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FACTORS IN THE REGULATION OF CYCLES OF BINGE EATING BEHAVIOR

A Dissertation Presented

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Abstract

The reasons why people may periodically resort to binge eating behavior have long been a focus of study, and the reasons are elusive and varied. For people troubled by poor sleep and living with chronic stress, binge eating may be an attempt by the brain's glucose-depleted executive processing center to both regulate (i.e., increase) glucose levels and induce restorative sleep. Recovery resulting from restorative sleep may lead to a reduction in perceived stress, improved mood, and increased willpower, reducing the likelihood of another binge episode in close temporal proximity to the sleep-induced recovery. A repetitive cycle may ensue when stress inevitably again disturbs sleep, lowering mood, reducing willpower, and heightening sensitivity to stigma and stress.

The purpose of the research described here is to synthesize recent findings from three diverse fields of scientific inquiry to predict factors that influence episodes of binge eating. Combining studies of sleep and sleep disorders, stress and stigma research, and recent work on self-regulatory capacity, I attempt to show how poor sleep ultimately leads to binge eating. A seven-day study consisted of three parts: an initial set of baseline questionnaire and physiological measures; collection of objective sleep quality data using an electronic motion logger; and an online daily diary in which participants completed measures of self-regulatory capacity and reported details about their sleep, stress levels, experiences with stigma, mood, and eating events. The data partially supported a path model where sleep quality, stress, mood, and self-regulation affected binge eating behavior.

Dedication

For her many sacrifices, unflagging support of me and my seemingly endless formal education, for thoughtful and insightful comments and contributions to this research, for her patience, coaching, cajoling, encouragement, devotion, and love, this work is dedicated to my best friend, my partner, my wife, Maggie.

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I am grateful for friends and colleagues who always made me feel welcome, were available and happy to discuss ideas and untangle statistical knots. I am especially indebted to James Hodge, my friend, office mate, traveling companion, and fellow research assistant for his wise counsel on many topics. I also especially wish to thank Albert Kšičan. Finally I want to acknowledge the support and love of my son Colin and daughter Haley. I am very proud of you both.

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Introduction

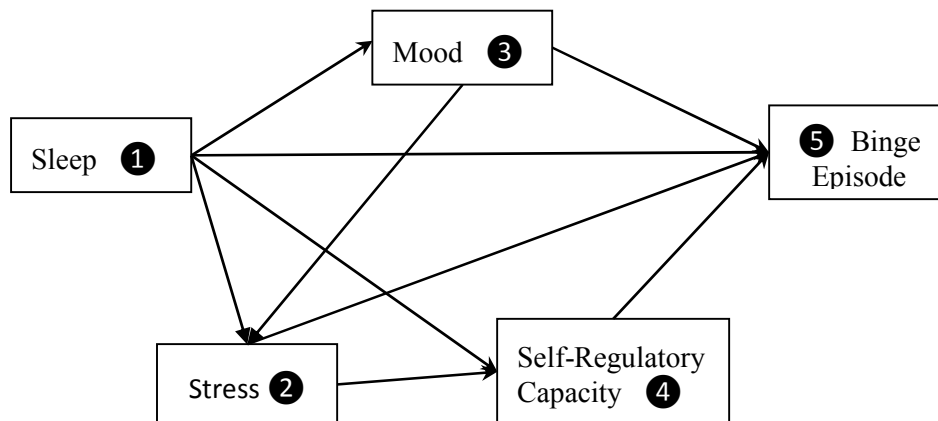
A client at a weight loss center was speaking about a recent experience she had after work one evening. “I stood in front of the pantry and just started eating. I wasn’t really even hungry, but I couldn’t stop. It was like I was watching someone else; my hand just kept reaching into the bag and putting the chips into my mouth. It was like I was on autopilot.” This person is describing a binge eating episode, a behavior characterized by excessive consumption of food and feelings of loss of control. Although binge eating often leads to overweight and obesity, it is not exclusive to the obese (See Lingswiler, Crowther, & Stephens, 1989 for a review).

The reasons why people may periodically resort to binge eating behavior have long been a focus of study (Polivy & Herman, 1993; Striegel-Moore, 1993; Wolff, Crosby, Roberts, & Wittrock, 2000). The main idea in the following research is that for people living with chronic stress and troubled by poor sleep, binge eating may be an attempt by the brain’s glucose-depleted executive processing center to both regulate (i.e., increase) glucose levels and induce restorative sleep. Recovery resulting from restorative sleep may lead to improved mood, a reduction in perceived stress, and increased willpower, reducing the likelihood of another binge episode in close temporal proximity to the sleep-induced recovery. A repetitive cycle may ensue when stress inevitably again disturbs sleep, reducing willpower, lowering mood, and heightening sensitivity to stigma and stress.

The purpose of the research presented here is to synthesize recent findings from three diverse fields of scientific inquiry to describe cycles of binge eating behavior and to show how several factors relate to binge eating frequency. Combining studies of sleep

and sleep disorders (Crispim et al., 2007; Knutson, Spiegel, Penev, & VanCauter, 2007), stigma stress research (e.g. Crandall, Nierman, & Hebl, 2009), escape theory (Heatherton & Baumeister, 1991), and self-regulatory capacity (Gailliot et al., 2007; Heatherton, 2011), I will attempt to show how lack of restful sleep can lead to negative mood and reduced self-regulatory capacity and can amplify perceived stress and stigma. Extending the work on escape theory, I will describe how binge eating may be a survival mechanism to induce sleep, triggered by changes in mood and depleted self-regulatory capacity, and that the recovery experienced as a result of the rest obtained serves to regulate binge frequency. The relationships between these factors can be visualized using the following model:

Figure 1: Hypothetical path model showing relationships between Sleep, Stress, Mood, Self-Regulation, and Binge Eating



Sleep may play an important role in regulating binge behavior. Although eating and especially overeating have been examined in detail, the importance of sleep to weight regulation and behavioral control has been frequently overlooked (Spiegel, Knutson,

Leproult, Tasali, & VanCauter, 2005). Recent discoveries in endocrinology have revealed hormones and neurotransmitters that are involved in the regulation of both feeding and sleep behaviors (Crispim et al., 2007). These two behaviors, crucial to survival, have been shown to share areas of the brain and are intimately related (Benca & Schenk, 2005; Crispim et al., 2007). I will show how sleep is an integral part of metabolism, and how chronic sleep disturbance and deprivation results in serious consequences for mood, self-control, and weight regulation.

The complex relationship between eating and sleep is the theme of this model. To better understand factors that contribute to loss of control over eating it is important to review how eating and sleep are interconnected, and how the body uses food. I will review research on the physiological aspects of weight regulation, the conversion of food, and the storage of fuel in the human body (Benton, 2001; Gropper, Smith, & Groff, 2008).

This review will lead to a discussion of neurological activation systems that have evolved to be adaptive, flexible, and robust, to ensure survival in a hostile world. However, since cultural development has progressed faster than evolution (Neuberg, Kenrick, & Schaller, 2010; New, Cosmides, & Tooby, 2007), humans today face some adverse consequences related to autonomic nervous system activation and the body's stress response (Arnsten, 1998). I will review the stress response and some of its consequences in our modern world.

For many people, stress is chronic and inescapable because it is a result of the way they look or some other aspect of their personal identity. Stigmatized identities, and the resulting stress, have evolved with human society (Stangor, 2009). In early social

evolutionary times, avoiding and isolating people with disease or people who differed from the group was adaptive (Collins, Crandall, & Biernat, 2006; Maner et al., 2005). Although some modern societies strive to be more inclusive, old behaviors and fears continue to have negative consequences for stigmatized individuals, resulting in stress and impacting health (C. T. Miller & Kaiser, 2001).

In a meta-analysis, Dickerson and Kemeny (2004) found that reactions to social threat resulted in greater sympathetic nervous system responses than did other forms of threat. Being heavier than most other people is stigmatizing, and the effects of the resulting social isolation on the individual are often severe (Heatherton, 2011; Kemeny, 2009; Smart-Richman & Leary, 2009). Thus exclusion or isolation because of one's weight can result in particularly potent stress responses and lead to behaviors motivated by the need to escape negative self-perceptions (Heatherton & Baumeister, 1991). I review some of the literature on the stigma of obesity (cf. Ashmore, Friedman, Reichmann, & Musante, 2008; Carr & Friedman, 2005; Cossrow, Jeffery, & McGuire, 2001; Puhl & Heuer, 2009; Schvey, Puhl, & Brownell, 2011) to show how even the fear of becoming overweight may increase stress and influence behavior.

