, working memory, and psychomotor vigilance (Dinges et al., 1997; Harrison & Horne, 2000; Wesensten, Belenky,
Thorne, Kautz, & Balkin, 2004). Recently, researchers have begun investigating the effects of sleep loss on the higher order cognitive process of decision-making and RTB.

Sleep Loss and RTB

Several theories exist as to why there might be a link between sleep loss and RTB. One theory involves the prefrontal cortex (PFC), which research suggests is involved in higher-order cognitive processes such as decision-making (Nilsson et al., 2005). The PFC is vulnerable to sleep deprivation, and TSD is linked to neuropsychological impairments (Horne, 1993). Specifically, the ventromedial prefrontal cortex (VMPFC) has been studied in the context of decision-making because this area is an important link between complex decision-making and emotions (Killgore, Balkin, & Wesensten, 2006).

According to the somatic marker hypothesis (SMH), decisions are influenced by the emotional markers that people associate with various choice options, and thus decisions (risky or otherwise) are guided by the positive or negative feelings associated with them (Casey, Pipingas, Silberstein, Downey, & Johnston, 2010). Thus, when activity in the VMPFC is decreased due to sleep deprivation, the ability to decide whether or not to engage in risky choices that would otherwise feel “wrong” might be impaired, and RTB might increase or decrease.

The distinction between gains and losses may also be an important component of the relationship between sleep loss and RTB. As previously stated, framing effects and reflection effects are central components of decision-making (Kahneman & Tversky, 1979), and sleep loss affects cognitive processes that contribute to decision-making (Harrison & Horne, 2000). This change in cognitive processes might be manifested in the way individuals think about risks and in the way they make decisions about whether to take risks or not. Sleep loss might change how
individuals perceive gains and losses (framing). While an individual might normally avoid risks for gains and seek risks for losses, sleep loss might change the way they think about the risks, and they might instead seek risks for gains and avoid risks for losses. Similarly, sleep loss might change how willing an individual is to gain or lose something. When a decision involves gaining something, well-rested individuals will be less willing to take risks than when a decision involves losing something (reflection). However, sleep loss might affect cognitive decision-making processes and alter this preference, such that the same individual is somewhat more willing to take risks for gains and somewhat less willing to take risks for losses. Therefore, one possible explanation for the link between sleep loss and RTB is that sleep loss is related to framing and/or reflection effects, which in turn are related to decision-making and thus RTB. Although few studies exist that examine how gains and losses might influence this relationship, several studies postulate that such a relationship might exist (Killgore et al., 2008; McKenna et al., 2007; Venkatraman, Chuah, Huettel, & Chee, 2007; Venkatraman, Huettel, Chuah, Payne, & Chee, 2011).

Finally, mood might help explain the relationship between sleep loss and RTB. Sleep loss has been shown to decrease positive mood (e.g., happiness) and increase negative mood (e.g., depression; Paterson et al., 2011). The mood maintenance model (Isen & Patrick, 1983) links mood to RTB and suggests that individuals in a positive mood take fewer risks to avoid jeopardizing their current mood, but that individuals in a negative mood take more risks in an effort to gain a positive outcome that will improve their mood (Harrison & Horne, 2000). Therefore, sleep loss might increase negative mood, which would in turn increase RTB.
Prior Reviews of the Literature

Thus far, only one other review has been published that explores risk-taking and sleep loss. Harrison and Horne (2000) addressed sleep deprivation, which is one aspect of sleep loss, and its effect on decision-making, which includes, among other things, risk-taking. Although an in-depth examination of the relationship between sleep loss and RTB was beyond the scope of that article, this literature review provides a detailed analysis of these variables.

The previous review focused primarily on how the complexity and nature of a task impacts an individual’s sensitivity to sleep loss. Harrison and Horne (2000) noted that simple, repetitive tasks that were monotonous and lacked novelty were very sensitive to one night of TSD, but that complex, rule-based tasks (e.g., IQ types of performance tests) generally were not sensitive to sleep loss. However, real-world decision tasks that require complex skills but are not rule based (e.g., anticipating consequences of events, thinking innovatively, controlling mood and uninhibited behavior) were sensitive to one night of TSD. They further explained that these real-world tasks depend heavily on the integrity of the prefrontal cortex, which is sensitive to sleep loss.

The previous review identified risk assessment and risk-taking propensity as one aspect of real-world decision making that is affected by sleep loss, and cited two studies that investigated sleep loss and risk-taking. It also outlined several models of decision-making that inform risk-taking studies, including rationalistic decision-making (i.e., expected utility model, wherein decision-making is based on weighing the expected outcome of a decision by its probability), normative descriptive models of decision-making (i.e., framing, certainty versus ambiguity of risks, affective state, and performance insight), and naturalistic decision-making,
wherein individuals are placed in realistic contexts that require them to make spontaneous decisions based on their innate decision-making processes.

Although sleep loss and risk-taking were discussed, the purpose of the article was to identify and differentiate decision-making processes that are or are not sensitive to sleep deprivation. The current review attempts to provide a detailed exploration of the relationship between sleep loss and RTB, which was beyond the scope of the Harrison and Horne (2000) review.

Purpose of Current Review

The purpose of this literature review is to summarize the results from empirical studies that examine the relationship between sleep loss and RTB, to highlight emergent trends in this area of research, to explore possible mediators and moderators of the relationship, and to discuss areas for future research. Many of the studies to date explored similar hypotheses, which resulted in a critical mass of primary studies for review. However, because interest in this area of study is currently developing, this literature review also aims to describe aspects of the existing research that need to be investigated more thoroughly, thus guiding prospective research.

One of the primary areas that merit investigation is the possible existence of mediators and moderators of the relationship between sleep loss and RTB. Many researchers theorize that such mediators and moderators exist, but few if any studies empirically evaluate them. This review will organize the existing theories, describe how researchers studied them, and explore ways in which future research might address this deficiency.
Method

I conducted a literature search for empirical articles investigating the relationship between sleep loss and RTB. The inclusion criteria for this literature review included two components. First, included studies had an actual measure of sleep or experimentally manipulated sleep. Second, included studies examined general (e.g., sensation seeking, impulsivity, overall decision-making preference for risky gambles or safe gambles) or specific risk-taking behavior (e.g., smoking, alcohol and drug use). I operationally defined general RTB as a different construct from specific RTB after noticing that some studies examined general personality constructs such as sensation seeking, impulsivity, and risk preference, whereas other studies examined specific health risk behaviors such as smoking, drug use, and adolescent delinquency (which the researchers operationalized as RTB). In an effort to provide an exhaustive review of the literature, I included both types of studies, but operationally defined these types of RTB as separate constructs. However, studies that examined the results of engaging in risky behaviors while sleepy (i.e., likelihood of being in an automobile accident) rather than the decision to engage in RTB while sleepy (i.e., likelihood of choosing to drink alcohol) were excluded.

The literature search was conducted through February 20, 2011, and had five components. First, I searched the PsycINFO (Psychological Abstracts) database and the Medline database, pairing the key terms “risk behavior,” “risk taking,” and “risk” with “fatigue,” “sleep,” and “sleepiness.” The search yielded 11 studies that met the inclusion criteria. Second, I searched the ProQuest Dissertations and Theses Database using the key words “risk” and “sleep” and found one dissertation that met the inclusion criteria. Third, I reviewed the discussion and reference sections of each of these studies and the dissertation and found one additional study
that met the inclusion criteria. Fourth, I searched the online databases of all available articles for both the Journal of Sleep Research and Sleep: Journal of Sleep and Sleep Disorders Research and found no additional articles that addressed the relationship between sleep and risk-taking behavior. Fifth, I contacted the primary authors of the 13 articles to inquire about possible unpublished studies, and found three additional studies.

Thus, I found a total of 16 studies that met inclusion criteria and addressed the relationship between sleep loss and risk-taking behavior. The studies considered in the present review are listed in Table 1 and Table 2.

Results

The review of the literature on the relationship between sleep loss and RTB is organized into two sections. First, I review the approaches used to measure sleep loss and RTB. Second, I review the empirical findings on the relationship between these variables.

Approaches Used to Measure Sleep Loss and RTB

Researchers utilize various methods to measure both sleep loss and RTB, including behavioral measures and self-report measures. Some of the studies included in the present review used more than one measure of each variable.

Behavioral Measures of RTB

Eleven studies included in this review measured RTB with a decision task in which participants were asked to make a choice between two or more options that resulted in different outcomes. Gambling tasks were the most common decision task. Two studies used the Iowa
Gambling Task (IGT), five studies used the Balloon Analogue Risk Task (BART), one study used a lottery choice task (LCT), and one study used a stop light task. Two studies used a simple dilemma choice task, two studies used a non-gambling discounting task, and two studies utilized more than one behavioral measure of RTB.

- The Iowa Gambling Task. The Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994) is a decision task that was designed to mimic real world decision-making. The IGT assesses the ability to learn to avoid short-term high-risk scenarios, and to adapt and modify decision-making to maximize long-term gains. Four decks of cards (labeled A, B, C, and D for the purposes of discussion) are presented on a computer screen, and each deck has a payoff ratio that allows the participant to win or lose hypothetical money. Two of the decks (A and B) contain small wins but even smaller losses, and two of the decks (C and D) contain large wins but even larger losses. Therefore, decks A and B are considered “safe” because choosing these decks will result in long-term gains throughout the task, and decks C and D are considered “risky” because they will result in long-term losses throughout the game.

Each draw of a card from a deck results in gaining and losing a certain amount of money. For example, trial one from deck A might result in a win of $50 and a loss of $0 for a net profit of $50, and trial two might result in a win of $50 and a loss of $50, for a net profit of $0. Trial three from deck D might result in a win of $100 and a loss of $50 for a net profit of $50, and trial four might result in a win of $100 and a loss of $1250, for a net loss of $1150. By maximizing net profits by avoiding risky decks, the participant can accumulate money throughout the game.

The decks appear identical to the participants, and the payoff ratio for each deck never changes during the trials, ensuring that the participant has the opportunity to learn the payoff ratio for each deck.
Table 1

Sleep Loss and RTB: Experimental Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Participants</th>
<th>Sleep Measure</th>
<th>Risk Measure</th>
<th>General Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acheson et al. (2007)</td>
<td>20 adults</td>
<td>TSD; SSS; Act; SL</td>
<td>BART; DDT; EDT</td>
<td>As sleep loss increases, RTB stays the same overall, decreases for women</td>
</tr>
<tr>
<td>Jones et al. (2006)</td>
<td>32 adults</td>
<td>TSD</td>
<td>SPQ</td>
<td>As sleep loss increases, SR likelihood of engaging in RTB increases</td>
</tr>
<tr>
<td>Killgore et al. (2006)</td>
<td>34 adults</td>
<td>TSD; Poly</td>
<td>IGT</td>
<td>As sleep loss increases, RTB increases</td>
</tr>
<tr>
<td>Killgore (2007)</td>
<td>54 adults</td>
<td>TSD; MEQ; Poly; Act</td>
<td>BART; BSSS; EVAR</td>
<td>As sleep loss increases, RTB decreases</td>
</tr>
<tr>
<td>Killgore et al. (2007)</td>
<td>26 adults</td>
<td>TSD; Act</td>
<td>IGT</td>
<td>As sleep loss increases, RTB increases</td>
</tr>
<tr>
<td>Killgore et al. (2008)</td>
<td>54 adults</td>
<td>TSD; Act</td>
<td>BART; BSSS; EVAR</td>
<td>As sleep loss increases, RTB decreases</td>
</tr>
<tr>
<td>Killgore et al. (2010)</td>
<td>25 adults</td>
<td>TSD</td>
<td>BART; EVAR</td>
<td>As sleep loss increases, RTB increases</td>
</tr>
<tr>
<td>McKenna et al. (2007)</td>
<td>38 adults</td>
<td>TSD; Act; SL</td>
<td>LCT</td>
<td>As sleep loss increases, RTB increases for gains, decreases for losses</td>
</tr>
<tr>
<td>Venkatraman et al. (2007)</td>
<td>39 adults</td>
<td>TSD; Act</td>
<td>Simple Decision Gambling Task</td>
<td>As sleep loss increases, brain areas involving RTB showed increased activity</td>
</tr>
<tr>
<td>Venkatraman et al. (2011)</td>
<td>29 adults</td>
<td>TSD; Act</td>
<td>Risky Decision Task</td>
<td>As sleep loss increases, general RTB increases, RTB increases for gains, no change for losses</td>
</tr>
</tbody>
</table>

*Note. TSD = Laboratory Total Sleep Deprivation; SSS = Stanford Sleepiness Scale; Act = Actigraphy; SL = Sleep Log; BART = Balloon Analogue Risk Task; DDT = Delay Discounting Task; EDT = Experiential Discounting Task; SPQ = Subjective Perception Questionnaire; SR = Self-Reports; Poly = Polysomnography; IGT = Iowa Gambling Task; MEQ = Morningness-Eveningness Questionnaire; BSSS = Brief Sensation Seeking Scale; EVAR = Evaluation of Risks Scale; LCT = Lottery Choice Task.*
Table 2

Sleep Loss and RTB: Correlational Studies

<table>
<thead>
<tr>
<th>Authors</th>
<th>Participants</th>
<th>Sleep Measure</th>
<th>Risk Measure</th>
<th>General Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown (2008)</td>
<td>35 adolescents</td>
<td>CSQ; Act; SL</td>
<td>BART; EPI; BSSS; DDT</td>
<td>As SR sleep loss increases, SR RTB does not significantly increase (BART no increase)</td>
</tr>
<tr>
<td>Catrett &amp; Gaultney (2009)</td>
<td>4353 adolescents</td>
<td>Add Health Study</td>
<td>Add Health Study</td>
<td>As SR possible insomnia increases, SR specific RTB increases</td>
</tr>
<tr>
<td>O’Brien &amp; Mindell (2005)</td>
<td>388 adolescents</td>
<td>Sleep Habits Survey</td>
<td>YRBS</td>
<td>As SR sleep loss increases, SR RTB increases</td>
</tr>
<tr>
<td>Roehrs et al. (2004)</td>
<td>13 adults</td>
<td>MSLT; Act</td>
<td>Stop Light Task</td>
<td>As sleep loss increases, RTB increases</td>
</tr>
<tr>
<td>Schoenborn &amp; Adams (2008)</td>
<td>NHIS Sample Adults</td>
<td>NHIS Sample Adult Form</td>
<td>NHIS Sample Adult Form</td>
<td>As SR sleep loss increases, SR specific RTB increases</td>
</tr>
<tr>
<td>Vail-Smith et al. (2009)</td>
<td>859 adults</td>
<td>Sleep Quality Index</td>
<td>National College Health Risk Survey</td>
<td>As SR sleep loss increases, SR specific RTB increases</td>
</tr>
</tbody>
</table>

Note. CSQ = Child Sleep Questionnaire; Act = Actigraphy; SL = Sleep Log; BART = Balloon Analogue Risk Task; EPI = Eysenck Personality Inventory; BSSS = Brief Sensation Seeking Scale; DDT = Delay Discounting Task; SR = Self-Reported; RTB = Risk-Taking Behavior; YRBS = Youth Risk Behavior Survey; MSLT = Multiple Sleep Latency Test; NHIS = National Health Interview Survey.
The order of “risky” versus “safe” decks can be altered or randomized to fit the needs of the experiment. Participants are told at the beginning of the task that “some decks are better than others” but are not given any further instructions as to which decks to choose. Each participant begins the game with $2000 of play money, and over the course of 100 trials, wins and loses money depending on the decks they choose.

A study by Killgore and colleagues (2007) administered the IGT to participants who were kept awake for 75 hours. Each participant completed the IGT at baseline (i.e., before any sleep deprivation), at 51 hours TSD, and at 75 hours TSD. Each IGT administration consisted of 100 trials, and the order of the decks was altered each time so that the “safe” and “risky” decks were not in the same positions during the three administrations. During analysis of the data, each of the three trials were broken up into five blocks of 20 trials each, so that trends in decision-making over time could be observed. Prior to sleep deprivation, the participants were able to learn to select from the “safe” decks and to avoid the “bad” decks. However, following sleep deprivation, the participants began the trial by choosing “safe” decks, but began progressively choosing “risky” decks during the latter half, suggesting that TSD impaired the participants’ ability to learn to avoid “risky” decks, resulting in increased RTB.

The IGT is a simple, easy to administer gambling task that reflects real-world decision-making. However, it was originally developed for patients with impairments in the VMPFC, and thus is sensitive to the hypothesis that the VMPFC mediates the relationship between sleep loss and RTB. Therefore, while the IGT is useful in testing this hypothesis, more data might be needed to determine the extent to which it is reliable and valid in other contexts. Additionally, administration of the task requires participants to repetitively click a mouse to indicate their risk
choices. Sleep deprivation and boredom might contribute to random responding rather than actual decision-making, thus producing invalid results.

- The Balloon Analogue Risk Task. The Balloon Analogue Risk Task (BART) was designed by Carl Lejuez and his associates (2002) to measure trait RTB (Benjamin & Robbins, 2007). The BART is significantly correlated with several self-report measures of RTB, including the Eysenck Impulsivity subscale score and the Zuckerman Sensation Seeking total score; thus, there is evidence for the validity of this measure of RTB.

Participants are presented with a series of 90 balloons on a computer screen, which they are instructed to inflate by pressing a button (some researchers shorten the task to 30 or 60 trials depending on the nature and time constraints of their experiment). Each press of the button is worth a certain amount of money, and participants may choose to stop inflating a balloon and “bank” the amount of money they have earned at any time. However, if the balloon is overinflated and explodes, the participant loses any money they accumulated while inflating that balloon. There is no obvious set point at which each balloon explodes, though the more pumps the participant makes, the greater the possibility of the balloon exploding, and the greater the risk. The goal of the task is to earn as much money as possible by the end of the 90 trials.