I next review the emerging literature on self-regulatory capacity. Recent research in the conscious control of behavior has shown that our capacity for control (i.e., self-regulatory capacity, or commonly, willpower) is limited (Baumeister, 1997; Muraven, Baumeister, & Tice, 1999; Vohs et al., 2006), although just what is responsible for that limitation is not clear (Beedie & Lane, 2011). Interestingly, a measure of autonomic responsiveness, vagal tone, has been suggested as a measure of self-regulatory capacity (Fabes & Eisenberg, 1997). Another line of research suggests that the same metabolic

processes that provide glucose to fuel the body are responsible for variance and depletion of self-regulatory capacity (Gailliot & Baumeister, 2007). Since glucose metabolism is vulnerable to stress and lack of sleep, self-regulatory capacity may also be negatively affected by poor sleep and high stress. Below I highlight relationships between sleep and stress, sleep and mood, and sleep and self-regulatory capacity and show how they relate to binge eating behavior.

Since binge eating in response to poor sleep and chronic stress frequently leads to overweight, many binge eaters are also chronic dieters (Agras & Telch, 1998). The factors considered by this research, taken together, suggest a cyclic process that is not encouraging for people attempting to control or lose weight. Dietary restriction triggers adaptive survival mechanisms that evolved to protect the organism from starvation, making weight loss more difficult, frustrating, and stressful (Schwartz et al., 2003). Stress can lead to sleep loss and diminished capacity to control one's actions, resulting in changes in appetite and overeating, leading to weight gain (Hall et al., 1998; Spiegel et al., 2005). The larger a person gets the more vulnerable that person is to stigmatization (Andreyeva, Puhl, & Brownell, 2008; Puhl, Andreyeva, & Brownell, 2008), which further increases stress.

This research is important because the negative health outcomes for people stuck in this cycle are often serious. Larger people are more likely to have physiological problems associated with glucose metabolism and insulin sensitivity and are vulnerable to diabetes and liver disease (Kaplan, 1998). Heavy weight people are also likely to develop sleep-related breathing problems including apnea, which further disturbs sleep (Soares et al., 2011). Research that leads to broader understanding of the factors

regulating binge eating may provide insights into breaking the cycle. My research integrates literature on sleep, metabolism, stress and stigma, and self-regulatory capacity. Interventions that address all of these factors may result in the achievement of a healthy weight and balanced metabolism for people who currently use food to cope with stress.

Eating and Metabolism

Eating is a seemingly simple process by which nutrients are taken into the body and converted to energy. Nutrients that are used by the body need to be replenished, and systems in the body and especially in the brain regulate the timing and quantity of food consumption (Sizer & Whitney, 2011). People typically consume food periodically through the waking hours of the day. Through a process of energy homeostasis, the body automatically corrects for energy fluctuations between meals. This process frees us from the need to constantly feed, while providing a stable supply of energy (Gropper et al., 2008). Ideally, the amount of food consumed and the energy requirements of the body are relatively balanced, resulting in a stable weight (Schwartz et al., 2003). What that weight is for each individual is determined by genetic predisposition (Andersson, 1996; Arner & Hoffstedt, 1999; Hofker & Wijnenga, 2009) and other factors such as amount of exercise the person gets (Hannan, Maio, Komolova, & Adams, 2009; Ryan, 2010) and sleep quality (Crispim et al., 2007; Marcheva, Ramsey, Affinati, & Bass, 2009; Soares et al., 2011; Spiegel et al., 2005). The systems responsible for maintaining stable weight seem to react strongly to periods of low food availability, activating responses that protect and supplement existing fat stores when food is limited (Schwartz et al., 2003). Schwartz and colleagues (2003) suggest that the body's bias toward protecting against starvation is adaptive, since it is unlikely that too *much* food ever posed a threat to

survival of the species. Perhaps, that is, until recently. Our modern lifestyle and the near universal and unlimited availability of food, especially in the United States are unique in evolutionary terms. The conditions under which humans evolved were very different.

According to nutritionistsSizer and Whitney (2011), glucose is the main nutrient for every living cell in the human body. Eating a meal results in the level of glucose in the blood rising as food is broken down into simple nutrients by digestion. The increased level of glucose triggers the release of the hormone insulin from the pancreas. Insulin signals the muscles and the liver to convert excess glucose in the blood into glycogen for storage. Glycogen in the muscles is kept exclusively to fuel the muscles and accounts for approximately two thirds of the body's supply (Sizer & Whitney, 2011). The liver stores the rest. When the glycogen storage capacity is reached, excess glucose is converted to fat in the liver and released into the bloodstream to be deposited in fatty tissues. Fat cells, unlike liver or muscle cells, can store nearly unlimited quantities of converted glucose. Between meals and during waking activities glucose levels in the bloodstream are depleted. When glucose levels drop, the pancreatic hormone glucagon is released resulting in enzymes in the liver converting glycogen back into glucose. Through this process, blood glucose levels are kept relatively stable (Berdanier & Zemleni, 2009; Gropper et al., 2008; Sizer & Whitney, 2011).

Compared to the muscles and organs in the body, the human brain consumes proportionally more oxygen and nutrients. Typically around two percent of adult body weight, the brain contains 15 percent of the body's blood and consumes 20 to 30 percent of the body's energy in the form of glucose (Sizer & Whitney, 2011). The brain requires a number of nutrients in addition to oxygen and glucose (Gropper et al., 2008).

Communication between neurons requires neurotransmitters which are formed from amino acids that come from proteins. Lipids are required for cellular repairs; minerals that are electrically charged facilitate the neurons' electrical operation. According to Gropper and colleagues (2008), while the level of these and other nutrients in the blood may fluctuate in the body, the balance in the brain is kept constant by homeostatic processes within the brain itself. The brain monitors levels of key nutrients and sends messages to other parts of the body that supply them. While most nutrients eaten over the course of a day may not reach the brain immediately, amino acids that are precursors to neurotransmitters are an exception, forming neurotransmitters the same day they are consumed (Fernstrom & Fernstrom, 2001). Regulatory proteins cross the blood-brain barrier and use amino acids to make larger or smaller amounts of the various neurotransmitters; the food a person eats changes brain chemistry by influencing the kind and quantity of neurotransmitters produced. Thus eating can have a relatively rapid impact on mood, emotion, and mental processes (Berdanier & Zempleni, 2009).

Homeostatic processes in the brain may also be unconsciously directing food choices people make (Macht, 2008; Macht & Simons, 2000). For example, foods high in carbohydrates raise the level of the neurotransmitter serotonin in the brain which may reduce desire for more carbohydrates (Wurtman, 1982). Consuming foods high in protein has the opposite effect, so after a protein-rich meal people may choose for their next meal one higher in carbohydrates (Sizer & Whitney, 2011). This observation and the theory that one type of food may lead to consumption of a different type at a later meal may account for troubles some food restricting dieters report (Lowe, 1993). Many popular diets severely limit carbohydrates in favor of proteins (e.g. Atkins, South Beach,

Scarsdale, Zone diets). Protein-rich diets that limit carbohydrates may result in increasingly more urgent cravings for them (Rogers & Smit, 2000).

Diets chronically low in carbohydrates also produce physiological responses similar to those of someone who is fasting (Ferraris & Carey, 2000). According to Ferraris and Carey, when food is not eaten for long periods, the glycogen in the liver is depleted. Since fat cannot be converted directly to glucose, enzymes in the bloodstream convert lean muscle protein into glucose. Thus weight loss as a result of an extended period of carbohydrate restriction is likely due to reduction in lean muscle mass, not fat loss. In addition, during periods of fasting, the body slows metabolism in order to conserve energy. In severe dietary restriction, the body may store more glucose as fat, partly as a result of lowered metabolism (Ferraris & Carey, 2000). This is what Schwartz and colleagues (2003) mean by the body's bias toward protection against starvation, and it is one of the key difficulties of weight loss by dietary restriction. The body's own muscle is not an ideal energy source, obviously. If food continues to be scarce, the body stops consuming lean muscle for fuel, since continued muscle consumption would soon result in death (Ferraris & Carey, 2000; Sizer & Whitney, 2011). In starvation conditions, after the consumable muscle is depleted, the body begins converting fat into chemicals called ketone bodies. Enzymes in the brain are capable of converting ketone bodies to energy. Consumption of ketones permits an otherwise healthy person with average fat stores to live for up to eight weeks without any food (Ferraris & Carey, 2000; Gropper et al., 2008).

While homeostatic processes are able to maintain relatively stable glucose levels between meals, the brain must also keep energy levels from dropping too low. Two

hormones in the endocrine system have been identified and connected to both eating and sleep: ghrelin and leptin (Bodosi et al., 2004). The orexigenic (appetite stimulating) hormone and neurotransmitter ghrelin is a product of endocrine cells in the stomach. Ghrelin elicits food intake, promotes fat deposition and has been shown to enhance restorative nonrandom eye movement (NREM) sleep in both rats and humans (Crispim et al., 2007; Sinton, Fitch, & Gershenfeld, 1999). The anorexigenic (appetite suppressing) hormone leptin is released from white fat tissue as a result of insulin-dependent metabolism in fat cells. Leptin suppresses feeding and stimulates energy expenditure, mediated by the sympathetic nervous system (Steiger, 2004). Reduction of total sleep time results in a change in the balance of these two hormones such that leptin is reduced and ghrelin is increased. The ghrelin-to-leptin ratio seems to be related to appetite level, driven primarily by decreased leptin (Spiegel et al., 2005). As a result, people who get less sleep have increased hunger and consequently greater food intake (Crispim et al., 2007).

There is evidence that ideal body weight is positively associated with slow wave and REM sleep, and that anorectics have significantly less slow wave sleep than do bulimics or people who do not have an eating disorder (Levy, Dixon, & Schmidt, 1987). Early research by Adams (1977) found correlations between body weight and REM sleep leading Evans (1983) to suggest that loss of REM sleep may lead to difficulty maintaining dietary restriction. Recently the role of sleep in proper metabolism and weight regulation has received a great deal of research attention (e.g., Ganjavi & Shapiro, 2007; Knutson et al., 2007; Patel, 2009; Patel & Hu, 2008; Soares et al., 2011; Spiegel et al., 2005), although a review of several popular college textbooks on nutrition (Berdanier

& Zempleni, 2009; Brown, 2010; Gropper et al., 2008; Simopoulos & Milner, 2010; Sizer & Whitney, 2011), found that all but one fail to mention sleep at all, and that one only mentions sleep in regards to the effects of high carbohydrate meals and tryptophan as sleep agents.

Sleep loss has severe consequences for glucose metabolism. A University of Chicago study (Spiegel, Leproult, & Van Cauter, 1999) of healthy young men who were limited to four hours sleep for six consecutive days showed impairment of carbohydrate tolerance and glucose processing. Glucose processing was 40% slower and glucose effectiveness (a measure of the ability of glucose to metabolize independent of insulin) 30% lower than in the normal sleep condition. Spiegel and colleagues (1999) note that the level of insulin resistance that occurred among sleep deprived participants was severe enough to qualify for a diagnosis of non-insulin dependent diabetes. There is evidence that these metabolic responses to sleep deprivation are related to sympathetic nervous system activation (Burton, Rahman, Kadota, Lloyd, & Vollmer-Conna, 2010). Heart rate variability, which decreases as a result of stress and indicates sympathetic nervous system activation, decreased in sleep-deprived participants suggesting that sleep loss is physiologically stressful (Spiegel et al., 2005; Spiegel et al., 1999).

In a follow up to their earlier study, Spiegel and colleagues (2005) confirmed the effects on glucose metabolism in a less severe short sleep paradigm. Healthy young men were investigated after two consecutive nights of ten hours sleep (extended sleep phase) and after two consecutive nights of four hours sleep (sleep debt phase). After the short sleep debt phase, glucose and insulin levels were the same as in the earlier study. In addition, appetite for high carbohydrate, calorie rich foods (e.g., cake, ice cream, pastry,

potato chips, pasta, etc.) was increased 30% compared with the same participants' cravings during the extended sleep phase of the study. In the sleep debt phase participants' ghrelin-to-leptin ratio was elevated (leptin reduced) more than 70% compared to the extended sleep phase. The imbalance of leptin and ghrelin in sleep deprived people may lead directly to excessive food intake and ultimately to obesity (Taheri, Lin, Austin, Young, & Mignot, 2004).

Weight loss by means of chronic dieting has been shown to fail more often than it succeeds (J. M. Friedman, 2004). We have seen that one reason for this is the body's bias toward protecting fat stores and responding to starvation by slowing down their depletion. Fighting the body's natural tendency can seem hopeless (Baucom & Aiken, 1981; Elfhag & Rössner, 2005). The frustration of repeated failures is an additional challenge (Heatherton & Polivy, 1992; Herman & Polivy, 1980). These feelings, coupled with the perceived need to control one's weight for medical as well as social reasons can activate adaptive systems that evolved to protect early humans from danger: the stress response of the sympathetic nervous system (Macht, 2008; Macht, Haupt, & Ellgring, 2005).

Stress and the Sympathetic Nervous System

All animals have evolved a system which allows for response to perceived threat and a complimentary system that allows for rest and regeneration (McEwen & Stellar, 1993; Piet & Manzoni, 2010). Any good introductory psychology text will provide detailed information regarding the stress response summarized here (e.g., Ciccarelli & White, 2012; Myers, 2011). In humans the autonomic nervous system is made up of two divisions: the sympathetic and parasympathetic nervous systems. When certain

environmental stimuli are present, the sympathetic nervous system is activated. The hormone and neurotransmitter epinephrine is released into the bloodstream. In response to the release of epinephrine, the body's systems undergo a series of rapid changes to prepare for a physical response to the threat, a process traditionally referred to as "fight-or-flight." Characteristic responses include dilation of the pupils to collect more light and presumably improve vision, increased heart and respiration rates to provide additional oxygen to the muscles, an increase in blood glucose from liver stores to provide fuel for the brain and muscles, and cessation of digestion and other non-essential processes. In a hostile world of predators and prey, enhancing the ability of the organism to fend off or escape from attack is clearly adaptive. For modern humans, however, these responses can be less adaptive than they were for our ancient ancestors (Piet & Manzoni, 2010).

A number of studies have concluded that stress leads to poor health outcomes involving immune system-mediated illnesses like the common cold, influenza, herpes, and perhaps also AIDS and cancer (Cohen & Herbert, 1996; Faulkner & Smith, 2009; Holmes & Rahe, 1967). Heart disease has also been linked to chronic stress and autonomic nervous system activation (Dekker et al., 2008; G. Miller, Chen, & Cole, 2009). Both chronic stress and chronic sleep loss deplete resources and strain metabolic processes that supply energy to the body and especially to the brain (Gailliot et al., 2007; Harrison & Horne, 2000).

The phylogenetically oldest part of the brain is responsible for preparing the body for action, and also regulates heart rate, digestion, and other automatic processes. (Ciccarelli & White, 2012). Since this part of the brain is not the seat of conscious thought, our bodies can respond to a perceived threat without our conscious knowledge of

the nature of that threat (Dutton & Aron, 1974). The prefrontal cortex of the brain can also take conscious control of the body, overriding the fight-or-flight response (Arnsten, 1998), though as we will see, the capacity to override has some limits. Research has shown that humans use environmental cues to determine the reason for the physiological changes associated with sympathetic nervous system activation and provide an emotional response accordingly (Schachter & Singer, 1962). Selye (1956, 1976, 1985) suggested that failure to appropriately respond to threats, either physical or emotional, results in a set of physiological responses he called *stress*. Selye's experiments with rats demonstrated that *any* source of stress resulted in the same physiological changes over time, a three phase reaction he called the *general adaptation syndrome*.