RTB is measured by the “adjusted number of pumps,” which is calculated by taking the average number of pumps on each balloon excluding the balloons that exploded (i.e., the average number of pumps prior to banking money). The exploded balloons are excluded from the risk-taking calculation because the participants are limited in the number of inflations they can make by the fact that the balloon explodes; they might choose to continue pumping the balloon (i.e., engage in RTB) but are prevented from doing so by the balloon exploding. The balloon can be pumped a maximum of 128 times. The average explosion point of the balloons is 64, and
therefore in theory participants should pump each balloon 64 times to maximize their potential earnings. Pumping the balloon just under or up to 64 times would be the most advantageous course of action, although most participants on the BART pump the balloons much less than 64 times due to the ambiguous nature of the task. Some have argued that measuring risk-taking by the adjusted number of pumps is problematic because participants who pump closer to 64 times are viewed as high in RTB even though these participants maximize their potential profits.

Killgore (2007) attempted to overcome this problem by using a risk/benefit ratio, which calculates the proportion of risk each participant takes relative to the proportion of benefit they obtain (i.e., \([\text{number of exploded balloons/total number of balloons}] \div [\text{total money cashed in/maximum possible money}]\)). A ratio greater than 1.0 indicates higher risk incurred for less financial reward (i.e., more risk-seeking), and a ratio less than 1.0 indicates greater benefit relative to the level of risk incurred (i.e., less risk seeking). A study by Killgore, Kamimori, and Balkin (2010) utilized this Risk/Benefit Ratio as well as the adjusted number of pumps, and found significant effects using the former method of calculation, but no main effects or interaction effects using the latter.

A study by Acheson, Richards, and de Wit (2007) utilized the BART as part of a battery of risk tasks that were administered following 24 hours of TSD. Thirty trials were administered at baseline, and again following sleep deprivation, with the order of TSD and normal sleep counterbalanced. Contrary to the research hypotheses, this study found that TSD decreased RTB as measured by the BART in women, and did not significantly affect RTB in men.

The BART is a straightforward, empirically validated measure of RTB that is easy to administer in a laboratory setting. However, there are two disadvantages to this gambling task. First, like the IGT, the BART involves repetitious pressing of a button, and is therefore subject to
error from random responses due to boredom and sleep deprivation. Additionally, the formula for calculating adjusted risk automatically biases the risk-taking score downward because it only accounts for unexploded balloons (Pleskac, Wallsten, Wang, & Lejuez, 2008). It may not accurately represent how much risk the participant was willing to take.

- The Lottery Choice Task. The Lottery Choice Task (Smith, Dickhaut, McCabe, & Pardo, 2002) was designed to assess risk preference separately for decisions that result in gains and decisions that result in losses. Additionally, the LCT measures risk-taking when the odds of a risk are known or ambiguous. This gambling task involves two conditions: (a) a known risk condition, in which the odds of winning or losing money are known, and (b) an ambiguous risk condition, in which the odds of winning or losing are not known.

During the known risk condition, participants draw colored chips from two containers 10 times. Each container contains three colors of chips, and each color represents a different dollar amount of money. The first five times that the participant chooses chips, the dollar amounts are positive, reflecting the amount of money they will gain, and the second five times, the dollar amounts are negative, reflecting losses. The participant is told how many of each colored chip is in each container, and is informed how much each chip is worth. Therefore, the participant is aware of their chances of winning or losing a certain amount of money. Container one contains a ratio of chip colors and dollar amounts that is less variable than container two, and is thus deemed a less risky option.

The method for the ambiguous risk condition is identical to the known risk condition, except that participants are not told how many of each colored chip is in container one (the safer option). Thus, the participants are unable to calculate their exact chances of winning or losing a
certain amount of money, and must choose between an ambiguous container (container one) and a risky container (container two).

An experiment conducted by McKenna and colleagues (2007) utilized the LCT and other RTB measures under conditions of TSD. Participants completed the tasks when fully rested, and while sleep deprived, and were told that the amount of money they won or lost would reflect the amount of money they were paid upon completion of the study. Well-rested participants exhibited less RTB for gains and more RTB for losses. Following sleep deprivation, participants exhibited more RTB for gains and somewhat less RTB for losses, indicating that TSD had a significant effect on risk-taking behavior. No significant effects of TSD on ambiguity preference were observed.

The biggest strength of the LCT is its ability to distinguish between known risk and ambiguous risk preference, and to investigate how outcomes vary when they involve gains or losses. The task is visually easy to understand and simple to administer, and is more hands-on than a computer simulation involving hypothetical money. However, it is difficult to draw any firm conclusions about the effects of sleep loss on RTB because the LCT is not widely used or replicated in the sleep-risk research.

- The Stop Light Task. The Stop Light Task (Greenwald, Johanson, & Schuster, 1999) is a computerized laboratory model of RTB that requires participants to make decisions that result in monetary loss or gain, in which choices are cued by red, yellow, and green lights similar to a traffic signal. For each of the 48 trials, participants type 100 x-y key combinations within a limited time frame. Completion of all 100 combinations before time expires results in earning money, and failure to complete all 100 combinations results in losing money.

Participants begin typing the combinations when a green light appears on the computer
screen. A yellow light replaces the green light after a pre-determined number of combinations are completed, ranging from 15-50. At this time, participants must decide whether to stop typing combinations and neither gain or lose money, or to continue typing combinations in the hopes of winning more money. However, if all 100 combinations are not completed before the red light appears (between one and nine seconds later), the participant loses money. Therefore, the participant must decide whether they are willing to risk losing money for the sake of winning money. RTB is measured by the proportion of attempts to complete the combinations, regardless of whether the attempt is successful or not (i.e., how many times the participant is willing to take a risk, regardless of outcome).

Roehrs, Greenwald, and Roth (2004) utilized the Stop Light Task in a study that linked level of sleepiness with RTB. They found that sleepy participants made fewer risky choices than alert participants, but alert participants earned more money than sleepy participants, indicating that alert subjects were better able to judge when risky choices would result in a favorable outcome. Therefore, the findings from this article suggest that sleep loss increases the likelihood of making risky choices that result in less optimal outcomes.

Like the BART, the Stop Light Task provides a simple way to measure how willing a participant is to take a risk for the sake of earning a reward. This task is more labor intensive than the other tasks utilized in sleep-risk studies, which can be viewed as both an advantage and a disadvantage. On the one hand, the increased demand placed on the participant provides a more stimulating, engaging task, and might therefore reduce the amount of random decision-making that could invalidate the constructs being measured. However, this task measures willingness to engage in RTB, and sleep deprived participants might be less willing to engage in a labor-intensive task due to exhaustion. This lack of participation due to exhaustion would be
measured as risk aversion rather than as unwillingness to put forth the effort required to complete the task.

- Simple gambling decision tasks. Two of the studies included in this literature review created a unique simple gambling decision task to assess risk-taking preferences. In both instances, participants were presented with a series of gambles requiring them to make a decision between two or more options that resulted in winning or losing money.

For example, Venkatraman and colleagues (2007) designed a task that involved three types of gambles: high-risk gambles, which involved either a loss of money or a winning a large sum of money ($30-$70), low-risk gambles, which always involved gaining a smaller amount of money ($2-$40), and certain gambles, which had a 100% chance of winning some amount of money ($4-$30). These types of gambles were arranged so that participants were given two types of choices: a choice between a certain and low-risk gamble, or a choice between a low-risk and high-risk gamble. The researchers presented the choices graphically as a pie chart, with each amount of money to be won or lost depicted. A white ball moved along the outside of the pie chart for a certain amount of time (1.5 seconds to 4.5 seconds). After the allotted time, the ball stopped moving, coming to rest alongside one of the two gamble types, and the appropriate amount of money was won or lost.

Participants decided whether they wanted to engage in the certain/low-risk gambling type, which had a 50% chance of winning a small amount of money (e.g., $10) or a 50% chance of winning a slightly higher amount of money (e.g., $40), or the low-risk/high-risk gambling type, which had a 75% chance of losing an amount of money (e.g., $15) or a 25% chance of winning a large amount of money (e.g., $65). Six sets of 10 trials each were conducted for each volunteer in each of three treatment conditions. After each decision was made, a message
appeared that displayed the winnings as well as what would have been won had the other option been chosen. As each decision was made, the researchers used MRI technology to map neural activity during decision-making.

The researchers found that sleep deprived participants displayed increased activations in the area of the brain associated with risky decision-making, as well as decreased activity in an area that is involved in learning the negative consequences of risky behavior. This pattern of neural activity suggests that there is a possible shift in brain patterns toward risk-seeking behavior when sleep deprived.

Simple decision tasks such as these are easy to design and can be tailored to suit the needs of a particular experiment, thus making them a useful tool in measuring RTB. The tasks can be as simple or as complex as necessary, and the variety of options available to researchers is limitless. However, because these tasks are unique to each experiment, validity and reliability concerns can exist, and caution must be exercised both in designing and implementing these measures.

- Discounting tasks. Some researchers chose to measure RTB using discounting tasks, which force participants to make a decision between two options. Several variations of discounting tasks exist, though Delay and Probability Discounting Tasks (Kirby, Petry, & Bickel, 1999; Richards, Zhan, Mitchell, & de Wit, 1999) and Experiential Discounting Tasks (EDT; Reynolds & Schiffbauer, 2004) are two of the most widely utilized types.

As previously stated, impulsivity is one of the most widely researched personality constructs thought to play a role in an individual’s propensity to engage in RTB. Discounting tasks measure impulsivity by presenting participants with a set of choices, each comprised of a smaller, immediate reward and a larger, delayed reward. For example, Kirby’s version of the
delay and probability task asks participants if they would rather receive (a) $49 today or (b) $60
dollars in 89 days. Individuals who choose the immediate reward (e.g., $49) are considered to be
more impulsive than individuals who choose the delayed reward (e.g., $60), and therefore
thought to have a higher propensity for RTB.

One study included in this review utilized both the Kirby’s discounting task and the EDT
with participants who were kept awake for 24 hours (Acheson et al., 2007). Each task was
administered to each participant twice during the sleep deprivation session, and twice during the
normal sleep session. The researchers found that sleep deprivation did not significantly affect
RTB on either discounting task.

Discounting tasks are well correlated with other behavioral measures of impulsivity, are
easy and quick to administer, and are available in both paper-and-pencil and computer formats.
They are widely utilized in the field of risk-taking research, and are therefore easily accessible
and empirically validated. However, the questions asked of participants are very similar and
involve simple decisions between two choices, and thus participants, especially sleepy
participants, might choose between the options arbitrarily without putting much thought into
each decision.

Self-Report Measures of RTB

Nine of the studies utilized at least one self-report measure to assess RTB, for a total of
eight separate surveys included in this literature review. Of these studies, four combined a self-report
survey with one of the aforementioned behavioral measures, and three utilized more than
one self-report measure of RTB. Though a wide variety of surveys were used, they can be
categorized into sensation-seeking and impulsivity scales (four studies), health risk behavior and
specific risk behavior surveys (four studies), and one indirect self-report measure of RTB that was created specifically for the study.

- Sensation-seeking and impulsivity self-report measures. The Sensation Seeking Scale (SSS; Zuckerman, Eysenck, & Eysenck, 1978) is a 40-item questionnaire that presents participants with opposing statements involving sensation seeking (e.g., “A: I would not like to try any new drug which might produce strange and dangerous effects on me” or “B: I would like to try some of the new drugs that produce hallucinations”). Participants choose the statement (A or B) that best describes what they like or how they feel. An abbreviated eight-question Brief Sensation Seeking Scale (BSSS) tailored to adolescent populations was developed in 2002 (Hoyle, Stephenson, Palmgreen, Lorch, & Donohew) and was utilized by each of the studies included in the present review. In contrast to the forced-choice format of the SSS, the BSSS presents a series of single statements (e.g., “I like to do frightening things”). Participants rate each item on a 5-point rating scale from 1 = strongly agree to 5 = strongly disagree. Unlike delay and probability tasks discussed in the previous section, which present mathematical risk scenarios in a forced decision format, the SSS and BSSS require participants to identify with statements that describe examples of RTB. While the participants are not directly evaluating their propensity to engage in risk-taking, they are making statements about how much they like or dislike engaging in specific RTB. Thus, researchers can understand how likely or unlikely a participant feels they are to engage in risk-taking.

- The Eysenck Personality Inventory (EPI; Eysenck, Pearson, Easting, & Allsopp, 1985) is a self-report survey designed to measure three dimensions of personality. It includes several subscales, one of which is the impulsivity subscale. The impulsivity subscale consists of 19 yes or no questions designed to reflect a person’s level of engaging in impulsive behavior,
with higher scores indicating a higher tendency toward impulsivity. “Do you often do things at the spur of the moment?” and “do you usually work quickly, without bothering to check?” are examples of the types of questions asked on the EPI impulsivity subscale.

- The English translation of the Evaluation of Risks Scale (EVAR; Sicard, Jouve, Blin, & Mathieu, 1999) is a 24-item survey of risk-relating traits, including impulsivity and sensation seeking. Statements such as “I feel like gambling” are centered over a 100-millimeter line, with one end labeled “not at all” and the other labeled “very much,” and participants are asked to mark the point on the line that indicates their current desire to engage in each behavior. The measure yields a total risk-taking propensity score, as well as five factors, including self-control, danger-seeking, energy, impulsivity, and invincibility.

- Health risk surveys and specific RTB self-report measures. The Youth Risk Behavior Survey (YRBS; Brener, Collins, Kann, Warren, & Williams, 1995; O’Brien & Mindell, 2005) was developed by the Centers for Disease Control (CDC) in 1990 and is conducted once every two years to assess several specific risk-taking behaviors estimated to cause the highest rates of morbidity and mortality among adolescents. Participants are asked how often they engage in behaviors such as alcohol use, sexual behaviors, and unsafe behaviors within a specific time frame, and are presented with possible answers in a multiple-choice format. Items include questions such as “during the past 30 days, on how many days did you smoke cigarettes?”

A second survey created by the CDC is the National College Health Risk Survey (NCHRS), which is a 100-item self-report inventory of specific risk behaviors that are likely to have a negative impact on health (Centers for Disease Control, 1997). Each item requires participants to respond to questions in a multiple-choice format about the frequency of engaging
in risky behaviors such as tobacco use, sexual behaviors, and behaviors that contribute to injuries.

The National Health Interview Survey (NHIS) is conducted regularly by the CDC and the National Center for Health Statistics (NHCS; Schoenborn & Adams, 2008). The survey consists of three modules: the family core, the sample adult core, and the sample child core. The sample adult core is the module of interest for the purposes of this review, and explores the association between sleep duration and the prevalence of specific health risk behaviors. Information is collected via personal interviews conducted by employees of the United States Census Bureau, and relate to basic health information, demographic information, and the prevalence of engaging in health risk behaviors such as smoking, alcohol use, and obesity.

One of the studies included in this literature review utilized archival data from the National Longitudinal Study of Adolescent Health (Add Health; Udry, 1998), which was designed to explore connections between insomnia, depressive symptoms, and risky behaviors. RTB was assessed using a Likert-type scale that measured how frequently a participant engaged in specific RTB such as alcohol and drug use, and the survey included a 13-item measure of delinquency as well as a series of seven yes or no questions pertaining to decision making. Additionally, the survey presented statements such as “I live without thought for tomorrow” and asked participants to indicate their agreement on a 5-point Likert-type scale ranging from “strongly agree” to “strongly disagree.”

Indirect Self-Report Measure of RTB

One study designed and implemented a four-item self-report survey that indirectly measured RTB (Jones, Dorrian, Jay, Lamond, Ferguson, & Dawson, 2006). Researchers asked
sleep-deprived participants to answer questions pertaining to their perception of their ability to complete a task safely. Questions such as “how safely could you drive a car right now?” were rated on a 7-point Likert-type scale. Each participant also completed a psychomotor vigilance task, and the results of the ability to perform physical tasks was compared to their perception of their ability to complete the task as well as their willingness to engage in the behavior despite being sleepy. Participants who perceived themselves capable of executing driving tasks and willing to do so despite decreased ability to perform psychomotor vigilance tasks were deemed “risky.”

Self-report measures are often utilized in research studies because they are easily administered and often less time consuming or expensive than experimental manipulation of RTB. Surveys can be electronically administered, and can be tailored to answer specific research questions. While many risk-taking surveys are well correlated with RTB, self-report measures have an inherent potential for error. It is possible that participants may skip questions, misunderstand the questions, or answer untruthfully, haphazardly, or randomly. Additionally, individuals might respond to the survey in a socially desirable way, or might tend to respond in a specific manner to all questions. For example, participants might hesitate to give “extreme” answers, and thus cluster all of their responses around the middle (i.e., choose only Items 2, 3, and 4 in a 5-point Likert scale), or might agree with every statement (i.e., yea-saying).

**Experimental Manipulation of Sleep Loss**

Ten studies used TSD to experimentally manipulate sleep in a laboratory. Two studies paired laboratory TSD with a self-report measure of sleepiness, and eight utilized TSD and some other measure of sleepiness, such as actigraphy or sleep logs.
Laboratory TSD requires participants to go without any sleep of a specified length of time, usually at least 24 hours, under controlled conditions in a sleep laboratory. Participants usually arrive at the facility in advance of the start of sleep deprivation, and often one night of normal sleep in the laboratory is used to acclimate participants to the environment. Activities such as reading, watching television, or engaging in light exercise are sometimes allowed, though the specific restrictions on activity vary depending on the study. Some studies choose to continuously monitor participants and measure or manipulate the variables of interest at regular intervals during the TSD, while others choose to measure variables at the end of the TSD. Participants are usually allowed to sleep before leaving the laboratory. Often, studies will require individuals to participate in two sleep laboratory sessions, one during which the TSD occurs, and one during which normal sleep occurs, though each session involves the same measures of the variables.

For example, a study conducted by Killgore (2007) experimentally manipulated sleepiness by subjecting participants to 61 hours of TSD. Groups of two or four participants arrived at the laboratory and slept from 11:00 pm to 7:00 am in a fully darkened room to ensure an even baseline of sleepiness. For the next 61 hours, participants remained awake and engaged in cognitive tasks, played games, watched television, and interacted with other volunteers. Surveys and experimental measures of RTB were administered at baseline, after 23.2 hours awake, and following 61 hours of TSD. Participants were administered the BART, the BSS, the EVAR, and the Morningness-Eveningness Questionnaire (a self-report measure of sleep tendencies), and were monitored by actigraphy and polysomnography. Killgore found that as sleepiness increased, RTB and self-reports of RTB decreased.

Laboratory TSD allows researchers to completely control and experimentally manipulate
sleep, allowing for more concrete statements to be made about causal relationships between sleep loss and RTB. However, TSD requires a longer commitment time from participants and researchers, an appropriately equipped facility, and more resources (e.g., controlled food, activities for the participants) than other measures of sleep. This can limit the number of participants that can be included in the study, and smaller sample sizes can result in reduced power in statistical analyses.

Self-Report Surveys and Other Measures of Sleep Loss and Sleep Quality

Six studies utilized some form of sleep measure other than laboratory TSD. Seven studies used self-report surveys, one study used the Multiple Sleep Latency Test (MSLT), and although no study used exclusively actigraphy, polysomnography, or sleep logs, 10 studies used one of these methods in conjunction with another measure of sleep. Five studies used more than one form of non-TSD measurement, and eight studies combined TSD with another measure.

- Self-report surveys of sleep. The Child Sleep Questionnaire (CSQ; Brown, 2008) is a 41-item self-report survey that is used to screen for sleep problems in children ages 2-18. Parents of younger children and adolescents are asked to answer questions about the frequency of sleep behaviors on a 5-point Likert-type scale ranging from “never” to “5 or more times a week.” Questions are centered on such topics as bedtime resistance, snoring, and sleepwalking. The CSQ also includes an 8-item modified Epworth Sleepiness Scale (ESS) that assesses daytime sleepiness.

The Sleep Habits Survey (SHS; Wolfson & Carskadon, 1998) was developed to assess unusual sleeping and waking behaviors that participants experienced over the course of two weeks prior to completing the questionnaire. Measures of total sleep times and bedtimes for both
school nights and weekends are included, along with measures of the differences between bedtime delay and oversleep for weeknights versus weekends. Academic performance, daytime sleepiness, sleep-wake behavior problems, and depressive mood are also assessed in the SHS. Most questions ask how frequently the participant experienced or engaged in a specific behavior or problem.

The NHIS, mentioned previously in the health risk surveys and specific RTB self-report surveys section, included a measure of sleep duration, which was correlated with specific RTB such as smoking and alcohol use (Schoenborn & Adams, 2008). The Sample Adult questionnaire was administered via household interviews, and asked participants how many hours they sleep in a typical 24-hour period. No other measures of sleep quality or sleep disturbances are included in this survey.

The Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976) assesses an individual’s tendency to prefer earlier or later rise and bedtimes. Participants who score higher on morningness tend to prefer morning activities to evening activities. The self-report survey contains 19 multiple-choice questions relating to the participant’s preference for certain sleep/wake behaviors. For example, participants are asked to indicate “when he/she would prefer to wake up or start sleep, rather than when he/she actually does.”

The Stanford Sleepiness Scale (SSS; Hoddes, Zarcone, Smythe, Phillips, & Dement, 1973) is a brief self-report measure of how sleepy a person feels at certain times during the day. The survey can be used to track sleepiness throughout the course of several days, or to provide information on sleepiness at the time of testing. Participants choose their rating of sleepiness from a 7-point Likert-type scale that ranges from feeling active, vital, alert, or wide awake to no longer fighting, sleep, sleep onset soon; having dream-like thoughts.
The Sleep Quality Index (SQI; Urponen, Partinen, Vuori, & Hasan, 1991) is an eight-item self-report inventory of general sleep difficulties. Participants respond to each question about sleep problems with a rating of 0, 1, or 2, with 2 indicating the most common or severe symptom. The weighted scores for all eight items are summed to create a total sleep quality score, which included “good sleep quality,” “occasional sleep difficulties,” and “poor sleep quality.”

The Add Health study (Udry 1998), which was described in the health risk surveys and specific RTB self-reports section, included a brief, two-item measure of possible pediatric insomnia. The goal of this portion of the survey was to assess disturbed sleep and daytime consequences. One question asked about trouble sleeping, and the other asked about morning tiredness over the course of the past year, and participants indicated the frequency of each indicator of possible insomnia using a 5-point Likert-type scale ranging from never to every day.

The advantages and disadvantages of self-report measures of sleep are similar to those discussed for RTB. Self-reports are quickly and easily administered, can be administered in whatever format is appropriate to the study, and can be tailored to answer specific research questions. However, surveys have a higher potential for error in the form of omitted or untruthful answers, social desirability bias, and yea-saying.

Self-report surveys of sleep have an additional limitation because sleep loss is generally the independent variable in each of the reviewed studies. In other words, the researchers are usually interested in determining the effect of sleep loss (i.e., independent variable) on RTB (i.e., dependent variable). When self-report surveys are used to measure sleep loss, no experimental manipulation is occurring (as with laboratory TSD). Rather, participants are asked to report on their experiences of sleep loss, describe how sleepy they feel, and quantify how much they have
slept. These reports are then correlated with behavioral or self-report measures of RTB to provide an idea of how sleep loss affects risk-taking behavior. Although a correlational relationship can be described, no causal relationship between sleep loss and RTB can be identified using sleep surveys. This inability to draw conclusions about cause and effect is the major limitation of self-report measures of sleep.

- **Other measures of sleep.** The Multiple Sleep Latency Test (MSLT; Carskadon, Dement, & Mitler, 1986) is designed to determine a participant’s basal level of sleepiness at the time of testing. Participants are instructed to go to sleep, and sleep stages marked by rapid eye movement (REM) are observed using polysomnography. Sleep latency is scored as the number of minutes it takes to reach the first epoch (30 second duration) of Stage One sleep, which marks a uniform point at which all participants are deemed “asleep.” Thus, researchers are able to determine how sleepy each participant is based on how long it takes them to fall asleep, and therefore compare sleepiness to risk-taking behavior in a uniform manner.

  Actigraphy and polysomnography are two methods of measuring sleep that involve monitoring cycles of rest and activity (Ancoli-Israel, Cole, Alessi, Chambers, Moorcroft, & Pollack, 2003). Actigraphy involves wearing a watch-like device that identifies rest-activity rhythms that occur as a participant engages in normal daily activities and sleep. Actigraphy provides one-dimensional data, whereas polysomnography, which involves monitoring a participant during sleep, provides three types of data, electroencephalography (EEG), electrooculography (EOG), and surface electromyography (EMG), which together determine whether a person is asleep or awake. Polysomnography requires a participant to spend a night in a sleep laboratory and be monitored by machines and electrodes, while actigraphy is no more
invasive than wearing a new watch. Nine of the studies included in this review used actigraphy, and two studies used polysomnography, to provide a measure of sleep patterns.

Three studies chose to use sleep logs to gain information about sleep patterns, in which participants were asked to keep a record of bedtimes and wake times for a specified length of time prior to the start of the study. Some studies asked for qualitative descriptions of sleep or other information such as mood, though the level of detail required varied depending on the needs of the study.

Unlike sleep logs, the MSLT, actigraphy, and polysomnography are useful in providing quantifiable information about a participant’s general sleep patterns. Sleep logs also provide information, but are dependent upon participation cooperation and memory, and are therefore less reliable. However, sleep logs do not require the use of any additional equipment, and are therefore more convenient and cost effective than any of the other methods.

**Empirical Findings on the Relationship between Sleep Loss and RTB**

The results of the studies that investigated sleep loss and RTB are divided into four areas. First, I report the results for the overall relationship between sleep loss and RTB. Then, I report the results for variables that are proposed to affect the relationship between sleep loss and RTB, including (a) the VMPFC, (b) mood, and (c) gains versus losses.

Overall Relationship between Sleep Loss and RTB

Overall the majority of studies (12 of 16) found that higher levels of sleepiness were associated with higher levels of RTB. For example, Killgore and colleagues (2007) exposed 26 volunteers to 75 hours of TSD, and asked them to complete the IGT at baseline, following 51
hours of TSD, and following 75 hours of TSD. When the participants were well rested, their decisions shifted to “safe” decks as the task progressed, indicating that they were able to learn which decks resulted in long-term benefits. However, sleep-deprived participants shifted their preference toward “risky” decks, or decks that yielded short-term gains and long-term losses. Thus, RTB indicated by performance on the IGT was impaired by sleep deprivation. Several other studies, which employed a variety of measures of sleep loss and RTB, found similar results, indicating that higher levels of sleepiness are generally associated with higher levels of RTB. Seven of the 12 studies that supported this conclusion involved experimentally manipulating sleepiness using laboratory TSD. Thus, it is reasonable to conclude that a causal relationship exists between sleep loss and RTB.

Although the majority of studies found a positive association between sleep loss and RTB, four studies did not. For example, Killgore (2007) subjected 54 participants to 61 hours of laboratory TSD, and asked them to complete the BART at baseline, following 23 hours of TSD, and following 61 hours of TSD. He found that compared to baseline, sleep-deprived participants had lower scores for risk, indicating that sleepy participants were less willing to engage in RTB as measured by the BART. Killgore suggested that this decrease in RTB, which was contrary to his hypothesis, was possibly due to the fact that sleep-deprived participants were less willing to expend the energy necessary to have higher risk scores. Because risk scores are contingent on the number of key presses each participant makes, sleepy participants might have been less willing to press the button as frequently, which influenced their risk scores.

Mechanisms by which Sleep Loss is Related to RTB

- VMPFC. The VMPFC has been hypothesized to mediate the relationship between
sleep loss and RTB. Sleep deprivation has been linked to decreased metabolic activity in the VMPFC (Thomas et al., 2003), and sleep deprivation has been linked to increased RTB. Thus, some researchers have suggested that the increase in RTB is due to changes in the VMPFC.

To examine this hypothesis, Killgore et al. (2006) conducted a study in which participants underwent 49 hours of laboratory TSD. They completed the IGT once at baseline and once following the sleep deprivation. Relative to baseline, performance on the IGT was significantly impaired following TSD. Fully rested participants gradually shifted their preference for deck selection toward the “safe” decks (those that result in a net gain) and away from the “risky” decks (those that result in a net loss) during the latter half of the task. When these same participants were tested following TSD, their pattern of responding reversed, and shifted their preference toward “risky” decks as the game progressed, indicating that they were likely less able to weigh the short-term benefits of “risky” decks against the long-term benefits of the “safe” decks.

The sleep-deprived participants in this study showed decision-making patterns similar to patients with lesions in the VMPFC. The researchers suggested that sleep loss might adversely affect the VMPFC, which in turn might affect RTB. Drawing from the Somatic Marker Hypothesis (SMH), which is related to VMPFC functioning, Killgore and his colleagues (2006) posited that sleep deprivation might have a negative effect on the functions of the VMPFC that rely on the ability to integrate emotion with other cognitive processes. Thus, both the VMPFC and emotion could possibly play a role in mediating the relationship between sleep loss and RTB.

- Mood. Mood may also be a mediator of the relationship between sleep loss and RTB. Sleep loss has been shown to increase negative mood (Paterson et al., 2011), which has been
theorized to prompt individuals to increase RTB in an attempt to achieve a positive outcome, thereby making them feel better and regulating their mood (Harrison & Horne, 2000).

Catrett and Gaultney (2009) utilized the Add Health Study to investigate whether sleep loss (which they operationalized as insomnia) was related to RTB in adolescents when depression was controlled for. They found that increased sleep loss correlated with some increased RTB (i.e., drunk driving) when depression was controlled, but that depression was a better indicator of other RTB (i.e., participation in violence). Not surprisingly, both sleep loss and depression were associated with other risk behaviors (i.e., smoking and delinquency). Given the high level of intercorrelation between these constructs, as well as the previous research suggesting that sleep loss has an impact on mood and that mood has an impact on RTB, it is possible that mood mediates the relationship between sleep loss and RTB.

- Gains versus losses. Reflection effects and framing effects, both of which revolve around gains- and loss-based motivation for decisions, are important influences on RTB. Reflection effects refer to the tendency to alter RTB when the outcomes of decisions involve either gaining something or losing something (e.g., when the outcome involves winning money, RTB increases, when the outcomes involves losing money, RTB decreases). Framing effects involve a change in risk preference based on an individual’s perception of whether a decision outcome involves gains or losses, independent of the actual outcome. In this case, the outcomes of each option might be identical, but RTB will change depending on how the individual perceives the options to differ.

This focus on gains and losses might influence the relationship between sleep loss and RTB, because sleep loss might impact both how individuals perceive risk (framing), and how willing they are to take risks when choices result in gains or losses (reflection). In either case,
when the outcome involves gains or the individual perceives the outcome to involve gains, the relationship between sleep loss and RTB may be different than when the outcome involves losses or the perception of losses. Therefore, gains and losses might change the relationship between sleep loss on RTB either through reflection effects or framing effects.

McKenna et al. (2007) used the LCT and laboratory TSD to investigate sleep loss and RTB. As previously described, the LCT requires participants to make a series of decisions under known risk and ambiguous risk conditions. Five trials of each type of risk involve positive dollar amounts (gains), and five trials of each type of risk involve negative dollar amounts (losses). The information and risk conditions are identical in the gains and losses trials; the only difference is whether the outcome involves gains or losses. Therefore, the LCT measures reflection effects.

This study found that when participants were well rested, they engaged in less RTB when the decisions involved gains and more RTB when they involved losses. However, under conditions of TSD, the opposite was true. Sleepy participants exhibited more RTB for gains and less RTB for losses. This switch in risk preference under conditions of TSD indicates that sleep loss significantly affected RTB. Furthermore, it appears that the effects of sleep loss on RTB differ when the outcomes involved gains and losses. Thus, it is possible that gains and losses might moderate the relationship in the context of reflection effects.

Framing effects might also help explain the relationship between sleep loss and RTB. One study by Venkatraman and his colleagues (2011) investigated how sleep loss might alter an individual’s perception of gains and losses, and therefore affect RTB. Participants were presented with a risky decision-making task specifically developed for this study at baseline and following one night of TSD. Each decision, or gamble, was comprised of five possible
outcomes: a large gain (e.g., $65 to $85), and intermediate gain (e.g., $35 to $50), an intermediate loss (e.g., -$35 to -$50), a large loss (e.g., -$65 to -$85), and a central reference outcome (e.g., $0). Each outcome had a probability between 0.1 and 0.3, and the probability always summed to 1 across the five outcomes. Each gamble was displayed for 4 or 6 seconds, and participants completed 120 trials. Half of the gambles were gains-focused and half were loss-focused.

After each gamble was presented, participants were given two options for improving the gambles. In the gains-focused trials, participants could either add money to the largest gain (i.e., maximize the highest gain) or could add money to the reference outcome of $0 (i.e., improve the overall probability of winning money compared to losing money). In the loss-focused trials, participants could either add money to the largest loss (i.e., minimize the highest loss) or could add money to the reference outcome of $0 (i.e., improve the overall probability of winning money compared to losing money). Participants were given 6 seconds to decide which option to choose.

The gambles were designed to determine whether participants preferred seeking gains or avoiding losses. Participants were said to prefer seeking gains if they chose to maximize the highest gain rather than improve the overall odds of winning money during the gains-focused trials. During the loss-focused trials, participants who chose to improve the overall odds of winning money rather than minimize the largest loss were said to prefer seeking gains. Participants in the gains-focused trials who chose to improve the overall odds, and in the loss-focused trials chose to minimize the largest loss, were said to prefer avoiding losses.

During each trial, participants were monitored using fMRI to map neural responses to decision-making. Following completion of the gambles, participants were monitored as they
passively watched 40 gambles resolved to gains or losses to evaluate their neural sensitivity to rewards.

Well-rested participants focused on avoiding losses (which researchers deemed the less risky course of action), while sleep deprived participants shifted focus to seeking gains (the more risky course of action). Thus, risk-taking preference for gains-framed gambles increased with sleep deprivation. More importantly, this shift in risk preference suggests that sleep deprived participants experienced an unfounded rise in expectation for gain. These behavioral observations were supported by neuroimaging findings in which sleep deprivation altered VMPFC responses, which is associated with reward anticipation, and right anterior insula activation, which is associated with emotional processing.

The researchers suggested that sleep deprivation might create an optimism bias in which participants behave as if positive consequences (gains) are more likely or valuable, and negative consequences (losses) are less likely or harmful. Therefore, participants’ perception of gains and losses is affected by sleep deprivation, which is a framing effect (i.e., independent of outcomes, participants’ perception of gains and losses influenced their risk preference). This might occur because sleep deprivation causes participants to pay more attention to gains relative to losses, and to change their perception of the value of the outcomes (i.e., increase emphasis on gain outcome relative to loss outcome, even though there is not actually a change in the outcome).

The findings from this study illustrate that framing effects might mediate the relationship between sleep loss and RTB. Sleep loss may cause a shift in perception of gains and losses, which may influence risk preference. However, additional studies that separate framing effects from reflection effects are needed to draw firm conclusions about the effect of framing on the relationship between sleep loss and RTB.
Measurement Issues that May Influence the Relationship between Sleep Loss and RTB

- Behavioral measures. Several studies have utilized behavioral measures in addition to self-report measures of RTB, which is advantageous because there are several weaknesses of self-report measures (e.g., social desirability). However, the type of behavioral measure used has varied from study to study. Of the 11 studies that utilized a behavioral measure of risk-taking, five used the BART, two used the IGT, two used simple decision tasks, two used discounting tasks, one used the LCT, and one used the Stop Light Task. There is some question as to whether each of these behavioral tasks measures the same construct (i.e., convergent validity).

It is interesting to note that four of the five studies that used the BART were the only studies of the 16 studies reviewed that did not find that increased sleepiness is linked to or causes increased RTB. No study to date has investigated the convergent validity of the BART and IGT in the context of sleep loss, and thus it is impossible to definitively determine why this discrepancy exists, though possibilities have been proposed. Most notably, the BART may represent a more physically demanding task than the other measures of risk-taking behavior. Participants are required to repeatedly press a button to inflate balloons on a computer screen. Sleep deprived individuals might be less willing to expend the energy required to inflate the balloons (Killgore, 2007), and it might be this decreased motivation to perform the task that is resulting in lower risk-taking scores, not actual risk preference (Acheson et al., 2007).

One study that utilized the BART found that RTB increases as sleep loss increases (Killgore et al., 2010). This study included 77 hours (4 days) of laboratory TSD, which was far longer than any other study included in this review. The authors of this study hypothesize that this extreme duration of TSD was the reason the results were so different than previous studies that utilized the BART. They argue that participants who are sleep deprived have the tendency
to engage in riskier behaviors, but that the aforementioned motivation decrease caused by the BART masks this tendency, resulting in decreased RTB. However, they hypothesize that following 77 hours of continual wakefulness, this balance between risk-taking, motivation, and sleep becomes unstable, resulting in increased RTB. As this study is the only one thus far to report increased RTB during TSD using the BART, more research is needed before any firm conclusions can be drawn.