The first stage of the general adaptation syndrome is alarm. In this phase, the autonomic nervous system's sympathetic circuits trigger the fight-or-flight responses outlined previously, releasing stress hormones and neurotransmitters. At an earlier time in human evolution, the outcome of this first phase would have been determined by a brief flurry of physical activity with one of two potential outcomes: (1) escape from the threat (by retreat or victory in mortal combat), or (2) failure to escape or overcome the predator, resulting in death. Either way, the stress was fleeting. Such is not the case for modern humans, who may endure a host of daily stressors that cannot be easily avoided or escaped (Piet & Manzoni, 2010). Financial worries, job-related stress, noise, traffic, and crowding are all a common part of modern life and have been shown to lead to increased stress (Holmes & Rahe, 1967). Certain stressors have also been shown to be particularly potent. Cole and colleagues (2003) found that social threat or uncertainty in social situations may have the biggest impact on the sympathetic nervous system. In a

meta-analysis, Dickerson and Kemeny (2004) found that the response of the stress hormone cortisol was most pronounced in social threat situations.

The second stage of the general adaptation syndrome is called resistance. In the resistance stage, the body uses reserves of energy to cope with the stressor. In the case of chronic stress, this is the stage in which most sufferers live; the body adapts to the level of stress and attempts to return to normal functioning. However, the constant stress keeps the body in a state of autonomic hyper-vigilance. While the sympathetic nervous system remains active, the parasympathetic system, which is responsible for rest and regeneration is suppressed. Living in a chronic state of autonomic hyper-vigilance has serious consequences for human functioning (Tanaka et al., 2011). A number of researchers have shown that chronic stress leads to compromised health including increased susceptibility to upper respiratory illness and influenza (Cohen & Herbert, 1996), herpes virus (Faulkner & Smith, 2009), and asthma (G. Miller et al., 2009). This state of stress has also been shown to result in opposing and damaging effects on the circulatory system: it increases heart rate, while constricting blood vessels, resulting in increased blood pressure (Matthews et al., 2004). Over time, high blood pressure and chronically increased heart rate can lead to heart disease, dementia, and stroke (Dekker et al., 2008; G. Miller et al., 2009).

Aspects of Selye's model have evolved over time (see Goldstein & Kopin, 2007, for a review); stress is now seen as the result of a perceived threat to homeostasis. Responses to stress vary depending on the perception of the challenge and the perceived ability to cope with it (McEwen & Stellar, 1993). As such, stress has been shown to result in metabolic changes (Dallman et al., 2003). According to Dallman and

colleagues, stress hormones known as glucocorticoids act in excitatory ways on the brain, resulting in three main effects. First, they increase the chronic stress response in the amygdala, the center of emotion, influencing mood. Second, they increase perceptions of pleasure resulting from eating foods rich in sugar and fat, heightening cravings for those foods. Third, glucocorticoids increase abdominal fat deposits. While in rats chronic stress decreases body weight, in humans it has the opposite effect (Boggiano et al., 2007; Dallman et al., 2003). Dallman and colleagues (2003) suggest that people may eat “comfort foods” to reduce the activity of the chronic stress response in the hypothalamus and its attendant anxiety.

Without relief from Selye’s second stage of the general adaptation syndrome, the individual enters the third stage: exhaustion (Selye, 1985). As a result of prolonged resistance, energy stores are depleted resulting in dangerously low blood glucose levels. These low levels of energy lead to decreased resistance to stress, physical and mental exhaustion and eventually to illness and death. The human body can survive for years living in a state of chronic stress, and Selye’s third stage is only reached at the end of life. People living with chronic stress may reach a state of localized exhaustion which forces the exhausted body to rest (Goldstein & Kopin, 2007; Selye, 1985; Uchino, Smith, Holt-Lunstad, Campo, & Reblin, 2007). This is an important finding for this research as it demonstrates that rest and sleep can act as an antidote to stress. It is during rest that further resources, drawn from stores that Selye (1985) called *adaptation energy*, are gathered and the body continues the struggle, though not indefinitely. In his last published work, Selye (1985) suggested that each of us is born with a supply of adaptation energy. He advocated living in harmony with one’s environment or risk

permanently depleting the apparently limited supply of adaptation energy we have, bringing on disease and early death.

Stigma and Stress

Living in harmony with one's environment may be easier said than done for people whose very identity isolates them from the rest of society. Stigma refers broadly to a socially devalued identity (Crocker, Major, & Steele, 1998; Crocker, Voelkl, Testa, & Major, 1991; Major & O'Brien, 2005). Stigmatized individuals possess some attribute, usually visible, that sets them apart in an undesirable way from the rest of society. Stigma carries with it the presumption that the stigmatized person experiences not only prejudicial attitudes, but also systematic discriminatory behaviors in the form of policies and practices that have an impact on life outcomes (Krieger, 1999). More recently, discrimination has been operationalized broadly to include a wide variety of maltreatment in interpersonal interactions. Using data from the National Survey of Midlife Development in the United States (Brim et al., 1996), Puhl and colleagues (2008) found that interpersonal discrimination experiences (e.g., being treated with less courtesy than others, receiving poorer service in restaurants or stores than others) were reported by 28% of obese (BMI > 35) men and 45% of obese women. On the basis of this and similar studies, most researchers agree that obesity qualifies as a stigmatized identity (Cossrow et al., 2001; C. T. Miller & Downey, 1999; Puhl & Brownell, 2001; Puhl & Heuer, 2009).

The relationship of body size to anti-fat attitudes is complex, with some studies showing that although anti-fat prejudice decreases as BMI increases, higher BMI is also associated with greater body dissatisfaction, and greater body dissatisfaction is related to

higher anti-fat prejudice (O'Brien et al., 2013). It is not only the thin who harbor anti-fat attitudes. Perez-Lopez and colleagues (2001) found that level of anti-fat attitude was not related to actual-to-ideal weight discrepancy. Obesity has been shown to trigger disgust and avoidance (Oaten, Stevenson, & Case, 2009). It is an identity with few if any redeeming qualities from the perspective of those who have it; an identity to which one may be resigned, but perhaps never fully accept. Since being overweight is thought to be controllable, it is not only stigmatizing but also leads to feelings of guilt and weakness of will that damage self-esteem (Crandall et al., 2001; C. T. Miller & Downey, 1999).

Overweight and obese individuals do not seem to share a group identity for support and to buffer their self-esteem. The reactions of overweight people to weight stigma and discrimination, though generally seen as heterogeneous (K. E. Friedman et al., 2005; M. A. Friedman & Brownell, 1995), can contribute negatively to their psychological well-being (Carr & Friedman, 2005; Link & Phelan, 2001). Overweight and obese individuals are likely to have a negative self-image and suffer from esteem-related psychopathologies such as depression, social and generalized anxiety, and social phobia (Ashmore et al., 2008; C. T. Miller & Downey, 1999; Schwalberg, Barlow, Alger, & Howard, 1992). In addition, larger people are also more likely to have weight-related sleep disordered breathing (i.e., apnea), resulting in less restful sleep and further disruption of metabolic processes (Patel, 2009; Spiegel et al., 2005; Vgontzas, Bixler, Chrousos, & Pejovic, 2008).

We have seen how stressors negatively affect health generally and can lead to serious illness or even death in Selye's three stage general adaptation syndrome (Selye, 1985). Stigma adds an additional layer of stress and obesity has a further impact on

health. Thus in my model (see Fig. 1) stress, amplified by poor sleep, leads to consequences for mood, self-regulation, and binge eating behavior. By lowering mood and reducing self-regulation, chronic stress, perhaps as a result of a stigmatized identity, may drive people to use food as a way to obtain sorely needed rest.

Mood

According to Greeno, Wing, and Shiffman (2000), negative affect is the most studied antecedent of binge eating, and research consistently shows that it precedes binge episodes. At least two theories have been put forth to explain this relationship. The first, outlined by Greeno, Wing, and Shiffman, suggests that binge episodes are triggered by negative affective states (e.g., feeling miserable) and that eating is an attempt to change or modulate the negative affective state by distraction or interfering with the thoughts involved with the negative state. This idea is sometimes referred to as the psychosomatic comfort hypothesis (Polivy & Herman, 1999). From a learning theory perspective, the perception that eating elevates mood would result in eating behavior being negatively reinforcing (Skinner, 1958).