- General versus specific measures of RTB. Few studies included in this review investigated whether sleep loss affects general RTB (i.e., risk propensity) in the same manner as specific RTB (i.e., smoking, drug use, etc.). While three studies did measure specific RTB, they utilized only self-report surveys of sleep and risk behaviors, unlike the majority of studies that investigated general risk-taking and included self-report and behavioral or experimental measures. Additionally, no study measured general and specific RTB together in the context of sleep loss.

Of the studies that measured general RTB (Acheson et al., 2007; Brown, 2008; Killgore, 2007), each found no significant difference in scores on self-report measures of general RTB (i.e., EVAR, BSSS, DDT) among participants with increased levels of sleep loss. In contrast, among the studies that measured specific risk-taking behavior (Catrett & Gaultney, 2009; O’Brien & Mindell, 2005; Vail-Smith, Felts, & Becker, 2009), each found scores on self-report measures of specific RTB were positively correlated with increased levels of sleep loss. These findings do not mean that sleep loss is not related to general RTB, however. As previously stated, decreased performance on behavioral measures of RTB (i.e., IGT, LCT, Stop Light Task) have been linked with increased levels of sleep loss, and these behavioral measures of RTB have been linked to sensation seeking and disinhibition scores (Buelow & Suhr, 2009; Crone, Vendel,
& van der Molen, 2003). It is possible that sleep loss affects general RTB and specific RTB; the discrepancy in findings to date might be related to methodological differences. Thus, more studies that investigate both specific and general RTB in the context of sleep loss are needed.

Discussion

The study of the relationship between sleep loss and RTB is still in its early stages. Relatively few studies have been conducted exploring these variables, and any conclusions should be interpreted with caution. The purpose of this literature review was to organize and describe what information and studies exist that explore the relationship between sleep loss and RTB, to highlight possible explanations for these findings, and to inform future research that might further investigate sleep loss and RTB.

It is important to study the relationship between sleep loss and RTB. As previously noted, 29% of adults report sleeping 6 hours or less each night (Schoenborn & Adams, 2008), and the percentage of adults who report inadequate sleep is increasing (Luckhaupt et al., 2010). Sleep loss has been linked to several physical, cognitive, and behavioral issues (Luckhaupt et al., 2010; Dinges et al., 1997; Harrison & Horne, 2000). RTB, by its very definition, involves the potential danger or harm, and the majority of studies suggest that sleep loss increases RTB. Since sleep loss is a growing issue and presents a variety of adverse effects, including an increased potential for dangerous or harmful behavior, it is necessary to study its impact and create solutions for coping with the challenges presented by inadequate sleep.

The majority of the studies found that as a person’s level of sleepiness increases, their tendency to engage in RTB, or their self-reports of RTB, also increased. Two studies found the opposite to be true, and two studies found that sleep loss is not significantly related to RTB.
However, the studies as a whole do suggest that there is a positive relationship between sleep loss and RTB. There were a few studies that evaluated possible mechanisms by which sleep loss might influence RTB. Mechanisms that have received at least some empirical attention include changes in the VMPFC, changes in mood, and changes in individuals’ focus on gains versus losses. The extant research on these possible mechanisms, however, is limited.

**Limitations**

The most notable limitation of this literature review is that only 16 articles were found that explored both sleep loss and RTB, and of these, only eight experimentally manipulated sleep loss. Since such a small number of articles exist that investigate these variables, any results from the studies must be interpreted with caution. Even though a majority of the studies agree that as sleep loss increases, RTB increases, too few studies have been conducted to imply a firm causal link between the two.

Several limitations exist that pertain to measurement issues. Although only 16 studies were included in this review, six separate behavioral measures of RTB, eight self-report measures of RTB, and ten measures of sleep (not including laboratory TSD) were utilized. Although there are advantages to variety in measurement techniques, it is problematic in this instance because there are so few studies that measure sleep loss and RTB using the same methodology, and thus it is somewhat difficult to compare findings across these studies. Similarly, some studies investigated constructs such as sensation seeking and impulsivity, while others investigated health risk behaviors (operationalized as risk-taking). I operationalized these separate types of RTB as general RTB (e.g., sensation-seeking) and specific RTB (e.g., substance use). Few studies investigated whether the relationship between sleep loss and general
RTB (i.e., sensation seeking) is similar to or different than the relationship between sleep loss and specific RTB (i.e., substance abuse).

Additionally, the reliability and validity of certain measures, as well as the small sample sizes of studies are potential measurement limitations of this review. Some of the measures used in the studies have limited evidence of reliability and validity. For example, only one unpublished study has tested the reliability of the IGT (Waters, Xiao, Denburg, Hernandez, & Bechara, 2011), and the simple decision tasks utilized in the Venkatraman et al. studies (2007, 2011) were created specifically for the experiment and have not been subjected to reliability or validity analyses. Moreover, most of the measures included in this review have not been extensively studied in the context of sleep loss, and therefore there is little evidence of the validity of these measures. In terms of sample size, the studies (4 of 16) that used only self-report measures of sleep loss and RTB generally had adequate sample sizes. Among the other 12 studies that used at least one behavioral measure of RTB, the sample sizes were quite small ($M = 33.25, SD = 10.08$), which might limit their generalizability to the general population.

Aside from measurement limitations, a few theoretical and research limitations exist. Few of the studies included in this review examined the direct relationship between sleep loss and RTB independent of all other variables. Instead, many examined how sleep loss might be related to RTB under specific conditions (e.g., effects of TSD on known-risk versus ambiguous-risk decisions, effects of TSD on morningness-eveningness traits and risk-taking, effects of alcohol, caffeine, and sleepiness on RTB, etc.). Thus, rather than the existing literature base beginning with many studies that causally link sleep loss to RTB and expanding research to include additional factors, much of the existing research studied both the basic relationship and specific aspects simultaneously.
Another notable limitation of this review is the limited amount of research examining potential mediators and moderators of the relationship between sleep loss and RTB. Most studies propose that mediators exist that might better explain the relationship between sleep loss and RTB (e.g., VMPFC theories, framing effects, etc.), and suggest that they be pursued as areas for future research, but few studies to date have experimentally examined them. Similarly, few studies have examined potential moderators of the relationship or populations or individuals for whom the relationship between sleep loss and RTB is especially problematic (e.g., pathological gamblers, individuals with substance abuse issues, etc.).

*Areas for Future Research*

Research about sleep loss and RTB is in its infancy, and there are several areas of future research that might be explored. Most importantly, more research must be conducted that (a) clarifies the measurement issues related to sleep loss and RTB, (b) replicates previous research, (c) allows for more concrete conclusions to be reached, and (d) examines variables that might help explain the relationship between sleep loss and RTB. Specifically, there is a need for:

1. More studies that experimentally manipulate sleep (e.g., laboratory TSD) rather than rely exclusively on self-report measures.

2. More studies that utilize behavioral measures of RTB (e.g., gambling tasks) or a combination of behavioral measures and self-report measures, rather than only self-report measures.

3. Studies that assess the validity of behavioral measures of RTB, particularly the IGT and the BART, including whether extreme amounts of TSD might account for the difference in findings from studies using the IGT versus the BART.
4. Studies that evaluate whether sleep loss influences general RTB (e.g., sensation seeking) and specific RTB (e.g., substance abuse) similarly.

5. More studies that examine the possible role of the VMPFC in explaining the relationship between sleep loss and RTB.

6. Studies that investigate the possibility that mood mediates the relationship between sleep loss and RTB.

7. Studies that investigate gains and losses in terms of reflection effects, and the possibility that the relationship between sleep loss and RTB changes when participants are making decisions that involve gaining something or losing something.

8. Studies that investigate gains and losses in terms of framing effects, particularly studies that manipulate only the participants’ perception of gains and losses, independent of whether the outcome changes (i.e., framing effects independent of reflection effects).

The investigation of the relationship between sleep loss and RTB is still in its early stages. Although the framework for studying these variables has been established, further research is needed to solidify the conclusions that have been drawn and to continue broadening the scope of understanding about sleep loss and RTB.
CHAPTER 3  
STATEMENT OF THE PROBLEM

The study of the relationship between sleep loss and risk-taking behavior (RTB) is a relatively new area of research. To date, only 16 studies exist that investigate this relationship, and of those, only 10 studies included an experimental design in which laboratory total sleep deprivation (TSD) was utilized. Twelve of the sixteen studies found a positive relationship between sleep loss and RTB, two studies found no significant relationship, and two studies found a negative relationship between sleep loss and RTB. Additionally, most of the studies varied in terms of study procedure, measurement (e.g., self-report surveys, TSD), and sample size. This dearth of research, combined with the mixed results from the existing studies, present several exciting areas of research that need to be addressed.

Several discrepancies and limitations existed among these 16 studies. Most notably, the majority of the studies utilized different measurements of both sleep loss and RTB. This lack of uniformity in measurement may account for some of the variation in the results. For example, 11 of the studies utilized a behavioral measure of RTB (i.e., participants are required to make a choice between two or more options that result in different outcomes), and one of the most frequently used behavioral measures was the Balloon Analogue Risk Task (BART). Interestingly, four of the five studies that utilized the BART found no significant relationship between sleep loss and RTB, though the other six studies that utilized some other behavioral measure (i.e., the Iowa Gambling Task) found a positive relationship between these variables.

Eleven studies investigated risk-taking behaviors such as sensation seeking or impulsivity (operationally defined as general RTB), and five studies investigated risk-taking behaviors such as substance use and other health risk behaviors (operationally defined as specific RTB).
However, no studies included measures of both general and specific RTB. It is possible that there is a different relationship between sleep loss and general RTB than between sleep loss and specific RTB, and that this difference in relationship accounts for some of the variability in the results of the existing literature.

Furthermore, few of these studies investigated the mechanisms of the link between sleep loss and RTB (i.e., potential mediators of the relationship). Most studies posit that some variables might exist that can help explain why sleep loss is linked to risk-taking behaviors (e.g., VMPFC theories, framing effects, etc.) and suggest they be pursued as areas for future research, but few if any studies have experimentally investigated potential mediators as a primarily research goal.

This purpose of the current study is to explore several of these limitations in the extant literature. First, it will serve to replicate previous studies that utilized one behavioral measure of RTB, the Iowa Gambling Task (IGT) to measure RTB in the context of sleep loss. Second, it will attempt to accrue evidence for the reliability (i.e., temporal stability) and validity of the IGT. Third, it will utilize the IGT, self-report measures of general RTB, and self-report measures of specific RTB to investigate how sleep loss affects each type of risk-taking. Fourth, it will examine mood as a mediator of the relationship between sleep loss and RTB. Fifth, it will examine framing (as gains versus losses) as a mediator of the relationship between sleep loss and RTB.

The Iowa Gambling Task (IGT) is a behavioral measure of decision-making that has been used to study RTB, pathological gambling, and injuries to the ventromedial prefrontal cortex (VMPFC; Buelow & Suhr, 2009). Thus far, only two studies have utilized it to investigate RTB in the context of sleep loss (Killgore, Balkin, et al., 2006; Killgore, Lipizzi, et al., 2007). Both
studies found that sleep deprived participants showed higher levels of RTB on the IGT than well-rested participants, which supports other studies that have reported a positive relationship between sleep loss and RTB (Jones et al., 2006; McKenna et al., 2007; Venkatraman et al., 2011). However, as there are only two studies that have utilized the IGT in the context of sleep loss, replication and an examination of the reliability and validity of the IGT is needed to determine whether this measure is a useful tool in studying the relationship between sleep loss and RTB.

A second area of research that has not yet been addressed is whether sleep loss affects general RTB (i.e., sensation seeking) in the same manner as specific RTB (i.e., drug use). Several studies have paired general measures of RTB with behavioral measures such as the IGT, and others have studied specific RTB in the context of sleep loss, but results are somewhat mixed. Of the studies that measured general RTB (Acheson et al., 2007; Brown, 2008; Killgore, 2007), each found no relationship between self-reports of general RTB and higher levels of sleep loss. In contrast, the studies that measured specific RTB (Catrett & Gaultney, 2009; O’Brien & Mindell, 2005; Vail-Smith et al., 2009) found that self-reports of specific RTB increased among participants with higher levels of sleep loss. However, no study has investigated both general and specific risk-taking concurrently, so it is possible that methodological issues might be responsible for the difference in results. Therefore, a study is needed that investigates both types of RTB among the same participants.

Several mediators of the relationship between sleep loss and RTB have been hypothesized (Harrison & Horne, 2000; Killgore et al., 2008; McKenna et al., 2007; Venkatraman, Chuah, Huettel, & Chee, 2007; Venkatraman, Huettel, Chuah, Payne, & Chee, 2011). Two of these mediators are mood and framing. Sleep loss has been shown to decrease
positive mood and increase negative mood (Paterson et al., 2011). According to the mood maintenance model, individuals in a positive mood take fewer risks because they do not want to jeopardize their current positive mood, and individuals in a negative mood take more risks because they want to improve their mood by gaining a positive outcome (Harrison & Horne, 2000). Therefore, mood might mediate the relationship between sleep loss and RTB because sleep loss increases negative mood, which in turn increases RTB. However, only one study (Catrett & Gaultney, 2009) investigated sleep loss, negative mood, and RTB, and there is a need for further studies to lend credence to their finding that negative mood mediates the relationship between sleep loss and RTB.

Framing may also explain a portion of the relationship between sleep loss and RTB because sleep loss might affect how individuals perceive risks, which would influence their resultant RTB. Specifically, sleep loss may cause individuals to focus more on gains and less on losses, which in turn may increase RTB. A study by Venkatraman et al. (2011) investigated the idea that sleep loss might alter an individual’s perception of gains and losses, and therefore affect RTB. Well-rested participants tended to choose a less risky course of action, while sleep deprived participants chose riskier courses of action that focused on seeking gains. In other words, risk-taking preference for gains-framed gambles increased with sleep deprivation. This may be because sleep loss causes a shift in perception of gains and losses, which affects risk preference. However, further studies are needed to investigate whether framing choices as gains or losses mediates the relationship between sleep loss and RTB.
CHAPTER 4 METHOD

Participants

The original sample for this study consisted of 324 undergraduate students from the University of North Texas. Computer error resulted in incomplete data for 45 participants, and thus the final sample consisted of 279 participants (190 female, 88 male, 1 transgendered). Participants ranged in age from 18 to 44 ($M = 20.10$, $SD = 2.68$). Several ethnicities were represented within the sample, with 52.3% of participants identifying as Caucasian, 17.9% as Latino or Hispanic, 12.9% as African-American, 10.8% as Asian or Pacific Islander, 4.3% as multiracial or other, and 1.8% as Native American. Participants were invited to complete a follow-up study two weeks after completing the initial study. The sample for the follow-up study consisted of 50 participants (37 female, 12 male, 1 transgendered). Participants ranged in age from 18 to 34 ($M = 20.20$, $SD = 3.07$). Fifty-six percent of the sample identified as Caucasian, 6% as Latino or Hispanic, 3% as African-American, 14 % as Asian or Pacific Islander, 3% as multiracial or other, and 3% as Native American (see Table 3 for further demographic information).

Design

This study used a cross-sectional, correlational design.

Measures

Demographic Questionnaire

A 16-item questionnaire was used to collect demographic information from participants. Questions regarding participants’ gender, age, marital status, ethnicity, and level of education,
among others, were included in multiple choice and short answer format.

Table 3

Demographic Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Primary Study (IGT Time 1) N = 279</th>
<th></th>
<th>Follow Up Study (IGT Time 2) N = 50</th>
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Measures of General Risk-Taking Behavior

Iowa Gambling Task (IGT; Bechara et al., 1994)

The IGT is a behavioral measure of risk-taking behavior (RTB) that requires participants to learn to avoid high-risk scenarios with short-term payoffs, and instead develop decision-making strategies that maximize long-term gains. Four decks of cards are presented, two of which are considered “good” (i.e., decks A and B) because their result in long-term gains throughout the task, and two of which are considered “bad” (i.e., decks C and D) because they result in long-term losses. Each card from a deck results in gaining and losing a certain amount of money. A card from a “good” deck might result in a win of $50 and a loss of $0, for a net profit of $50. A card from a “bad” deck might result in a win of $100 and a loss of $1250, for a net loss of $1150. The payoff ratio for each deck never changes during the task, which consists of 100 draws.

The IGT is scored by dividing the 100 trials into five blocks of 20 (i.e., trials 1-20 in block 1, trials 21-40 in block 2, etc.). Within each block, the number of cards drawn from the “good” decks (i.e., A and B) and “bad” decks (i.e., C and D) are summed separately. A net score is then calculated for each block by subtracting the number of “bad” draws from the number of “good” draws (i.e., net score = [C + D] – [A + B]). Positive net scores indicate advantageous choices, and negative net scores indicate disadvantageous choices (Bechara & Damasio, 2002). Advantageous (less risky) decision making is indicated by a trend toward positive net scores as the task progresses from block 1 to block 5. Disadvantageous (more risky) decision making trends toward negative scores, reflecting a participant’s choice of riskier decks as the task progresses.

Several studies have utilized the IGT to explore risky decision-making and behavior, and
a review of the IGT by Buelow and Suhr (2009) presented evidence that the IGT is a valid measure of RTB. One unpublished study thus far has investigated the reliability of the IGT, and found that scores for normal, healthy participants showed evidence of reliability ($r = .95$ between test 1 and test 2, $r = .73$ between test 2 and test 3), but also indicated a moderate practice effect (Waters et al., 2011).

Kirby Delay Discounting Task (DDT; Kirby et al., 1999)

The DDT measures impulsivity by presenting participants a set of choices between smaller, immediate rewards or larger, delayed rewards. The task consists of 27 choices, with rewards ranging from $11 to $85, and delays ranging from 7 days to 186 days. Individuals perceive rewards to have more or less value depending on the length of the delay before receiving it, and in fact “discount” the value of the reward accordingly. Thus, individuals will view an offer of $40 after two days as more valuable than an offer of $40 in 10 days, because they discount the value of the reward depending on how long it will take them to receive it.

The amount of that discount is described by the hyperbolic function $V = A / (1 + kD)$, where $V$ is the value of the reward after it has been discounted, $A$ is the reward quantity, $D$ is the delay in days, and $k$ is a free parameter that determines the discount rate (Mazur, 1993). For each choice presented in the DDT, an “indifference point,” or a $k$ value representing the point at which each the immediate and delayed rewards have an equal value, is calculated using the aforementioned equation. A participant who chooses the immediate reward therefore has a larger $k$ value than the indifference point, and a participant who chooses the delayed reward has a smaller $k$ value than the indifference point. Using this framework, a participant’s overall level of impulsiveness is calculated as one $k$ value estimation for all 27 questions. This value is
determined by taking the geometric mean between the lowest implied indifference \( k \) value in which the participant chose the delayed option, and the highest implied indifference \( k \) value in which the participant chose the immediate option, and determining which \( k \) value is most consistent with all 27 responses (Monterosso, Ainslie, Xu, Cordova, Domier, & London, 2007).

The Kirby DDT is one version of a binary choice delay-discounting task, and scores on these types of tasks show evidence of very strong temporal stability of \( r = .91 \) (Simpson & Vuchinich, 2000). Furthermore, one study showed alternate-form reliability for the Kirby DDT scores to be \( r = .82 \) (Epstein, Richards, Saad, Paluch, Roemmich, & Lerman, 2003). The DDT has shown evidence of validity when compared with multiple studies as a measure of impulsivity (Smith & Hantula, 2008). For the current sample, the Cronbach’s alpha coefficient was .92.

**Brief Sensation Seeking Scale (BSSS; Hoyle et al., 2002)**

The BSSS is an 8-item self-report survey adapted from the Zuckerman Sensation Seeking Scale, Form V (Zuckerman et al., 1978). Participants are presented with statements such as “I get restless when I spend too much time at home,” and are asked to rate the extent to which they agree with the statements on a 5-point scale ranging from 1 = *strongly agree* to 5 = *strongly disagree*. The scale was originally intended for use with adolescents, but studies have since provided evidence for validity with young adult participants. BSSS scores are significantly correlated with specific RTB such as drug and alcohol use, as well as general RTB such as impulsivity (Stephenson, Hoyle, Palmgren, & Slater, 2003). Scores on the scale have shown some evidence for internal consistency, as measured by a Cronbach’s alpha of .70 among young adult participants (Stephenson, Velez, Chalela, Ramirez, & Hoyle, 2007). For the current sample, the Cronbach’s alpha coefficient was .79.
Barratt Impulsiveness Scale, Eleventh Revision (BIS-11; Stanford, Mathias, Dougherty, Lake, Anderson, & Patton, 2009)

The BIS-11 is a 30-item measure of general impulsivity that takes into account the multi-dimensional nature of impulsivity. Six first-order factors of impulsivity (i.e., attention, motor, self-control, cognitive complexity, perseverance, cognitive instability) and three second-order factors (i.e., attentional impulsiveness, motor impulsiveness, nonplanning impulsiveness) are identified. Participants are presented with statements such as “I concentrate easily” and are required to rate them on a 4-point scale ranging from 1 = rarely never to 4 = almost always/always. Responses are summed for a total score.

The BIS-11 has a long history of use in impulsivity research and has been translated into several languages, with each version showing evidence of validity (Bayle et al., 2000; Fossati, Ceglie, Acquarini, & Barratt, 2001; Someya et al., 2001). Scores on the BIS-11 have been correlated with several valid measures of impulsivity and have shown evidence of internal consistency (Cronbach’s alpha = .82 for undergraduate students, .79 for substance abuse patients, .83 for general psychiatric patients; Patton et al., 1995). For the current sample, the Cronbach’s alpha coefficient was .85.

Measures of Specific RTB

Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST; WHO ASSIST Working Group, 2002)

The ASSIST is a self-report measure designed to screen for substance use. Participants are asked to endorse whether or not they have ever used any of 10 substances listed (i.e., tobacco products, cocaine, alcoholic beverages, etc.) and are then asked a series of six questions about each substance pertaining to frequency of use, desire to use, and the impact the substance has had
on their lives. Responses are then weighted and summed, with higher scores indicating higher risk level for each substance. The ASSIST was originally designed as a verbal interview, but has been adapted to a computerized survey for the purposes of this study. Scores on the ASSIST have shown evidence of internal consistency (Cronbach’s alpha = .80) and the survey has evidenced good construct, predictive, and discriminant validity (Humeniuk & Ali, 2006). For the current sample, the Cronbach’s alpha coefficient was .89.

South Oaks Gambling Screen (SOGS; Lesieur & Blume, 1987)

The SOGS is a commonly used screening instrument based on clinical criteria for pathological gambling. It consists of 20 items such as “do you feel you have ever had a problem with betting or money gambling?” Most of the items are answered either yes or no, though some items are in multiple-choice format. The responses are assigned a numeric value and a total score is calculated. Scores of 1 to 4 indicate the participant has some problems with gambling, and scores of 5 or greater are indicative of probable pathological gambling behavior. Scores on the SOGS have shown evidence of internal consistency (Cronbach’s alpha = .97), have demonstrated a temporal stability correlation of .71, and have been validated with several other measures of problem gambling (Wickwire, Burke, Brown, Parker, & May, 2008). For the current sample, the Cronbach’s alpha coefficient was .89.

Sexual Compulsivity Scale (SCS; Kalichman, Johnson, Adair, Rompa, Multhauf, & Kelly, 1994)

The SCS is a 10-item scale designed to measure hypersexual behavior. Participants are presented with statements such as “my desires to have sex have disrupted my daily life” and are asked to rate them on a 4-point scale ranging from 1 = not at all like me to 4 = very much like
me. Scores are summed, with higher scores indicating higher sexual addiction. Scores on the SCS have shown evidence of internal consistency and have been validated with several other measures of addiction, as well as several personality factors (Hook, Hook, Davis, Worthington, & Penberthy, 2010). For the current sample, the Cronbach’s alpha coefficient was .91.

Mediators of the Relationship between Sleep Loss and RTB

Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988)

The PANAS is a 20-item self-report measure of positive and negative affect. Participants are presented with a list of 20 words (i.e., excited, guilty, proud, nervous) that are associated with either positive or negative mood, and are asked to indicate the extent to which they currently feel that emotion, or the extent to which they have felt that emotion over the past week, using a 5-point scale ranging from 1 = very slightly or not at all to 5 = extremely. A positive affect score and a negative affect score are calculated, with higher scores representing higher levels of affect. Scores on the PANAS have shown evidence of internal consistency (Cronbach’s alpha .86 to .90 for positive affect, .84 to .87 for negative affect) and have been validated with several measures of mood, including the Beck Depression Inventory and Hopkins System Checklist. For the current sample, the Cronbach’s alpha coefficient was .89.

Framing Questionnaire

A 5-item questionnaire was designed for the present study to assess how participants framed the IGT in regard to focusing on gains versus losses. Participants are asked to identify the main purpose of the IGT in an open-ended format, which was coded for references to gains- and loss-based framing. Participants were then asked to answer the same question using a 5-
point rating scale ranging from 1 = *avoid losing as much money as possible* to 5 = *win as much money as possible*, and to identify their main focus while completing the IGT using the same scale. Finally, two questions regarding the extent to which participants were focused on winning and losing money are asked on a 5-point scale ranging from 1 = *not at all focused* to 5 = *very focused*.

*Measures of Sleep*

Pittsburg Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1988)

The PSQI is a 19-item self-report questionnaire designed to assess sleep quality and sleep disturbances over a 4-week period. Some questions, such as “during the past month, when have you usually gone to bed at night?” are in short answer format. Others such as “during the past month, how often have you had trouble sleeping because you cough or snore loudly” present four answer options ranging from “not during the past month” to “three or more times a week,” and require participants to select the appropriate time frame. Seven component scores and one global score of sleep quality are derived from the 19 questions. A global score greater than 5 is considered to indicate significant sleep disturbance. Scores on the PSQI have been shown evidence for internal reliability (Cronbach’s alpha = .83) and a temporal stability of .85. A validity study by the questionnaire’s creators (Buysse et al., 1988) showed that the PSQI scores were able to discriminate between control groups of participants with no sleep complaints and clinical patients with documented sleep disturbances, and PSQI scores showed limited correlation with polysomnographic readings. For the current sample, the Cronbach’s alpha coefficient was .77.
Epworth Sleepiness Scale (ESS; Johns, 1991)

The ESS was designed as a quick, simple survey of daytime sleepiness in adults. Participants use a 4-point scale ranging from 0 = *would never doze* to 3 = *high chance of dozing* to indicate their level of sleepiness in eight situations (e.g., sitting and reading). Unlike other measures of sleepiness, which measure general levels of sleepiness at certain times of day (e.g., 8 am, 10 am, 12 pm, etc.) or quality of sleep at night, the ESS provides common everyday scenarios during which participants might experience sleepiness. Scores of 10 to 14 are considered to indicate moderate sleepiness, and scores of 15 or greater indicate severe sleepiness.

The validity of ESS scores was evidenced in a study by Johns (1991) in which there was a strong correlation between ESS results and daytime sleep latency, a laboratory measure of sleepiness, and nighttime polysomnography. Reliability studies demonstrated evidence of temporal stability ($r = .82$) over a 5-month period of time, and one study demonstrated a Cronbach’s alpha coefficient of .88 (Johns, 1992). For the current sample, the Cronbach’s alpha coefficient was .75.

Sleep Survey

A brief survey was used to assess participants’ level of sleepiness at the time of testing. The first nine items of the survey are short-answer questions such as “what time did you go to bed last night” and “what time did you wake up this morning.” These questions were created specifically for this study and are intended to quantify the amount of sleep each participant had the previous night. The National Sleep Foundation recommends that adults sleep between 7 and 9 hours per night, and suggest that less than 6 hours per night can affect subjective feelings of sleepiness, mood, reaction time, and critical thinking (Bonnet & Arand, 2011).
The tenth item on the survey is the Stanford Sleepiness Scale (SSS; Hoddes, Dement, & Zarcone, 1972), a one-item survey that asks participants to rate their current level of sleepiness on an 7-point scale ranging from 1 = *feeling active, vital, alert, or wide awake* to 7 = *no longer fighting sleep, sleep onset soon; having dream-like thoughts*. Participants who endorse a rating of 6 or 7 indicate subjective feelings of sleepiness. This survey has been widely utilized in sleep research, is often administered several times over the course of a single study (e.g., 8 am, 10 am, 12 pm, etc.), and SSS ratings have been correlated ($r = .70$) with scores on the Wilkinson Vigilance Test (Hoddes et al., 1973).

**Procedure**

Procedures for the current study were approved by the University of North Texas Institutional Review Board and are in accordance with the guidelines for ethical treatment of human participants. Participants were recruited from undergraduate classes and received course credit for their participation. Participants who volunteered to participate received an email that included an explanation of the study’s procedures and informed consent guidelines, as well as a link to an online implementation of the IGT. Each participant was assigned an ID number to ensure anonymity, and gave consent by typing this number into an online version of the informed consent form (see Appendix A). The instructions for the IGT were as follows:

In this short experiment, you will see four decks of cards such as the ones displayed below. You will repeatedly pick a card from one of the four decks by clicking on it with your mouse. You are absolutely free to switch from any deck to another, at any time, and as often as you wish. You will start the game with $2000 of credit. Each time you click a card, you will win some money, but you may also lose some money. Some of the decks of cards are more profitable than others. The computer does not change the position of the decks once the game begins, and it does not make you win or lose money at random. The goal of the game is to win as much money as possible and to try to avoid losing as much as you can. Remember that some decks are better or worse than others, and to win
you should try to pick the good decks and avoid the bad decks. At the end of the experiment, you will receive further instructions. Click “Start” to begin the game.

Participants then began the task and completed 100 trials of the IGT (i.e., chose 100 cards). Following completion, participants completed the framing questionnaire, a demographic questionnaire, and the self-report measures of sleep, RTB, and mood. Participants were directed to a debriefing message that included instructions for asking any follow up questions regarding the study. Participants then received course credit or extra credit for their participation.

Two weeks after completing the task and the surveys, participants were contacted and invited to participate in a follow up study. Participants were sent a link to a second online IGT, and a second sleep questionnaire. Participants again typed their ID number into an online informed consent form, and completed the task and the questionnaire. Participants were then directed to a debriefing message that included instructions for asking any follow up questions regarding the study, and received course credit for their participation. Fifty of the original 279 participants completed the second IGT administration, and the average time delay between administrations was 17.98 days ($SD = 5.16$).

Hypotheses and Planned Analyses

**Hypothesis 1: Scores on the IGT Show Evidence of Temporal Stability**

Justification

Killgore, Balkin, et al. (2006) and Killgore, Lipizzi, et al. (2007) utilized the IGT multiple times within one study with the same participants (i.e., at baseline while the participants were well-rested, and one or more times once the participants underwent TSD). Although neither of these studies explicitly examined temporal stability, no significant practice effects or
complications arising from administering the IGT more than once were reported. More recently, Waters et al. (2011) administered the IGT three times to normal participants and to participants with damage to the VMPFC. Scores evidenced reliability for normal participants ($r = .95$, $r = .72$) but not for VMPFC participants, though a moderate practice effect was noted between tests 1 and 2, and a large practice effect was noted between tests 2 and 3 for normal participants. VMPFC participants’ scores showed no practice effects. Waters and her colleagues proposed that alternate versions of the IGT with slightly different payoff ratios be used for retesting, and found no practice effects among normal or VMPFC participants when these alternate versions were utilized.

Planned Analysis

A two-level multilevel model was used for this analysis. It consists of repeated measures (Level 1) nested within individuals (Level 2). A random intercept at the individual level is included to allow for individual-specific intercepts. The outcome variable is the standardized scores for the second administration of the IGT (i.e., IGT Time 2), and the predictor variable is the standardized scores for the first administration of the IGT (i.e., IGT Time 1). The hypothesis will be supported if a significant main effect of IGT Time 1 on IGT Time 2 is found.

_Hypothesis 2: RTB as Measured by Scores on the IGT are Positively Correlated with Both Specific RTB and General RTB, as Measured by Self-Report Surveys_

Justification

Although there are few studies that have utilized both the IGT and self-report measures of RTB, the IGT has been linked to specific risk behaviors, as well as high sensation seeking and disinhibition in children. The distinction between general and specific RTB is an operational
definition intended to highlight the differences between types of risk-taking behaviors that are studied. Buelow and Suhr (2009) investigated the construct validity of the IGT and reported that several researchers have found poor performance on the IGT among individuals with substance abuse and pathological gambling. Additionally, a study by Crone et al. (2003) demonstrated that children with high sensation seeking and disinhibition scores performed poorly on the IGT. Therefore, it is reasonable to conclude that the IGT will correlate with self-report measures of both specific RTB (i.e., substance abuse) and general RTB (i.e., sensation seeking and impulsivity).

Planned Analysis

A series of multilevel models similar to those described in Hypothesis 1 were conducted. The model includes a random intercept and a random slope for time at the individual level, to allow for individual-specific intercepts and slopes. The outcome variable is net scores for IGT Time 1. Predictor variables are time (Level 1), RTB measure (Level 2), and the interaction between time and RTB measure (cross-level interaction). The hypothesis will be supported if there is a significant interaction between time and RTB measure (i.e., an interaction indicates that individuals with low levels of RTB show greater improvement on the IGT than individuals with high levels of RTB).

Hypothesis 3: Levels of Sleepiness are Positively Correlated with Levels of Specific RTB (i.e., Substance Abuse) but Are Not Correlated with Levels of General RTB (i.e., Impulsivity) as Measured by Self-Report Surveys

Justification

Several studies that have utilized self-report measures of sleep and self-report measures
of RTB have found that sleepy participants demonstrate increased levels of specific RTB (Catrett & Gaultney, 2009; O’Brien & Mindell, 2005; Vail-Smith et al., 2009). Additionally, an analysis of the data from the 2006-2008 NHIS Sample Adult data revealed that participants who slept less than 6 hours per night (less than the recommended amount of sleep for adults) had a higher prevalence of smoking and consuming more than five alcoholic drinks per day, which are both examples of specific RTB (Schoenborn & Adams, 2008). However, studies by Acheson et al. (2007), Brown (2008), Killgore (2007) found that scores for general measures of RTB such as the DDT, EVAR, and BSSS did not significantly change with sleep loss.

Planned Analysis

The Pearson product moment correlation coefficient was calculated between (a) measures of sleep loss and (b) self-report measures of general and specific RTB.

Hypothesis 4: Rested Participants Show an Increase in Net Score Performance as the IGT Progresses, Indicating that They Are Able to Learn to Select “Safe” Decks and Avoid “Risky” Decks; Sleepy Participants Show a Smaller Increase in Net Score Performance as the IGT Progresses, Indicating They Were Not Able to Learn to Select “Safe” Decks and Avoid “Risky” Decks as Well as the Rested Participants

Justification

Several studies have demonstrated that rested participants with no injury to the ventromedial prefrontal cortex demonstrate a pattern of net scores on the IGT that increases as the test progresses, such to the point that this has been established as normal functioning in the IGT professional manual (Bechara, 2007). Other studies on sleep deprived patients (Killgore, Balkin, et al., 2006; Killgore, Lipizzi, et al., 2007), on the other hand, have demonstrated that
sleepy participants’ net scores decreased as the task progressed, similar to patients with lesions in the VMPFC.

Planned Analysis

This hypothesis was tested using a multilevel modeling regression analysis, consisting of repeated measures (Level 1) within individuals (Level 2). The dependent variable is scores on the IGT. Fixed effects include time, level of sleep loss, and the interaction between time and level of sleep loss. Random effects include the intercept of IGT scores and the slope of time on IGT scores. A significant time by level of sleep loss interaction will indicate that rested and sleepy participants have different trajectories of score performance on the IGT over time.

Hypothesis 5: Negative Mood Mediates the Relationship between Sleep Loss and RTB

Justification

Sleep loss has been shown to increase negative mood (Paterson et al., 2011), which has been theorized to prompt individuals to increase RTB in an attempt to achieve a positive outcome, thereby making them feel better and regulating their mood (Harrison & Horne, 2000).