The second theory relies on the observation that reducing one's self-awareness can be an effective coping strategy to deal with the stress of frustration, anger, sadness, or other aversive negative emotions or moods. Thus binge eating episodes are an attempt to turn off, or escape from, the intense awareness of one's self that results from being made to face personal shortcomings and aversive negative evaluations (Heatherton & Baumeister, 1991). As Vohs and colleagues (2006) report, active responding, self-regulation, decision-making, and controlled processes are the domain of the *self*. By deconstructing the self to the lowest level (i.e., to sensations and muscle movement),

meaning and symbolic reasoning (as well as inhibitions) disappear (Heatherton & Baumeister, 1991). Heatherton and Baumeister's escape theory proposes that the act of binge eating results in *cognitive narrowing*, wherein the individual's focus is on the immediate sensations involved with eating, effectively silencing critical self-examination.

For heavy weight people, aversive negative evaluations can be one result of stigmatizing experiences (Ashmore et al., 2008) that may lead to binge eating. When these stigmatized heavy weight people are trying to control or reduce their weight, bingeing is an especially self-defeating behavior. Based on escape theory, Heatherton and Baumeister (1991) predicted that binge eaters would have certain characteristics including high standards and expectations, and high levels of self-awareness, and that binges would be preceded by unhappy moods and unfavorable comparisons of the self with (often self-imposed, and unrealistic) high standards. Each of these hypotheses has found support in experimental research (Baumeister, 1997; Heatherton & Baumeister, 1991; Heatherton, Herman, & Polivy, 1991).

Self-Regulatory Capacity

Overeating and the failure of dieting for weight loss have often been attributed to a failure of self-control, or diminished self-regulatory ability (Johnson, 2002). Assuming this conjecture is correct, the reasons for the failure of willpower may be less under the control of the individual than it may seem. Humans operate in a stimulus-rich environment and have learned through experience to respond in specific ways to the stimuli we encounter. For example, when food is present it can act as a discriminant stimulus, signaling that eating behavior is appropriate (Ciccarelli & White, 2012;

Skinner, 1958). Our species has developed a very wide range of circumstances that determine the appropriateness of particular behaviors. These regulating circumstances can be socially motivated as well as chosen for a specific purpose of personal relevance (Baumeister, DeWall, Ciarocco, & Twenge, 2005). Without such behavioral regulators our basic drives for food, shelter, warmth, sex, and sleep would control us, just as they control animals. Thus the mere presence of food does not necessarily provide sufficient justification to eat. If, however the food is presented at the appropriate time of day, is designated for our consumption, and we are in an environment where the consumption of food is considered to be appropriate, etc., we may choose to eat.

Self-regulation is also an important element of goal-achievement (Baumeister, 1997; Hagger, Wood, Stiff, & Chatzisarantis, 2010; Mead, Alquist, & Baumeister, 2010). We may frequently be faced with impulses that are contrary to a longer-term goal. In terms of the previous example, even when the conditions are otherwise right for eating, our goal of losing weight or avoiding certain foods for health reasons can further influence whether or not we eat. The *self* is the conscious part of us that operates in the moment, but has the ability to perceive a past and a future that includes us (Deci & Ryan, 2000). As such, it is the part of our mind that has the ability to override impulses, dictate goal-directed behaviors, and also to instruct other parts of the brain to learn new behaviors through the direction of attention (Tangney, Baumeister, & Boone, 2004). The self can be thought of as an agent acting on behalf of the entire organism when required, and refraining from doing so when intervention is not required (James, 1918/1890). Vohs and colleagues (2006) point out that the agentic self is the controller of controlled processes, the decision maker, the initiator of active responding, and also the regulator of

behavior. Taking conscious control of automatic behaviors, overriding unwanted thoughts and impulses, and suppressing inappropriate emotional responses are all elements of self-regulation (Baumeister, 1997; Mead et al., 2010).

The ability to self-regulate behavior is presumed to be under conscious control (Baumeister, 1997; Gailliot et al., 2007; Muraven & Baumeister, 2000), and as such it consumes energy by metabolizing glucose. A number of studies (Gailliot et al., 2007; Inzlicht, McKay, & Aronson, 2006; Johns, Inzlicht, & Schmader, 2008; Muraven & Baumeister, 2000; Muraven et al., 1999; Schmeichel & Vohs, 2009; Twenge, Catanese, & Baumeister, 2002; Vohs et al., 2006) have shown that self-regulatory capacity is limited. For example, the capacity to resist temptation can be expended; a process referred to as *ego-depletion* (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Govorun & Payne, 2006; Hofmann, Rauch, & Gawronski, 2007; Inzlicht et al., 2006; Job, Dweck, & Walton, 2010; Mead et al., 2010).

Exerting self-control to accomplish a desired outcome seems to impair the individual's ability to subsequently control another task in close temporal proximity (Baumeister et al., 1998). The two tasks need not be related to show this effect. Early experiments (see Hagger et al., 2010, for a review and meta analysis) consisted of taking baseline measurements of grip strength using a spring-loaded hand grip exerciser. Participants were instructed to hold the grip device closed for as long as they were able to. After releasing the device, some participants were then given a thought suppression exercise known as Wegner's Bear ("try not to think about a white bear;" D. M. Wegner, Schneider, Carter, & White, 1987). Doing so requires self-control to shift one's thoughts away from the intrusive thoughts of the white bear. Following the thought suppression

exercise participants' grip strength was again measured. Participants in the thought suppression condition showed a marked decrease in their ability to hold the grip device closed compared to those who were not given the thought suppression task (Muraven & Baumeister, 2000; Muraven et al., 1999).

These findings seemed to contradict the observation that when people are able to overcome a habit (e.g., smoking) their ability to overcome another habit is often enhanced (Muraven & Baumeister, 2000). This suggests that self-regulatory capacity, in some respects, resembles a muscle: "exercising" may increase "strength." To test this hypothesis in a follow up study, Muraven and colleagues (1999) asked participants to consciously practice correct posture for two weeks. At the end of the two weeks, participants returned to the lab and repeated the grip measurements and thought suppression exercises. The results showed that while there was no improvement in baseline grip between the earlier and later sessions (indicating that practice did not improve overall strength or depth of reserves), there was an improvement in performance following the thought suppression exercise. These results led the researchers to conclude that short term exertion diminishes the power of self-control – in effect making the figurative muscle tired – but in the long run self-control can be made stronger by exertion.

Although their research did not discuss what the nature of the "ego" being depleted by exercising self-control might be, Muraven and Baumeister (2000) state that ego strength (i.e., self-regulatory capacity) is restored by resting. If the person is unable to rest sufficiently to recharge their self-regulatory capacity, they may become chronically deficient and have impaired self-control. This conclusion led to an

exploration of glucose as the fuel in the self-regulatory tank. Recent research has shown that self-regulatory activity, like other brain processes, consumes glucose. However, unlike automatic processes, self-regulatory activity seems to consume vastly more (Gailliot & Baumeister, 2007; Gailliot et al., 2007).

Imaging studies using positron-emission tomography (PET scans), have shown that pre-frontal cortex activity is reduced following a difficult attention-control task (Heatherton, 2011). In a study of successful and unsuccessful dieters, DelParigi and colleagues (2006) found that successful dieters had increased activity in the same areas of the prefrontal cortex associated with attention control. The implication of these studies is that glucose is consumed by attention control and that dieting, like other self-regulatory activities, consumes energy and is difficult to sustain. They also show that given sufficient resources, dieters can overcome the urge to eat – at least temporarily.

Individual Differences: Vagal Tone and Electrodermal Response

It would seem that some people have more self-regulatory capacity than others. There may be a genetic or developmental characteristic that can predict a person's ability to cope with stress by exercising self-regulatory control, thus reducing the negative effects of chronic stress. Heart rate variability, or vagal tone, has been proposed as a physiological indicator of coping ability. Early in the twentieth century researchers recognized that there were individual differences in autonomic nervous system responsiveness that were reflected in resting heart rate variability (Eppinger & Hess, 1917). Because oxygen is taken into the body intermittently by respiration, oxygen level in the blood likewise varies. In order to compensate for this variability, the heart speeds

up or slows down in synchrony with respiration, a phenomenon called respiratory sinus arrhythmia. Research shows that lower heart rate and higher heart rate variability (together referred to as high vagal tone) indicate greater regulatory control (Grossman, 1983; Porges, 1991). In a review, Porges (1991) reported evidence for a relationship between high vagal tone and mental effort, behavioral stress responsiveness, and the ability to sustain attention in children. Fox (1989) also found evidence in young children for a relationship between vagal tone and coping style, frustration level, and the ability to focus attention.

Karoly's (1993) definition of regulatory control includes processes that guide an individual's goal-directed behaviors and implies the ability to modulate thought, mood, behavior, and attention. Working with this definition, Fabes and Eisenberg (1997) investigated the relationship between regulatory control and adult individual's responses to stressful situations using vagal tone to predict individual responses to stress. Their main hypothesis was that the ability to cope constructively with stressful situations would depend on regulatory control. Further, they suggested that vagal tone could be used to show individual differences in the ability to physiologically react and self-regulate, and to cope in age-appropriate ways to challenging environments. Fabes and Eisenberg found that vagal tone was positively correlated to participants' regulatory control and negatively correlated to participants' likelihood of experiencing frustration.

The vagus nerve regulates heart rate and heart rate variability, and is partly responsible for autonomic activation (Grossman, 1983). Stress puts demand on metabolic processes, which in turn increases consumption of energy resources necessary for self-regulation. In response, the vagus nerve increases heart rate and activates the

sympathetic nervous system (Fabes & Eisenberg, 1997). Under chronic stress, the individual's ability to react and self-regulate physiologically, as well as emotionally and behaviorally, may be impaired. Low vagal tone may therefore be both an indicator of chronic stress and of self-regulatory capacity. High vagal tone adults in Fabes and Eisenberg's (1997) studies demonstrated the ability to shift their attentional focus away from stressful stimuli, thus reducing stress.

Anxiety and stress response can also be measured using electrodermal response (Fisher & Kotses, 1973; Mandryk, Inkpen, & Calvert, 2006). When the autonomic nervous system is activated one of the body's responses is the movement of sweat toward the surface of the skin. This response is thought to prepare the body to regulate temperature as well as to make the body slippery and difficult for antagonists to grasp (Ciccarelli & White, 2012). Perspiration is electrically conductive and its movement toward the surface changes the capacitance of the skin. The change in electrical capacitance is measurable using sensing instruments typically attached to the fingers or palms of the hand (Cacioppo & Tassinary, 1990; Stern, Ray, & Quigley, 2001). Together with vagal tone, this measure provides evidence of sympathetic nervous system status and responsiveness (Porges, 1991), providing insight into both level of stress and ability to self-regulate.

The anorexigenic (appetite suppressing) hormone leptin has also been connected to vagal tone in studies of obese and non-obese individuals (Molfino et al., 2009; Paolisso, Manzella, Montano, Gambardella, & Varricchio, 2000; Quilliot, Böhme, Zannad, & Ziegler, 2008). Leptin suppresses feeding and stimulates energy expenditure by way of sympathetic nervous system activation (Steiger, 2004). However, for the

obese (and even formerly obese people who have lost weight) leptin has less of an effect on the sympathetic nervous system, a condition referred to as leptin resistance (Munzberg & Myers, 2005). In a study of normotensive obese women (mean BMI 33.2 +/- 2.3 kg/m²) Quilliot and colleagues (2008) used heart rate variability as a measure of sympathetic nervous system activation, because the effects of leptin on the sympathetic nervous system are not easily measured directly. In their sample, heart rate variability was found to be negatively correlated with leptin level. In non-obese subjects, Paolisso et al. (2000) found the opposite: leptin concentrations were positively correlated with heart rate variability. Results similar to those of Paolisso et al. (2000) were found in an animal model reported by Bodosi and colleagues (2004), suggesting that obesity itself can have an impact on the ability to regulate weight and cope with stress.

Baseline self-regulatory capacity may help determine who is more likely to binge eat following an acute stressful event against a background of chronic stress. Combined, the relationships between sleep, stress and sympathetic nervous system activation, heart rate variability, leptin, and appetite may provide insight into antecedents of binge eating. Perceptions of stress and appraisal of ability to cope, however, may also be important predictors of binge eating. Those perceptions depend in large part on sleep quality (Morin, Rodrigue, & Ivers, 2003).

Sleep

Long term survival of individuals in the resistance stage of Selye's (1985) general adaptation syndrome depends on rest. Chronic sleep loss, even if it is sporadic, causes the steady breakdown of metabolic and cognitive processes, and total sleep deprivation will kill a person faster than total food deprivation (Eidelman, 2002). Although

researchers are still not certain why we sleep, it is clear that we must (Carlson, 2004; Eidelman, 2002; Muzur, Pace-Schott, & Hobson, 2002; Shapiro & Flanigan, 1993). While the amount of sleep each of us requires varies, the National Sleep Foundation (2011) recommends that adults get seven to nine hours per night.

Eidelman (2002) connects stress to sleep in postulating that stress is a result of unresolved fatigue, and therefore stress does not cause fatigue but is an integral part of it. Fatigue, in Eidelman's model, is a physiological monitor that stimulates regenerative sleep. Sleep loss, as we have seen, has been linked to weight gain and diabetes (Patel, 2009; Patel & Hu, 2008; Spiegel et al., 2005; Spiegel et al., 1999; Spiegel, Tasali, Penev, & VanCauter, 2004). Harrison and Horne (2000) found that sleep deprivation has a major negative impact on decision making. Wu and colleagues (1991) found that lack of sleep resulted in decreased glucose metabolism in brain regions associated with attention control. Loss of attention control, and thereby self-regulatory capacity, may lead to reduced ability to resist temptations, leading to overeating and ultimately to overweight and obesity.

In a study of mood stability, Yoo and colleagues (Yoo, Gujar, Hu, Jolesz, & Walker, 2007) found that sleep deprived participants showed a greater amygdala response compared to controls. The researchers showed that the medial-prefrontal cortex acts as a regulator on the brain's limbic system, and that lack of sleep results in less control. Yoo showed increasingly aversive images to participants who had been deprived sleep for approximately 35 hours, and to controls who had slept normally at home prior to fMRI scanning. Sleep deprived participants showed a 60% more intense amygdala response to the aversive images, as well as three times more amygdala activation volume.

Significantly, both groups responded similarly to neutral images. The imaging data showed greater connectivity between the amygdala and medial-prefrontal cortical areas in participants who had slept versus those who were deprived of sleep. For the sleep deprived, the amygdala showed increased connectivity to the locus coeruleus and midbrain, structures associated with sympathetic nervous system activation.

Sleep is a behavior characterized by a series of states and stages that are repeated several times during a typical night. There are three states of consciousness: Wake, REM or rapid-eye-movement, and non-REM (NREM) sleep. According to the National Sleep Foundation (NSF, 2011), NREM sleep has three stages. Stage 1 is characterized by light sleep; the first stage entered as we fall asleep. In Stage 2 the body temperature drops, breathing and heart rate are regular and the sleeper becomes disengaged from the surrounding environment. In Stage 3, called slow wave sleep, muscles relax, breathing is slower, and blood pressure drops. Tissue growth and repair, restoration of energy, and a variety of hormones (e.g., growth hormone) are released. This is the most restorative sleep.

About 25% of the night is spent in REM sleep. REM is thought to provide energy to the brain and body, and may be involved in the consolidation of memories (Muzur et al., 2002). Muzur and colleagues describe REM sleep as follows: At the start of the REM phase, the neurotransmitter acetylcholine is released in the brain, in effect generally waking up much of the cerebral cortex and increasing cortical activity. However, the dorsolateral prefrontal cortex (the area of the brain responsible for logic, self-reflective awareness, and conscious thought) remains relatively inactive because it is inhibited by acetylcholine. Thus in this part of the sleep cycle the brain generally is active, but the

executive portion is not. Sleep deprivation has been shown to interfere with executive function, decision making, and mood, possibly as a result of the lack of deactivation of the prefrontal cortical areas achieved during REM sleep (Muzur et al., 2002).

Both REM and NREM sleep seem to be particularly crucial to cognitive functioning and metabolism. A person deprived of, for example, slow wave sleep will tend to fall into that state immediately upon sleep onset, while in normal sleep other stages precede slow wave sleep. Similarly people deprived of REM sleep respond by falling immediately into REM upon sleep onset (Carlson, 2004). Shapiro and Flanigan (1993) point out that homeostasis requires that energy expended during the day must be balanced by recuperation at night. One theory of the function of sleep suggests that it is primarily neurological restoration that takes place during sleep and that each cycle of REM and NREM sleep results in partial recuperation. Based on that theory, the number of times people cycle through the stages of sleep may be an important aspect of recovery; fewer hours of sleep would result in fewer cycles and less restorative sleep (Shapiro & Flanigan, 1993).