Planned Analysis

This hypothesis was tested using the steps for mediation outlined by Baron and Kenny (1986). In Step 1, I conducted a bivariate regression analysis to establish that the initial variable (sleep loss) significantly predicts the criterion variable (RTB). In Step 2, I conducted a bivariate regression analysis to establish that the initial variable (sleep loss) significantly predicts the mediating variable (negative mood). In Step 3, I conducted a multiple regression analysis to
establish that the mediating variable (negative mood) predicts the criterion variable (RTB) while controlling for the initial variable (sleep loss). If the initial variable (sleep loss) is no longer significant, it will indicate evidence of full mediation. If the initial variable (sleep loss) is reduced but remains significant, it will indicate evidence of partial mediation. The significance of the mediated effect was tested using the Sobel test.

Hypothesis 6: Framing Mediates the Relationship between Sleep Loss and RTB

Justification

Venkatraman et al. (2010) showed evidence of a shift in perception of gains and losses following sleep deprivation, in which individuals’ risk-taking preference for gains-framed gambles increased with sleep deprivation. They suggested that this shift in preference is due to an optimism bias in which sleepy participants behave as if positive consequences (gains) are more likely or valuable, and negative consequences (losses) are less likely or harmful. Therefore it is possible that sleep loss causes a shift in perception or preference toward gains, which in turn causes an increase in RTB.

Planned Analysis

This hypothesis was tested using the steps for mediation outlined by Baron and Kenny (1986). In Step 1, I conducted a bivariate regression analysis to establish that the initial variable (sleep loss) significantly predicts the criterion variable (RTB). In Step 2, I conducted a bivariate regression analysis to establish that the initial variable (sleep loss) significantly predicts the mediating variable (framing). In Step 3, I conducted a multiple regression analysis to establish that the mediating variable (framing) predicts the criterion variable (RTB) while controlling for
the initial variable (sleep loss). If the initial variable (sleep loss) is no longer significant, it will indicate evidence of full mediation. If the initial variable (sleep loss) is reduced but remains significant, it will indicate evidence of partial mediation. The significance of the mediated effect was tested using the Sobel test.
Testing for Assumptions

Before conducting the primary analyses, I checked for missing data, outliers, and normality. The data set included a small amount of missing data (less than 2% per variable), which I replaced using mean substitution (i.e., the missing data point was replaced with the mean score for the sample). There were a small number of outliers (less than 4% per variable, primarily among substance use variables). Outliers are problematic because they may (a) lead to both Type 1 and Type 2 errors and (b) lead to results that do not generalize except to another sample with the same kind of outlier (Tabachnick & Fidell, 2007). However, the outliers in my sample were not a result of a mistake due to data entry, and came from participants who were part of the population I wished to sample. Therefore, I recoded outliers to 3 standard deviations above or below the mean. I checked the data for normality by examining the skewness and kurtosis values for each variable. Four variables had a skewness value greater than 1 (Substance Use Total, Gambling Total, Sexual Compulsivity Total, and Negative Mood Total). I transformed these variables using a square root transformation, which reduced the skewness and kurtosis. I give descriptive statistics and correlations between study variables in Tables 4 and 5.

Hypothesis 1

Hypothesis 1 was that scores on the Iowa Gambling Task (IGT) show evidence of temporal stability. I tested this hypothesis using multilevel modeling (MLM). The data are grouped with repeated measures nested within individuals. MLM is a statistical method that is appropriate for such data because it allows for the examination of individual growth trajectories by analyzing the information contained in the repeated measures (Raudenbush & Bryk, 2002).
Table 4

Descriptive Statistics

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Note. * indicates variables that were transformed using square root.
Table 5

Correlations

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Note. * p < .05. ** p < .01. PSQI = Global Sleep Quality; ESS = Daytime Sleepiness; SS = Subjective Sleepiness; Hours = Hours of Sleep; BSSS = Sensation Seeking; BIS = Impulsivity; DDT = Delay Discounting; ASSIST = Substance Use; SOGS = Problem Gambling; SCS = Sexual Compulsivity.
I used a two-level MLM for this analysis that consisted of repeated measures (Level 1) nested within individuals (Level 2). For this analysis, I included a random intercept at the individual level, which allows for individual-specific intercepts. The outcome variable was standardized scores for the second IGT administration (IGT Time 2), and the predictor variable was standardized scores for the first IGT administration (IGT Time 1). A significant main effect of IGT Time 1 on IGT Time 2 would indicate that individuals’ scores on IGT Time 1 were related to scores on IGT Time 2, thus showing evidence of temporal stability.

This hypothesis was supported, albeit weakly. There was a significant main effect of IGT Time 1 on IGT Time 2 ($B = 0.11, p = .035$). This indicates that although there is some evidence of temporal stability between Time 1 and Time 2, the relationship is not strong. To further explore the relationship between scores at Time 1 and Time 2, I assessed for possible practice effects. IGT responses are divided into 5 blocks of 20 trials, and the progression of responses over time indicates whether risk-taking behavior (RTB) increases or decreases as the task progresses. I conducted dependent samples t-tests for each block of scores (Block 1, Block 2, Block 3, Block 4, Block 5) at IGT Time 1 and IGT Time 2. There were no significant differences between IGT Time 1 and IGT Time 2 at Block 1 ($t(49) = -1.44, p = .158$), at Block 3 ($t(49) = -.04, p = .966$), or at Block 5 ($t(49) = -.36, p = .723$). However, there were significant differences between IGT Time 1 and IGT Time 2 at Block 2 ($t(49) = -3.23, p = .002$) and at Block 4 ($t(49) = -2.67, p = .010$). For these two blocks, participants had higher scores at Time 2 than Time 1.

Hypothesis 2

Hypothesis 2 was that RTB as measured by the IGT is positively correlated with both
specific RTB (i.e., substance use) and general RTB (i.e., impulsivity). I tested this hypothesis using a series of MLM similar to those described in Hypothesis 1. I centered each variable prior to analysis, and included in the model a random intercept and random slope for time at the individual level, which allow for individual-specific intercepts and slopes. The outcome variable was net score on the IGT task (first administration). I included the following predictor variables: time (Level 1), RTB measure (Level 2), and the interaction between time and RTB measure (cross-level interaction). A significant interaction between time and the RTB measure would indicate that individuals with low levels of RTB showed greater improvement on the IGT task over time than did individuals with high levels of RTB (i.e., a significant relationship between the IGT and RTB measure).

This hypothesis was not supported. There were no significant interactions between any of the measures of specific RTB and IGT scores (total substance use $B = .01, SE(B) = .06, p = .831$, problem gambling $B = .03, SE(B) = .26, p = .101$, sexual compulsivity $B = -.63, SE(B) = .91, p = .490$). There were also no significant interactions between any of the general RTB measures and IGT scores (total delay discounting $B = -.10, SE(B) = .10, p = .324$, sensation seeking $B = -.01, SE(B) = .03, p = .583$, impulsivity $B = -.01, SE(B) = .01, p = .520$).

Hypothesis 3

Hypothesis 3 was that self-reported levels of sleepiness are positively correlated with levels of self-reported specific RTB (i.e., substance use) but are not correlated with levels of self-reported general RTB (i.e., impulsivity). I tested this hypothesis by calculating the Pearson product moment correlation coefficient between (a) global sleep quality and (b) measures of specific and general RTB. Higher scores on global sleep quality indicate poorer overall sleep
quality, and thus higher levels of sleepiness. Positive correlations between global sleep quality and RTB measures would indicate a positive relationship between sleepiness and RTB.

This hypothesis was supported. Global sleep quality was significantly positively correlated with the specific risk-taking behaviors of substance use ($r = .16, p = .007$) and sexual compulsivity ($r = .24, p < .001$), though not with problem gambling ($r = -.08, p = .212$). Global sleep quality was not significantly correlated with measures of general RTB (delay discounting $r = -.06, p = .325$, sensation seeking $r = .07, p = .267$, impulsivity $r = .09, p = .126$). Therefore, there was a small positive correlation between level of sleepiness and substance use and sexual compulsivity (Cohen, 1988).

**Hypothesis 4**

Hypothesis 4 was that rested participants show greater increases on IGT scores over time than sleepy participants. I tested this hypothesis using a series of MLM similar to those described in Hypotheses 1 and 2. The outcome variable was net score on the IGT. I included the following predictor variables: time (Level 1), sleep measure (Level 2), and the interaction between time and sleep measure (cross-level interaction). A significant interaction between time and the sleep measure would indicate that individuals with high levels of sleep (i.e., lower levels of sleepiness) showed greater improvements on the IGT than individuals with low levels of sleep (i.e., higher levels of sleepiness).

This hypothesis was not supported. No significant interaction between time and any sleep measure were found (global sleepiness $B = .03, SE(B) = .04, p = .448$, daytime sleepiness $B = .04, SE(B) = .04, p = .281$, subjective sleepiness at time of testing $B = .12, SE(B) = .16, p = .287$, hours of sleep prior to testing $B = .03, SE(B) = .08, p = .699$).
Hypothesis 5

Hypothesis 5 was that negative mood mediates the relationship between sleep loss and RTB (as measured by self-reports). I tested this hypothesis using Baron and Kenny’s (1986) steps for mediation. First, I conducted a bivariate regression analysis to determine whether the initial variable (sleep loss) significantly predicted the criterion variable (RTB). Second, I conducted a bivariate regression analysis to determine whether the initial variable (sleep loss) significantly predicted the mediating variable (negative mood). Third, I conducted a multiple regression analysis to determine whether the mediating variable (negative mood) predicted the criterion variable (RTB) while controlling for the initial variable (sleep loss). There would be evidence of full mediation if the initial variable (sleep loss) was no longer significant. There would be evidence of partial mediation if the initial variable (sleep loss) was reduced but remained significant. Finally, I tested the significance of the mediated effect using the Sobel test.

This hypothesis was partially supported. In step 1, the initial variable (global sleep quality) significantly predicted two RTB outcome variables (total substance use, $\beta = .16, t(278) = 6.15, p < .001$ and sexual compulsivity, $\beta = .24, t(278) = 9.21, p < .001$). In step 2, the initial variable (global sleep quality) significantly predicted the mediating variable (negative mood, $\beta = .14, t(278) = 5.21, p < .001$). In step 3, the mediating variable (negative mood) significantly predicted the outcome variable (substance use) while controlling for the initial variable (global sleep quality, $\beta = .09, t(278) = 3.42, p = .001$). The relationship between global sleep quality and substance use was reduced slightly but remained significant ($\beta = .15, t(278) = 5.64, p < .001$). The partially mediated effect of global sleep quality on substance use via negative mood was significant, Sobel $z = 4.16, p < .001$ (see Figure 1).
Negative mood also significantly predicted sexual compulsivity while controlling for the initial variable (global sleep quality, $\beta = .24, t(278) = 9.27, p < .001$). The relationship between global sleep quality and sexual compulsivity was reduced slightly but remained significant ($\beta = .21, t(278) = 8.11, p < .001$). The partially mediated effect of global sleep quality on sexual compulsivity via negative mood was significant, Sobel $z = 4.99, p < .001$ (see Figure 2).

Figure 1. Mediator effects of negative mood on the relationship between sleep loss (i.e., global sleep quality) and risk-taking behavior (i.e., total substance use). The number in parentheses is the effect of the independent variable on the dependent variable with the mediator in the model. *$p < .01$, **$p < .001$.

Figure 2. Mediator effects of negative mood on the relationship between sleep loss (i.e., global sleep quality) and risk-taking behavior (i.e., sexual compulsivity). The number in parentheses is the effect of the independent variable on the dependent variable with the mediator in the model. *$p < .01$, **$p < .001$.
This mediation effect, although significant, is very small. Therefore, negative mood likely only accounts for a small portion of the relationship between sleep loss and RTB.

Hypothesis 6

Hypothesis 6 was that framing mediates the relationship between sleep loss and RTB. I tested this hypothesis using Baron and Kenny’s (1986) steps for mediation described in Hypothesis 5.

This hypothesis was not supported. In Step 1, the initial variable (global sleep quality) did not significantly predict the RTB outcome variables (IGT net score, $\beta = .05$, $t(278) = -2.26$, $p = .370$). In order for framing to mediate the relationship between sleep loss and RTB, the initial variable (sleep quality) must predict the outcome variable (IGT net score). Therefore, there is not evidence that framing mediates the relationship between sleep loss and RTB.
The present study examined the relationship between sleep loss and risk-taking behavior (RTB). I tested hypotheses related to (a) the overall relationship between sleep loss and RTB, (b) evidence for temporal stability of scores on the Iowa Gambling Task, (c) general and specific RTB, and (d) variables that act as mediators of the relationship between sleep loss and RTB.

Overall Relationship between Sleep Loss and RTB

The present study showed limited evidence that increased sleep loss is associated with increased RTB. Scores on the Pittsburg Sleep Quality Index (PSQI), a global measure of an individual’s sleep quality and total amount of sleep over the course of a month, were positively correlated with scores on some measures of RTB, specifically total substance use and sexual compulsivity. However, global sleep quality scores were not significantly related to scores on other measures of RTB, including self-report measures of sensation seeking and impulsivity, scores on a delay discounting task (DDT), scores on a measure of problem gambling, and scores on the Iowa Gambling Task (IGT). Participants’ subjective sleepiness at the time they completed the study was not significantly related to any self-report measure of RTB or their scores on the IGT, nor was their total amount (hours) of sleep prior to participation in the study.

Several studies have found that increased sleep loss is associated with lower scores on the IGT (i.e., higher RTB; Killgore et al., 2006; Killgore et al., 2007; Killgore et al., 2012), though the present study did not show evidence of a similar relationship. No studies to date have investigated the relationship between self-reported sleep loss and scores on the IGT. Thus, the dissimilarity between the current study and previous studies might be methodological (i.e.,
previous studies have used total sleep deprivation rather than self-report measures of sleep loss). The sleep loss experienced by participants in the present study (which reflected normal variations in sleep by college students) may not have been strong enough to be related to changes in behavior on a task such as the IGT.

Evidence for Temporal Stability of Scores on the Iowa Gambling Task

The current study found some evidence for temporal stability of the IGT. Participants completed the IGT twice, and their scores from Time 1 and Time 2 were significantly related to each other. However, it should be noted that the relationship between scores at Time 1 and Time 2 was weak. One unpublished study conducted by Waters et al. (2011) found strong evidence for temporal stability of the IGT. There are several possibilities for the weaker evidence for temporal stability found in the present study. First, part of the reason for the weak association between scores may be due to differential improvement on the task from Time 1 to Time 2. Indeed, scores on the second administration were higher than scores on the first administration, a trend that could be due to practice effects. If some participants improved while others did not, the temporal stability coefficient may have been reduced. Second, the research design of the present study may have contributed to the low temporal stability. Participants completed the IGT online, so there was no monitoring of participants to ensure they were taking the task seriously. At Time 2, participants had already completed the task previously, and some participants may have responded in a haphazard manner in order to complete the task quickly. Finally, there was no monetary reward for superior performance on the IGT. Using a reward such as this, which has been used in prior studies, may have ensured buy-in throughout the duration of the task.
It is important to determine whether the IGT is a stable measure of RTB and whether it is subject to practice effects, particularly if it will be used in laboratory total sleep deprivation (TSD) studies. Killgore et al. (2006) and Killgore et al. (2007) utilized the IGT multiple times within a single study (i.e., before sleep deprivation and following sleep deprivation). While these researchers did not study temporal stability nor report any practice effects, it would be important to know whether participants’ scores on the IGT at Time 2 were higher due to practice effects (as opposed to reduced RTB). It could be that the conclusions from TSD studies that utilize the IGT at multiple time points across the same study are problematic because scores at Time 2 are artificially inflated due to practice effects. Gaining further understanding as to the mechanisms of IGT temporal stability and practice effects are thus important to future research.

General and Specific RTB

Prior research has shown a difference in the relationship between sleep loss and certain types of RTB, operationally defined as specific RTB (e.g., substance use) and the relationship between sleep loss and other types of RTB, operationally defined as general RTB (e.g., sensation seeking), though no study to date has examined both specific and general RTB at the same time. Studies by Acheson et al. (2007), Brown (2009), and Killgore (2007) found that sleep loss was not significantly related to self-report general measures of RTB such as the DDT and Brief Sensation Seeking Scale (BSSS), and studies by Cattrett and Gaultney (2009), O’Brien and Mindell (2005) and Vail-Smith et al. (2009) found a significant relationship between sleep loss and measures of specific RTB such substance use. The present study found a similar pattern of results. Measures of specific RTB (e.g., substance use) were significantly related to sleep loss, but measures of general specific RTB (e.g., DDT, BSSS) were not.
This distinction between general and specific RTB might be important in conceptualizing the relationship between sleep loss and RTB. While the findings of the current study do not speak to a causal relationship between sleep loss and RTB, they do preliminarily highlight a difference that exists between the two types of RTB, which might be helpful in the design of future studies. Sensation seeking and impulsivity (two types of general RTB) are aspects of personality that are often studied within the context of risk-taking (Zuckerman & Kuhlman, 2000). It might be possible that these personality-based aspects of RTB are different from other aspects of RTB such as substance use or sexual compulsivity (i.e., specific RTB) that are based on specific behaviors that are classified as risky.

It is possible that this difference between general and specific RTB in the context of sleep exists because general RTB as a construct may be less sensitive to change due to factors such as sleep loss than specific RTB. Sensation seeking and impulsivity, both of which are operationally defined as general RTB, are aspects of one’s personality (i.e., “traits”). Personality variables tend to be relatively stable across an individual’s lifetime (Church, 2000). Perhaps general RTB that are analogous to personality variables are therefore more resistant to the effects of sleep loss. By contrast, behaviors such as engaging in substance use or problem gambling, operationally defined as specific RTB, might be conceptualized as “state” components of RTB that reflect a more fluid and “in the moment” construct than “trait” components. Perhaps specific RTB are therefore more likely to be influenced by factors such as sleep loss than are general RTB.

Variables that Mediate the Relationship Between Sleep Loss and RTB

The current study examined negative mood and framing as potential mediators of the relationship between sleep loss and RTB. Negative mood partially mediated the relationship
between global sleep quality and substance use and the relationship between sleep loss and sexual compulsivity. When negative mood was controlled for, the relationship between sleep quality and substance use (as well as sexual compulsivity) was reduced, indicating that negative mood explains a portion of the relationship between sleep loss and RTB. Framing did not significantly mediate the relationship between sleep loss and RTB.