As technology has advanced, sleep hours have declined (Knutson et al., 2007). For most of humankind's history, waking and sleep were influenced by the daily rising and setting of the sun. Circadian rhythms, activated by light sensing receptors in the suprachiasmatic nucleus of the brain regulated sleep onset and termination (Foley & Matlin, 2009). With advances in lighting and electrical distribution, people's activities were no longer confined to daylight hours. Sleep researchers (e.g., Broman, Lundh, & Hetta, 1996; Knutson et al., 2007; Patel, 2009; Spiegel et al., 2005) have noted that as technology has continued to advance, access to entertainment is now available

continuously. In addition, improved communication, computers and the internet, and global commerce allow not just entertainment, but work to move beyond daylight hours (Glorieux, Mestdag, & Minnen, 2008; Tapia, 2004).

With all of these activities available, people increasingly sleep less due to what researchers call *voluntary bedtime restriction* (Spiegel et al., 2005). In fact, according to the Centers for Disease Control's Morbidity and Mortality Weekly Report, between the 1960s and 1990s, modal sleep decreased from 8.0 – 8.9 hours per night to 7.0 hours per night. For younger adults, the proportion reporting sleeping less than 7.0 hours per night has increased from 15.6% in the 1960s to over 37% at the turn of the twenty-first century. By 2004, 25% - 30% of adults in the United States reported sleeping less than 6.0 hours per night (MMWR, 2005).

Getting adequate sleep each night results in predictable metabolic activity during both waking and sleep (Spiegel et al., 2005; Spiegel et al., 1999). Animal models have shown a reciprocal relationship between food and sleep such that as food availability is decreased, wakefulness increases (Bodosi et al., 2004). Under prolonged food deprivation, rats will stop sleeping entirely (Spiegel et al., 2005). The evolutionary purpose of this phenomenon is apparently to provide the organism with more time to find food.

The reduction in average hours of sleep seen in the United States between 1960 and 1994 (MMWR, 2005) coincides with a dramatic increase in the prevalence of overweight, obesity, and diabetes over the same period. Age adjusted prevalence rates of adult BMI's between 30 and 34 (Obesity I) increased from 9% to 15%. Rates of obesity with BMI's greater than 35 (Obesity II) doubled in the same time period, from 2.5% of

the population to 5% (Flegal, Carroll, Kuczmarski, & Johnson, 1998). Some research suggests that sleep loss by itself is sufficient to cause weight gain (Leproult & Van Cauter, 2009; Patel, 2009; Patel & Hu, 2008; Spiegel et al., 2005). Reporting on the results of a large longitudinal study of over 3,000 women and 3,100 men, Patel (2009) concludes:

After adjusting for age, race, level of education, smoking, alcohol and caffeine consumption, use of benzodiazepines and antidepressants, depression, physical activity, history of diabetes, heart disease and stroke, mean BMI was 2.5 kg m⁻² greater in men and 1.8 kg m⁻² greater in women sleeping less than 5 h compared with those obtaining 7-8 h of sleep. Similarly, reduced sleep was also strongly associated with obesity. Relative to those sleeping 7-8 h, the odds of obesity associated in those sleeping less than 5 h was elevated 3.7-fold in men and 2.3-fold in women (p. 63).¹

Most of the glucose used by the brain (the major site of glucose metabolism in the body; Boyle et al., 1994) is metabolized while in wakefulness and REM sleep (Spiegel et al., 2005). Sleep deprivation has been shown to result in cognitive deficits (Harrison & Horne, 2000), and imaging studies have shown that sleep deprivation results in a 7% decrease in brain glucose metabolism per day (Balkin, Sing, Wesensten, & Belenky, 1998). Less glucose metabolism in the brain means less cognitive activity. This deficit in energy consumption may also result in a reduction of self-regulatory capacity, an

¹ Of course this statement assumes that there is ample food available and would not necessarily apply to, for example, people living in places where food is scarce. Patel's research applies primarily to Western societies generally and to the United States specifically.

apparently glucose-dependent process (Gailliot et al., 2007; Heatherton, 2011; Muraven & Baumeister, 2000).

Model summary

Referring to the model (Fig. 1), I have attempted thus far to establish that lack of restful sleep leads to stress, negative mood, and reductions in self-regulatory capacity. All three of these conditions can result in predictable negative outcomes relative to eating and weight gain. Since leptin levels are lowered and ghrelin levels increase as a result of disturbed sleep, appetite is increased (Marcheva et al., 2009). Sleep loss has a negative impact on glucose metabolism and executive function (Wu et al., 1991) which leads to deficits in self-regulatory control (Gailliot & Baumeister, 2007). Self-regulatory control has been found to be negatively impacted by stress and stigma directly even in the absence of disturbed sleep or sleep deprivation (Baumeister, 1997). Diminished self-regulatory capacity also has been shown to impair emotion regulation (Wagner & Heatherton, 2011). The sleep-deprived have exaggerated amygdala response compared to controls, resulting in mood instability (Yoo et al., 2007). Stress and stigma directly and negatively impact mood (Ashmore et al., 2008), and negative mood is among the most frequently reported antecedents to a binge episode (Lingswiler et al., 1989).

My general hypothesis is that binge eating episodes will be cyclic. Binge episodes are likely to occur after a period of sleep loss when baseline stress is high, leading to reduced self-regulatory capacity, and labile mood. A history of inducing sleep by eating is negatively reinforcing, making binge eating behavior more likely when restorative sleep is again required. After the binge/sleep event, the person would be

expected to experience some recovery due to the effects of sleep. As a result, mood should improve, self-regulatory capacity is likely to be increased, and the individual will likely perceive their ability to cope with stress as adequate. Therefore, in the short term at least, there will be no drive to binge.

Hypotheses

The path model shown in Fig. 1 was designed to test the following primary hypotheses: (H1) sleep has direct effects on stress level, mood, self-regulatory capacity, and both direct and indirect effects on likelihood of a binge episode; (H2) stress has both a direct effect on binge likelihood and an indirect effect through its effect on self-regulatory capacity; (H3) similarly, mood has both a direct effect on binge eating likelihood and an indirect effect through its impact on stress. For the purpose of these path analyses each participant's daily data points were treated as independent. Two secondary hypotheses were tested using baseline data: (H4) states that there is a relationship between vagal tone (respiratory sinus arrhythmia), mood, and self-regulatory capacity; (H5) there is a relationship between body size (BMI) and stress level. These secondary hypotheses were tested using multiple regression.

Method

Participants

Fifty-seven adults responded to advertising placed in public places including weight loss centers, campus bulletin boards, and on-line community bulletin boards (e.g., Front Porch Forum and Craigslist; see Appendix A for sample advertisement). Twenty-four adults met the exclusion criteria (see Appendix C) and agreed to participate.

Exclusion criteria were selected to reduce alternative explanations for poor sleep quality (e.g., BMI > 40, use of prescription or over-the-counter sleep aids, diagnosis and treatment of major depressive disorder, etc.). People who reported the use of food as a stress coping mechanism were selected. People who cope with stress in other ways (e.g., smoking cigarettes or drinking alcohol frequently) were excluded. People with eating disorders (e.g., bulimia nervosa) were also excluded.

Ages ranged from 18 to 61 ($M = 34.5$, $SD = 14.53$). The sample was predominantly White (91.3%) and female ($n = 18$; 78.3%). Participants' body mass index ranged from 21.15 to 38.5 ($M = 28.82$, $SD = 5.21$). The majority of participants (78.3%; 15 females and 3 males) reported that they were dieting to lose weight.

Participants were compensated at the rate of \$10 per day plus an additional \$10 for the initial lab visit for a total of \$80.

Overview, Setting, and Apparatus

Upon arriving at the lab, each participant read and signed a consent form (see Appendix B). Weight and height were measured. Questionnaires were used to collect baseline measures of sleep quality, perceived stress level, weight stigma, mood, self-control, and binge eating behavior (see Table 1). Baseline physiological measures (vagal tone and electrodermal response) were measured while participants viewed a relaxation video (a Hawaiian beach) on a laptop computer. Next the same measures were made while participants watched a stress-inducing video (a helmet-cam video of a worker climbing a radio transmission tower), and then the measures were repeated as participants again watched the relaxation video. Measurements were made using a James Long[®] bioamplifier system. Vagal tone (respiratory sinus arrhythmia; RSA) was calculated

based on heart rate using a three-electrode electrocardiogram, and respiration rate using an elastic expansion device worn around the upper chest. Electrodermal response was measured using two finger sensors.