No studies to date have investigated negative mood as a possible mediator of the relationship between sleep loss and RTB. However, previous research has examined the possibility that a relationship exists between sleep loss, RTB, and negative mood. The mood maintenance model (Isen & Patrick, 1983) suggests that individuals in a positive mood take fewer risks to avoid negative outcomes (i.e., maintain their positive mood), while individuals in a negative mood tend to take more risks to pursue positive outcomes (i.e., a positive outcome will improve their negative mood; Harrison & Horne, 2000). Additionally, several studies have linked sleep loss to an increase in negative mood and a decrease in positive mood (Paterson et al., 2011). Catrett and Gaultney (2009) examined self-reported possible insomnia (i.e., sleep disturbances, sleep loss) and depressive symptoms (which can be operationalized as a type of negative mood) as predictors of various risk-taking behaviors in adolescents (e.g., substance use, delinquent behavior, drinking and driving). These researchers found correlations between possible insomnia, depressive symptoms, and some risk-taking behaviors. Their results indicate possible insomnia predicts some types of RTB and depressive symptoms predict some other types of RTB. For the majority of the RTB measured, possible insomnia was a stronger predictor of RTB than were depressive symptoms. However, this study did not specifically investigate the possibility that the depressive symptoms (negative mood) mediated the relationship between possible insomnia (sleep loss) and RTB.
The current study built on the relationships described in previous research and found partial mediation. These results are important because they provide support for the concept that at least a portion of RTB can be influenced by negative mood. While the present study cannot causally link mood to sleep and thus RTB, it does show evidence of a relationship between the three variables in which negative mood helps explain the relationship between sleep loss and RTB.

Venkatraman et al. (2010) applied the concept of framing (i.e., the way an individual thinks about a problem) to the relationship between sleep loss and RTB, and found sleep deprived individuals had an increased preference for risks involving gains compared to preferences assessed prior to sleep loss (i.e., rested baseline). In explaining their findings, these researchers suggested that this shift in preference might be due to an optimism bias brought on (in part) by sleep loss. Thus, sleep loss might contribute to a shift in preference, which in turn might influence RTB. The current study applied this idea of a relationship between sleep loss, perception (i.e., framing), and RTB in the form of a mediation analysis in which framing might help explain the relationship between sleep loss and RTB. Contrary to expectations, framing did not significantly mediate the relationship between sleep loss and RTB.

Limitations

There are several limitations of the present study. First, the study used a cross-sectional, correlational design rather than an experimental design. The majority of measures in the study were self-report measures, both for the independent variable (sleep loss) and the dependent variable (RTB), though some measures of RTB were behavioral. Therefore, causal conclusions cannot be determined from this study.
Second, this study utilized a convenience sample of undergraduate students, and therefore may not be generalizable to the general population. Undergraduate students are typically younger than most adults (persons above the age of 18) and therefore at a different developmental stage than many adults in the general adult population. This may have an impact on RTB, as prefrontal cortex development, which plays a role in decision-making, is not fully developed until about age 25 (the mean age of the current sample was 20.10). Additionally, certain behaviors may be more socially acceptable among college students (e.g., binge drinking, marijuana use) than among older adults in the United States, and reported levels of RTB might differ.

Third, participants completed surveys and behavioral measures online rather than in a controlled laboratory setting. Because of this lack of control, participants may have completed study measures in a haphazard manner, which may have negatively affected the results of this study.

Fourth, the temporal stability results for the IGT utilized only a small subset of participants (i.e., 50) who completed the initial study (i.e., 279). The small number of participants may have negatively affected the analyses that compared scores on the IGT across time points due to lack of power.

Finally, there is some question as to the validity of the IGT as a measure of RTB. Scores on the IGT are based on an individual’s ability to learn which decks are advantageous and which are disadvantageous. Each participant is presented four decks of cards and chooses cards at random until they learn which decks contain cards that are “good” and which contain cards that are “bad.” Participants then choose when to pick “good” and “bad” cards in order to maximize their profit. This decision-making is the RTB of interest (i.e., do individuals choose the “good”
decks rather than the “bad” decks once they learn which are which). However, scores on the IGT are dependent on whether a participant learns to distinguish between decks. Participants who never learn which decks are more advantageous will likely not make choices that lead to higher scores and will thus have scores that reflect higher RTB, even though their lower scores may reflect lower capacity for learning and not higher RTB.

Furthermore, while there has been some evidence of the construct validity of the IGT (see Buelow & Suhr, 2009), the results of the current study showed no significant relationship between scores on the IGT and scores on other measures of RTB (i.e., sensation seeking, impulsivity, DDT, substance use, sexual compulsivity, problem gambling). While it is possible this lack of significant results is due to methodological problems (e.g., participants completed the study outside a controlled laboratory environment) or some other limitation, it could also lend evidence to the idea that the IGT is not the best measure for assessing RTB.

Areas for Future Research

Several areas of research as to the relationship between sleep loss and RTB still need to be explored. First, further studies to determine the construct validity of the IGT are needed. To date, only one published study has investigated the validity of the IGT (Buelow & Suhr, 2009), and the results of the current study contradict previous findings. Specifically, it is as yet unclear as to whether the IGT is a measure of learning or RTB or both. Additionally, studies should examine the construct validity of several behavioral measures of RTB (e.g., Balloon Analogue Risk Task, Lottery Choice Task, DDT, etc.) and possibly develop new behavioral measures of RTB that better assess risk-taking preferences in the absence of confounding variables (e.g., learning). It might also be beneficial for future research to include multiple behavioral measures.
of RTB in the context of laboratory TSD, in which experimental manipulation of sleep loss allows for a better understanding of any causal relationship that might exist between RTB and sleep loss.

Second, additional research is needed as to the temporal stability of the IGT. Study designs that examine practice effects associated with the IGT at various intervals between administration would be useful (i.e., are the practice effects different when the time between administrations is 1 year versus 1 month versus 1 week?). Some studies to date (Killgore et al., 2006; Killgore et al., 2007) have administered the IGT multiple times within a few days, and it would be beneficial to understand any practice effects that might influence the results of such studies.

Third, future research should be conducted in the area of general versus specific RTB, especially in the context of laboratory TSD. To date, no studies have examined the possible differences between types of RTB (i.e., substance use and sensation seeking) within the context of sleep loss. A laboratory experiment that examines the differences between changes in specific RTB versus general RTB under conditions of TSD might help clarify whether sleep loss affects types of RTB differently (i.e., investigate the possibility that general RTB is more stable than specific RTB).

Fourth, further study is needed to examine possible mediators of the relationship between sleep loss and RTB. The current study found negative mood to be a partial mediator of this relationship, but this finding should be replicated. Also, studies that include laboratory TSD (rather than self-reports) should be conducted. Furthermore, studies that measure mood more thoroughly (i.e., multiple measures, more in-depth mood measures) should be conducted. Perhaps mood manipulation could also be included in future study designs to better understand
the relationship between negative mood, sleep loss, and RTB. Finally, it should be noted that, at least in the present study, the mediated effect of sleep loss on RTB through negative mood was very small. There are likely other potential mediators of the relationship besides negative mood (e.g., framing, etc.) that should be identified and investigated.

Implications for Counseling

Roughly 30% of adults in the United States report inadequate sleep, and this number has increased over the past 20 years (Schoenborn & Adams, 2008; Luckhaupt et al., 2010). Sleep loss is related to a variety of adverse outcomes, including increased RTB (Harrison & Horne, 2000; Luckhaupt et al., 2010). Additionally, many individuals have no control over their levels of sleep loss due to their occupation (i.e., nurses and doctors, airline pilots, commercial truck drivers, individuals involved in shift work), or due to conditions that can contribute to lack of sleep (i.e., sleep apnea). It is important for counselors to understand the problems faced by their clients (many of whom may experience sleep loss) and the potential challenges associated with sleep loss. The more counselors understand the unique needs of their clients, the better they will be able to plan interventions that will be relevant and helpful.

Several studies, including the present study, have demonstrated a link between sleep loss and RTB. It is therefore possible that individuals who struggle with sleep may have an increased risk for higher RTB, though a causal link has yet to be established. It may be helpful for clinicians to work with these such clients to address problems with sleep loss in an effort to possibly decrease chances for higher RTB. Education about the importance of sleep hygiene, bedtime relaxation exercises (e.g., breathing exercises, progressive muscle relaxation), and other interventions designed to reduce sleep loss might be helpful.
Similarly, it might be beneficial for clinicians working with clients who demonstrate higher levels of RTB to assess their sleep quality and sleep duration (i.e., factors that influence sleep loss). Interventions designed to improve sleep quality and quantity (such as those previously mentioned) might be a beneficial component of treatment for RTB.

The current study also found negative mood partially mediated the relationship between sleep loss and RTB. Therefore, it might be beneficial for clinicians working with individuals who demonstrate symptoms of sleep loss and/or elevated levels of RTB (e.g., recreational substance use, thrill-seeking) to implement interventions aimed at decreasing negative mood (e.g., cognitive behavioral therapy, anger management strategies, psycho-education). It is important to note that a causal relationship between sleep loss and RTB has yet to be established, and the partial mediation effect of negative mood is small and has yet to be replicated. These interventions and implications for counseling are tentative, but could be useful to some clinicians and clients.

Conclusion

Little research has been conducted to date investigating the relationship between sleep loss and RTB, despite the potential for adverse consequences of lack of sleep and risky decision-making. The current study examined the overall relationship between sleep loss and RTB, possible mediators of this relationship, and the reliability and validity of a behavioral measure of RTB, the Iowa Gambling Task. In general, sleep loss was associated with increased RTB, and negative mood was found to partially mediate this relationship. There was weak evidence for the temporal stability of the IGT, and the IGT was not related to other measures of RTB. Further
research in this area of study will better help us better understand the challenges faced by individuals affected by sleep loss, and inform potential interventions.
APPENDIX

INFORMED CONSENT AND MEASURES
Informed Consent Study 1

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits, and risks of the study and how it will be conducted.

Title of Study: A Study of Sleep and Decision-Making

Principal Investigators: Joshua N. Hook, Ph.D., University of North Texas (UNT) Department of Psychology.

Purpose of the Study: You are being asked to participate in a research study pertaining to how individuals make decisions in certain situations. You will be asked questions about the types of decisions you typically make in various situations, as well as questions about your sleep habits.

Study Procedures: You will be asked to fill out a survey with various questionnaires that will, in total, take about 120 minutes of your time to complete.

Foreseeable Risks: There are no foreseeable risks of this study except for possible feelings of discomfort due to answering survey questions regarding attitudes, feelings, and experiences. If you do experience feelings of discomfort, you may contact the principal investigator who can refer you to services for counseling. You may also choose to stop participation at any point.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to you but may contribute to the growing body of knowledge about decision-making.

Compensation for Participants: If your teacher gives course credit or extra credit through SONA for participation in research, you will receive 4 credits for your participation in this research study. After you complete study 1, you will be invited to complete a follow up study for which you will receive an additional 2 credits.

Procedures for Maintaining Confidentiality of Research Records: Your participation in this study will be confidential. Identifying information will not be obtained as part of this study and the confidentiality of your individual data will be maintained in any publications or presentations regarding this study.

Questions about the Study: If you have any questions about the study, you may contact Dr. Joshua Hook at telephone number 940.369.8076.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

Research Participants’ Rights: You have read or have had read to you all of the above and you confirm all of the following:
1. You understand the possible benefits and the potential risks and/or discomforts of the study.

2. You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits.

3. You understand why the study is being conducted and how it will be performed.

4. You understand your rights as a research participant and you voluntarily consent to participate in this study.

Type the participant ID number you received via email if you consent to participate in this study.

OR

Sign your name in the box below if you consent to participate in this study.
Informed Consent Study 2

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits, and risks of the study and how it will be conducted.

Title of Study: A Study of Sleep and Decision-Making

Principal Investigators: Joshua N. Hook, Ph.D., University of North Texas (UNT) Department of Psychology.

Purpose of the Study: You are being asked to participate in a research study pertaining to how individuals make decisions in certain situations. You will be asked questions about the types of decisions you typically make in various situations, as well as questions about your sleep habits.

Study Procedures: You will be asked to fill out a survey with various questionnaires that will, in total, take about 60 minutes of your time to complete.

Foreseeable Risks: There are no foreseeable risks of this study except for possible feelings of discomfort due to answering survey questions regarding attitudes, feelings, and experiences. If you do experience feelings of discomfort, you may contact the principal investigator who can refer you to services for counseling. You may also choose to stop participation at any point.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to you but may contribute to the growing body of knowledge about decision-making.

Compensation for Participants: If your teacher gives course credit or extra credit through SONA for participation in research, you will receive 2 credits for your participation in this research study.

Procedures for Maintaining Confidentiality of Research Records: Your participation in this study will be confidential. Identifying information will not be obtained as part of this study and the confidentiality of your individual data will be maintained in any publications or presentations regarding this study.

Questions about the Study: If you have any questions about the study, you may contact Dr. Joshua Hook at telephone number 940.369.8076.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

Research Participants’ Rights: You have read or have had read to you all of the above and you confirm all of the following:
   1. You understand the possible benefits and the potential risks and/or discomforts of the study.
2. You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits.
3. You understand why the study is being conducted and how it will be performed.
4. You understand your rights as a research participant and you voluntarily consent to participate in this study.

Type the participant ID number you received via email if you consent to participate in this study.

OR

Sign your name in the box below if you consent to participate in this study.

APPROVED BY THE UNT IRB
FROM 10/11/11 TO 10/10/12
Demographics Questionnaire

1. What is your gender? __________

2. What is your age? __________

3. What is your current marital status?
   a. Single
   b. Married
   c. Separated
   d. Divorced
   e. Widowed
   f. Other __________

4. What is your ethnicity?
   a. White/Caucasian
   b. Black/African-American
   c. Asian/Pacific Islander
   d. Latino/Hispanic
   e. Native American
   f. Multiracial __________
   g. Other __________

5. What is your sexual orientation?
   a. Heterosexual
   b. Homosexual
   c. Bisexual
   d. Other __________

6. What is your religious affiliation
   a. Christian
   b. Muslim
   c. Buddhist
   d. Hindu
   e. Jewish
   f. None
   g. Other __________

7. What year are you in school?
   a. First Year Undergraduate
   b. Second Year Undergraduate
   c. Third Year Undergraduate
   d. Fourth Year Undergraduate
   e. Fifth Year or Higher Undergraduate
   f. Graduate Student
   g. Other __________
Kirby Delay Discounting Task


**DIRECTIONS:** Read each statement and indicate which choice (A or B) you prefer. Answer each item as if you would actually receive that amount of real money.

1. Which would you rather have?
   - A. $54 now
   - B. $55 in 117 days
2. Which would you rather have?
   - A. $55 now
   - B. $75 in 61 days
3. Which would you rather have?
   - A. $19 now
   - B. $25 in 53 days
4. Which would you rather have?
   - A. $31 now
   - B. $85 in 7 days
5. Which would you rather have?
   - A. $14 now
   - B. $25 in 19 days
6. Which would you rather have?
   - A. $47 now
   - B. $50 in 160 days
7. Which would you rather have?
   - A. $15 now
   - B. $35 in 13 days
8. Which would you rather have?
   - A. $25 now
   - B. $60 in 14 days
9. Which would you rather have?
   - A. $78 now
   - B. $80 in 162 days
10. Which would you rather have?
    - A. $40 now
    - B. $55 in 62 days
11. Which would you rather have?
    - A. $11 now
    - B. $30 in 7 days
12. Which would you rather have?
    - A. $67 now
    - B. $75 in 119 days
13. Which would you rather have?
    - A. $34 now
    - B. $35 in 186 days
14. Which would you rather have?
    - A. $27 now
    - B. $50 in 21 days
15. Which would you rather have?
    - A. $69 now
    - B. $85 in 91 days
16. Which would you rather have?
    - A. $49 now
    - B. $60 in 89 days
17. Which would you rather have?
    - A. $80 now
    - B. $85 in 157 days
18. Which would you rather have?
    - A. $24 now
    - B. $35 in 29 days
19. Which would you rather have?
    - A. $33 now
    - B. $80 in 14 days
20. Which would you rather have?
    - A. $28 now
    - B. $30 in 179 days
21. Which would you rather have?
    - A. $34 now
    - B. $50 in 30 days
22. Which would you rather have?
    - A. $25 now
    - B. $30 in 80 days
23. Which would you rather have?
    - A. $41 now
    - B. $75 in 20 days
24. Which would you rather have?
    - A. $54 now
    - B. $60 in 111 days
25. Which would you rather have?
    - A. $54 now
    - B. $80 in 30 days
26. Which would you rather have?
    - A. $22 now
    - B. $25 in 136 days
27. Which would you rather have?
    - A. $20 now
    - B. $55 in 7 days
Brief Sensation Seeking Scale


**DIRECTIONS:** Read each statement and choose the number that best represents how much you agree or disagree. It is important that you respond to all items by circling only one choice. We are interested only in your likes or feelings, not in how others feel about these things or how one is supposed to feel. There are no right or wrong answers as in other kinds of tests. Be frank and give your honest appraisal of yourself. Use the following scale to answer:

1 = Strongly Agree  
2 = Agree  
3 = Neither Agree nor Disagree  
4 = Disagree  
5 = Strongly Disagree

1. I would like to explore strange places.  
   1  2  3  4  5

2. I get restless when I spend too much time at home.  
   1  2  3  4  5

3. I like to do frightening things.  
   1  2  3  4  5

4. I like wild parties.  
   1  2  3  4  5

5. I would like to take off on a trip with no pre-planned routes or timetables.  
   1  2  3  4  5

6. I prefer friends who are exciting and unpredictable.  
   1  2  3  4  5

7. I would like to try bungee jumping.  
   1  2  3  4  5

8. I would love to have new and exciting experiences, even if they are illegal.  
   1  2  3  4  5
Barratt Impulsivity Scale, 11th Revision


**DIRECTIONS:** People differ in the ways they act and think in different situations. This is a test to measure some of the ways in which you act and think. Read each statement and rate it according to the scale below. Do not spend too much time on any statement. Answer quickly and honestly.

1 = Rarely/never  2 = Occasionally  3 = Often  4 = Almost Always/Always

1. I plan tasks carefully.  
2. I do things without thinking.  
3. I make up my mind quickly.  
4. I am happy-go-lucky.  
5. I don’t “pay attention.”  
6. I have “racing” thoughts.  
7. I plan trips well ahead of time.  
8. I am self-controlled.  
9. I concentrate easily.  
10. I save regularly.  
11. I “squirm” at plays or lectures.  
12. I am a careful thinker.  
13. I plan for job security.  
15. I like to think about complex problems.  
16. I change jobs.  
17. I act “on impulse.”  
18. I get easily bored when solving thought problems.  
19. I act on the spur of the moment.  
20. I am a steady thinker.  
21. I change residence.  
22. I buy things on impulse.  
23. I can only think about one thing at a time.  
24. I change hobbies.  
25. I spend or charge more than I earn.  
26. I often have extraneous thoughts when thinking.  
27. I am more interested in the present than the future.  
28. I am restless at the theater or lectures.  
29. I like puzzles.  
30. I am future oriented.

**DIRECTIONS:** You will be asked some questions about your experience of using alcohol, tobacco products, and other drugs across your lifetime and in the past three months. These substances can be smoked, swallowed, snorted, inhaled, injected, or taken in the form of pills. Some of the substances listed may be prescribed by a doctor (like amphetamines, sedatives, pain medications). These questions are not asking about medications that are used as prescribed by your doctor. However, if you have taken such medications for reasons other than prescription, or taken them more frequently or at higher doses than prescribed, please answer yes to the appropriate questions.

All of your answers about drug use will be kept strictly confidential.

<table>
<thead>
<tr>
<th>In your life, which of the following substances have you ever used? (non-medical use only)</th>
<th>Circle One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco products (cigarettes, chewing tobacco, cigars, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Alcoholic beverages (beer, wine, spirits, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Cannabis (marijuana, pot, grass, hash, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Cocaine (coke, crack, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Amphetamine type stimulants (speed, diet pills, ecstasy, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Inhalants (nitrous, glue, petrol, paint thinner, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Opioids (heroin, morphine, methadone, codeine, etc.)</td>
<td>No Yes</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>No Yes</td>
</tr>
</tbody>
</table>

If you answered no to any of the questions, move on to the next survey.

**Tobacco Products** (cigarettes, chewing tobacco, cigars, etc.)

1. During the *past three months*, how often have you used tobacco products? (check one)
   - ___ Never ___ Once or Twice ___ 1-3x / month ___ 1-4x / week ___ 5-7x / day
2. During the *past three months*, how often have you had a strong desire or urge to use tobacco products? (check one)
   - ___ Never ___ Once or Twice ___ 1-3x / month ___ 1-4x / week ___ 5-7x / day
3. During the *past three months*, how often has your use of tobacco products led to health, social, legal, or financial problems? (check one)
   - ___ Never ___ Once or Twice ___ 1-3x / month ___ 1-4x / week ___ 5-7x / day
4. During the *past three months*, how often have you failed to do what was normally expected of you because of your use of tobacco products? (check one)
   - ___ Never ___ Once or Twice ___ 1-3x / month ___ 1-4x / week ___ 5-7x / day
5. Has a friend or relative or anyone else ever expressed concern about your use of tobacco products? (check one)
   ___ No, never  ___ Yes, in the past 3 months  ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using tobacco products? (check one)
   ___ No, never  ___ Yes, in the past 3 months  ___ Yes, but not in the past 3 months

Alcoholic beverages (beer, wine, spirits, etc.)
1. During the past three months, how often have you used alcoholic beverages? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use alcoholic beverages? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

3. During the past three months, how often has your use of alcoholic beverages led to health, social, legal, or financial problems? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of alcoholic beverages? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

5. Has a friend or relative or anyone else ever expressed concern about your use of alcoholic beverages? (check one)
   ___ No, never  ___ Yes, in the past 3 months  ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using alcoholic beverages? (check one)
   ___ No, never  ___ Yes, in the past 3 months  ___ Yes, but not in the past 3 months

Cannabis (marijuana, pot, grass, spirits, etc.)
1. During the past three months, how often have you used cannabis? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use cannabis? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

3. During the past three months, how often has your use of cannabis led to health, social, legal, or financial problems? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of cannabis? (check one)
   ___ Never  ___ Once or Twice  ___ 1-3x / month  ___ 1-4x / week  ___ 5-7x / day

5. Has a friend or relative or anyone else ever expressed concern about your use of cannabis? (check one)
   ___ No, never  ___ Yes, in the past 3 months  ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using cannabis? (check one)
   ___ No, never  ___ Yes, in the past 3 months  ___ Yes, but not in the past 3 months
**Cocaine** (coke, crack, etc.)

1. During the past three months, how often have you used cocaine? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use cocaine? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

3. During the past three months, how often has your use of cocaine led to health, social, legal, or financial problems? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of cocaine? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

5. Has a friend or relative or anyone else ever expressed concern about your use of cocaine? (check one)
   - ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using cocaine? (check one)
   - ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

**Amphetamine type stimulants** (speed, diet pills, ecstasy, etc.)

1. During the past three months, how often have you used amphetamine type stimulants? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use amphetamine type stimulants? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

3. During the past three months, how often has your use of amphetamine type stimulants led to health, social, legal, or financial problems? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of amphetamine type stimulants? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

5. Has a friend or relative or anyone else ever expressed concern about your use of amphetamine type stimulants? (check one)
   - ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using amphetamine type stimulants? (check one)
   - ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

**Inhalants** (nitrous, glue, petrol, paint thinner, etc.)

1. During the past three months, how often have you used inhalants? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use inhalants? (check one)
   - ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
3. During the past three months, how often has your use of inhalants led to health, social, legal, or financial problems? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of inhalants? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

5. Has a friend or relative or anyone else ever expressed concern about your use of inhalants? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using inhalants? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

Sedatives or Sleeping Pills (Valium, Serepax, Rohypnol, etc.)
1. During the past three months, how often have you used sedatives or sleeping pills? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use sedatives or sleeping pills? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

3. During the past three months, how often has your use of sedatives or sleeping pills led to health, social, legal, or financial problems? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of sedatives or sleeping pills? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

5. Has a friend or relative or anyone else ever expressed concern about your use of sedatives or sleeping pills? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

6. Have you ever tried and failed to control, cut down or stop using sedatives or sleeping pills? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

Hallucinogens (LSD, acid, mushrooms, PCP, Special K, etc.)
1. During the past three months, how often have you used hallucinogens? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

2. During the past three months, how often have you had a strong desire or urge to use hallucinogens? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

3. During the past three months, how often has your use of hallucinogens led to health, social, legal, or financial problems? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day

4. During the past three months, how often have you failed to do what was normally expected of you because of your use of hallucinogens? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
5. Has a friend or relative or anyone else ever expressed concern about your use of hallucinogens? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months
6. Have you ever tried and failed to control, cut down or stop using hallucinogens? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

Opioids (heroin, morphine, methadone, codeine, etc.)
1. During the past three months, how often have you used opioids? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
2. During the past three months, how often have you had a strong desire or urge to use opioids? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
3. During the past three months, how often has your use of opioids led to health, social, legal, or financial problems? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
4. During the past three months, how often have you failed to do what was normally expected of you because of your use of opioids? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
5. Has a friend or relative or anyone else ever expressed concern about your use of opioids? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months
6. Have you ever tried and failed to control, cut down or stop using opioids? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

Other (please specify or write not applicable) ________________________________
1. During the past three months, how often have you used this substance? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
2. During the past three months, how often have you had a strong desire or urge to use this substance? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
3. During the past three months, how often has your use of this substance led to health, social, legal, or financial problems? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
4. During the past three months, how often have you failed to do what was normally expected of you because of your use of this substance? (check one)
   ___ Never   ___ Once or Twice   ___ 1-3x / month   ___ 1-4x / week   ___ 5-7x / day
5. Has a friend or relative or anyone else ever expressed concern about your use of this substance? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months
6. Have you ever tried and failed to control, cut down or stop using this substance? (check one)
   ___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months

Have you ever used any drug by injection? (check one)
___ No, never   ___ Yes, in the past 3 months   ___ Yes, but not in the past 3 months
South Oaks Gambling Screen


1. Please indicate which of the following types of gambling you have done in your lifetime. For each type, mark one answer: “Not at All,” “Less than Once a Week,” or “Once a Week or More.”

<table>
<thead>
<tr>
<th>Please Check on answer for each statement:</th>
<th>NOT AT ALL</th>
<th>Less than once a week</th>
<th>Once a week or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Played cards for money.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Bet on horses, dogs, or other animals (at OTB, the track, or with a bookie).</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Bet on sports (parlay cards, with bookie at Jai Alai).</td>
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<tr>
<td>d. Played dice games, including craps, over and under or other dice games.</td>
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<tr>
<td>e. Went to casinos (legal or otherwise)</td>
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<tr>
<td>f. Played the numbers or bet on lotteries.</td>
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<tr>
<td>g. Played bingo.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>h. Played the stock and/or commodities market.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Played slot machines, poker machines, or other gambling machines.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>j. Bowled, shot pool, played golf, or some other game of skill for money.</td>
<td></td>
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<td></td>
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<tr>
<td>k. Played pull tabs or “paper” games other than lotteries.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>l. Some form of gambling not listed above (please specify):</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

2. What is the largest amount of money you have ever gambled with on any one-day?
   - [ ] Never Gambled
   - [ ] $1.00 or less
   - [ ] More than $1.00 up to $10.00
   - [ ] More than $10.00 up to $100.00
   - [ ] More than $100.00 up to $1,000
   - [ ] More than $1,000 up to $10,000
   - [ ] More than $10,000

3. Check which of the following people in your life has (or had) a gambling problem.
   - [ ] Father
   - [ ] Mother
   - [ ] Brother/Sister
   - [ ] My spouse/partner
   - [ ] My child(ren)
   - [ ] Another relative
   - [ ] A Friend or someone important in my life
4. When you gamble, how often do you go back another day to win back money you have lost?
   _____ Never           _____ Most of the time
   _____ Some of the time   _____ Every time that I lose
   (less than half of the time I lose)

5. Have you ever claimed to be winning money gambling, but weren’t really? In fact you lost?
   _____ Never
   _____ Yes, less than half the time I lost
   _____ Yes, most of the time

6. Do you feel you have ever had a problem with betting or money gambling?
   _____ No           _____ Yes           _____ Yes, in the past, but not now

7. Did you ever gamble more than you intended?
   _____ Yes           _____ No

8. Have people ever criticized your betting or told you that you had a problem, regardless of
   whether or not you thought it was true?
   _____ Yes           _____ No

9. Have you ever felt guilty about the way you gamble, or what happens when you gamble?
   _____ Yes           _____ No

10. Have you ever felt like you would like to stop betting money on gambling, but did not think
    that you could?
    _____ Yes           _____ No

11. Have you ever hidden betting slips, lottery tickets, gambling money, IOUs, or other signs of
    betting or gambling from your spouse, children, or other important people in your life?
    _____ Yes           _____ No

12. Have you ever argued with people you live with over how you handle money
    _____ Yes           _____ No

13. (If you answered “yes” to question 12) Have money arguments ever centered on your
    gambling?
    _____ Yes           _____ No

14. Have you ever borrowed from someone and not paid them back as a result of your gambling?
    _____ Yes           _____ No

15. Have you ever lost time from work (or school) due to betting money or gambling?
    _____ Yes           _____ No
16. If you borrowed money to pay gambling debts, who or where did you borrow from? (check “Yes” or “No” for each):
   a. From household money _____ Yes _____ No
   b. From your spouse/partner _____ Yes _____ No
   c. From relatives or in-laws _____ Yes _____ No
   d. From banks, loan companies, or credit unions _____ Yes _____ No
   e. From credit cards _____ Yes _____ No
   f. From loan sharks _____ Yes _____ No
   g. You cashed in stocks, bonds, or other securities _____ Yes _____ No
   h. You sold personal or family property _____ Yes _____ No
   i. You borrowed on your checking accounts (passed bad checks) _____ Yes _____ No
   j. You have (had) a credit line with a bookie _____ Yes _____ No
   k. You have (had) a credit line with a casino _____ Yes _____ No
The Sexual Compulsivity Scale


DIRECTIONS: A number of statements that some people have used to describe themselves are given below. Read each statement and then circle the number to show how well you believe the statement describes you.

<table>
<thead>
<tr>
<th>1. My sexual appetite has gotten in the way of my relationships.</th>
<th>Not at all like me</th>
<th>Slightly like me</th>
<th>Mainly like me</th>
<th>Very Much like me</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. My sexual thoughts and behaviors are causing problems in my life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. My desires to have sex have disrupted my daily life</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I sometimes fail to meet my commitments and responsibilities because of my sexual behaviors.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. I sometimes get so horny I could lose control.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. I find myself thinking about sex while at work.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I feel that sexual thoughts and feelings are stronger than I am.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. I have to struggle to control my sexual thoughts and behavior.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. I think about sex more than I would like to.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. It has been difficult for me to find sex partners who desire having sex as much as I want to.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>
Pittsburgh Sleep Quality Inventory


**DIRECTIONS:** The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, when have you usually gone to bed at night?
   USUAL BED TIME __________

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
   USUAL NUMBER OF MINUTES __________

3. During the past month, when have you usually gotten up in the morning?
   USUAL GETTING UP TIME __________

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spend in bed.)
   HOURS OF SLEEP PER NIGHT __________

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you…
   a. Cannot get to sleep within 30 minutes
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
   b. Wake up in the middle of the night or early morning
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
   c. Have to get up to use the bathroom
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
   d. Cannot breathe comfortably
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
   e. Cough or snore loudly
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
   f. Feel too cold
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
   g. Feel too hot
      Not during the past month _____  once a week _____  twice a week _____  times a week _____
h. Have bad dreams
   Not during the past month _____  less than once a week _____
   Once or more than twice a week _____
   Three or more times a week _____

i. Have pain
   Not during the past month _____  less than once a week _____
   Once or more than twice a week _____
   Three or more times a week _____

j. Other reason(s), please describe __________________________________________
____________________________________________________________________

How often during the past month have you had trouble sleeping because of this?
   Not during the past month _____  less than once a week _____
   Once or more than twice a week _____
   Three or more times a week _____

6. During the past month, how would you rate your sleep quality overall?
   Very good _____
   Fairly good _____
   Fairly bad _____
   Very bad _____

7. During the past month, how often have you taken medicine (prescribed or “over the counter”) to help you sleep?
   Not during the past month _____  less than once a week _____
   Once or more than twice a week _____
   Three or more times a week _____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?
   Not during the past month _____  less than once a week _____
   Once or more than twice a week _____
   Three or more times a week _____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?
   No problem at all _____
   Only a very slight problem _____
   Somewhat of a problem _____
   A very big problem _____

10. Do you have a bed partner or roommate?
    No bed partner or roommate _____
    Partner/roommate in other room _____
    Partner in same room, but not same bed _____
    Partner in same bed _____
Sleep Survey


1. What time did you go to bed last night? __________

2. How many minutes did it take you to fall asleep last night? __________

3. Did you wake up in the middle of the night last night? __________
   a. If so, how many times? __________
   b. If so, how long were you awake each time? ______________

4. What time did you wake up this morning? __________

5. How did you wake up this morning (e.g., alarm clock, someone woke you up, etc.)? 

6. What is the total amount of time you were asleep last night? __________

7. How many caffeinated beverages (e.g., coffee, soft drinks, energy drinks, etc.) have you consumed since waking up this morning? __________

8. Use the following scale to rate your level of sleepiness right now. __________

   1 = Feeling active, vital, alert, or wide awake
   2 = Functioning at high levels, but not at peak; able to concentrate
   3 = Awake, but relaxed; responsive but not fully alert
   4 = Somewhat foggy, let down
   5 = Foggy; losing interest in remaining awake; slowed down
   6 = Sleepy, woozy, fighting sleep; prefer to lie down
   7 = No longer fighting sleep, sleep onset soon; having dream-like thoughts
Positive and Negative Affect Schedule


DIRECTIONS: This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment OR indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure).

1 = Very Slightly or Not at All
2 = A Little
3 = Moderately
4 = Quite a Bit
5 = Extremely

1. _____ Interested
2. _____ Distressed
3. _____ Excited
4. _____ Upset
5. _____ Strong
6. _____ Guilty
7. _____ Scared
8. _____ Hostile
9. _____ Enthusiastic
10. _____ Proud
11. _____ Irritable
12. _____ Alert
13. _____ Ashamed
14. _____ Inspired
15. _____ Nervous
16. _____ Determined
17. _____ Attentive
18. _____ Jittery
19. _____ Active
20. _____ Afraid
Framing Questionnaire

Thank you for playing this game. Please answer the following questions about your participation in the game.

1. What was the main purpose of the game? ________________________________
   ______________________________________________________________________
   ______________________________________________________________________

2. What was the main purpose of the game?

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Avoid losing as much money as possible</td>
<td></td>
<td></td>
<td></td>
<td>Win as much money as possible</td>
</tr>
</tbody>
</table>

3. When playing the game, what was your main focus?

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<th></th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Avoid losing as much money as possible</td>
<td></td>
<td></td>
<td></td>
<td>Win as much money as possible</td>
</tr>
<tr>
<td>2</td>
<td>Equal focus on winning money and avoiding losing money</td>
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<td></td>
<td></td>
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</table>

4. When playing the game, to what extent were you focused on winning money?

<table>
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<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not at all focused on winning money</td>
<td></td>
<td></td>
<td></td>
<td>Very focused on winning money</td>
</tr>
</tbody>
</table>

5. When playing the game, to what extent were you focused on avoiding losing money?

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<th></th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Not at all focused on avoiding losing money</td>
<td></td>
<td></td>
<td></td>
<td>Very focused on avoiding losing money</td>
</tr>
</tbody>
</table>
REFERENCES

* Indicates a study used in the review of the literature.


*Killgore, W. D. S. (2007). Effects of sleep deprivation and morningness-eveningness traits on risk-taking. *Psychological Reports, 100*, 613-626. doi: 10.2466/PR0.100.2.613-626