Daily measures of subjective sleep quality, perceptions of stress, stigma, mood, and level of control over eating were collected for seven days using a computerized daily diary (see Table 1). Participants also reported details about the past night's sleep (e.g., bedtime, number of times awake, etc.), and eating events for the day. Objective measures of self-regulatory capacity were made using two computerized tasks described below. Objective sleep data was obtained using an Ambulatory Monitoring Inc. Motionlogger[®] actigraph which was worn on the participants' non-dominant wrist for one week. Collection of the actigraph and an exit interview were conducted at the end of the monitoring period.

Measures

Baseline Measures (See Table 1).

Baseline sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989; see Appendix E). The PSQI has 19 self-rated items; higher scores indicate poor sleep quality. The items are rated using a variety of methods including fill-ins (for numeric information like number of minutes it usually takes the participant to fall asleep at night), and 4-item Likert-type response scales (from *not during the past month* to *three or more times a week*). Most of the scale items are headed by *During the past month, how often have you had trouble sleeping because you...* and sample items are: *wake up in the middle of the night or early morning; have to get up to use the bathroom; cough or snore loudly*. Participants are

instructed to base their answers on the majority of days and nights in the past month and to answer all questions. There are seven component or subscale scores: overall subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. The scale was shown to be reliable in our sample ($\alpha = 0.77$).

Baseline perception of stress was assessed with Cohen, Kamarck, and Mermelstein's (1983) Perceived Stress Scale (PSS; see Appendix F). The scale consists of 14 items rated on a 5-point Likert scale (0 = *never* and 4 = *very often*). Higher scores indicate greater perceived stress. Participants are instructed to think about how often during the previous month they had feelings and thoughts like those on the scale. Sample items include *In the last month, how often have you been upset because of something that happened unexpectedly?* and *In the last month, how often have you felt that things were going your way?* (reverse coded). Half the items indicate low stress and half indicate high stress. Items are counterbalanced for desirability. The PSS has been used in studies on alcohol use (Rice & VanArsdale, 2010), the role of social support (Cohen, Clark, & Sherrod, 1986), and weight gain in college students (Provencher et al., 2009). This measure demonstrated good reliability in our sample ($\alpha = 0.77$).

Baseline mood was assessed with the Positive and Negative Affective Schedule – Expanded Form (PANAS-X; Watson & Clark, 1994; see Appendix G). The PANAS-X scale consists of sixty words that describe emotions or feelings. Participants are asked to read each word and to rate the extent to which the word represents their feelings using the *during the past few days* instruction. Sample positive affect words are *enthusiastic*, *inspired*, and *strong*. Sample negative affect words are *scared*, *jittery*, and *irritable*.

Sample words from the guilt subscale are *guilty*, *ashamed*, and *blameworthy*. The instrument uses a five-point Likert scale (1 = *very slightly or not at all* and 5 = *extremely*). Higher scores indicate higher levels of the specific affect measured. Composite scores were calculated for positive and negative affect, and guilt subscales. These measures each had good reliability in our sample (positive affect $\alpha = 0.91$; negative affect $\alpha = 0.75$; guilt $\alpha = 0.93$). Given the high level of correlation between the subscales, the guilt scale was chosen as the mood measure, as most relevant to binge eating.

A baseline measurement of self-control was included in the questionnaire packet. The Brief Self-Control scale (BSC; Tangney et al., 2004; see Appendix H) has 13 items and is thought to provide a trait measurement of self-control. Items are rated on a five-point Likert scale (1 = *not at all* and 5 = *very much*) with instructions stating the participant is to indicate how much each of the items reflect how they typically are. Higher scores indicate more self-control. Examples of items are: *I am good at resisting temptation*; *I do certain things that are bad for me if they are fun* (reverse scored); and *People would say that I have iron self-discipline*. This measure demonstrated good reliability in our sample, ($\alpha = 0.74$).

The binge eating scale (BES; Gormally, Black, Daston, & Rardin, 1982; see Appendix I) was used at the baseline measure of binge eating behavior. The reporting of binge eating episodes is notoriously subjective as individuals have very different ideas of what constitutes a binge (Fairburn & Wilson, 1993). The BES was originally designed to identify obese people with binge eating disorder. The scale consists of 16 items that are based on the DSM-III (American Psychiatric Association, 1980) binge eating disorder

criteria. Half of the items describe behavioral characteristics of binge eating and half describe thoughts and feelings. Most items include four statements (two items have only three statements) of increasing severity. For example Item 3 states (score in parenthesis): 1. *I feel capable to control my eating urges when I want to* (0); 2. *I feel like I have failed to control my eating more than the average person* (1); 3. *I feel utterly helpless when it comes to feeling in control of my eating urges* (2); 4. *Because I feel so helpless about controlling my eating I have become very desperate about trying to get control* (3).

Participants are instructed to read the statements and to mark the one that best describes their feelings regarding control of eating behavior. The items are scored from 0: *no binge eating problem*, to 3: *severe binge eating problem*. The BES is scored by adding the individual scores for each of the 16 items for a total score that can range from 0 to 46. Generally a cutoff of greater than or equal to 27 is considered *severe*, while scores equal to or less than 17 are considered to be *mild* or non-binge eaters (Greeno, Marcus, & Wing, 1995). The scale showed good reliability in our sample ($\alpha = 0.85$).

Physiological measures of stress reactivity were collected to investigate the relationship between vagal tone and self-regulatory capacity (Fox, 1989; Karoly, 1993; Porges, 1991). A three-part procedure was used (Sinnreich, Kark, Friedlander, Sapoznikof, & Luria, 1998). Baseline heart and respiration rate, and electrodermal response measures were obtained while participants watched a 7-minute relaxation video. The second part of the procedure involved the same measures collected while the participants viewed a stress-inducing video. By comparing the baseline respiratory sinus arrhythmia (RSA) to the same measurement obtained while the participant is likely to be experiencing some stress, a measure of responsiveness to stress can be obtained. People

under chronic stress will show less change in RSA (low vagal tone) and electrodermal response. People with high vagal tone, and thus greater self-regulatory capacity should respond to the stress-inducing video with greater heart and respiration rates, as well as a greater skin conductivity. After the stress-inducing video participants again watched the relaxation video. People high in vagal tone should quickly return to baseline as they view the relaxation video for the second time.

Sleep monitor and daily diary data entry system (See Table 1).

Each participant agreed to wear an electronic motion detector/logger (actigraph) for the seven days of the study. Each participant's actigraph data was analyzed to determine the sleep ratio during the hours the person was in bed and ostensibly asleep (percent sleep divided by percent awake). The instrument provides a determination of wakefulness based on an algorithm that takes into account intensity and frequency of motion. The sleep ratio is indicative of the level of restfulness that the sleep period provided: a low ratio of sleep to wakefulness would indicate frequent disturbances, and thus presumably less restful sleep, throughout the sleep period. The mean centered sleep ratio was the endogenous variable in the path model analysis.

The daily data entry system consisted of two parts: a purpose-built website where participants completed two tasks described as "game-like," and a diary questionnaire created in Lime Survey (see Appendix J for the entire daily diary report system). The game-like tasks were variations of standard measures of self-regulatory capacity (Stroop color-naming task and a two-choice impulsivity paradigm described in detail below). After completing the two tasks, participants were automatically redirected to Lime

Survey where they completed sections related to their daily experiences of sleep, stress, mood, eating, and stigma.

The sleep diary section provided questions regarding details of sleep for the previous night (see Appendix J). For example, *Thinking about sleeping last night, please answer the following questions*. Included in the sleep diary section were number and duration of any naps, bedtime, approximate time it took to fall asleep, number of times awake and/or out of bed during the night, total hours spent in bed, estimated hours spent sleeping, and a subjective sleep quality rating on a 5-point Likert scale (1 = *Terrible - I barely slept at all* and 5 = *Great - Best sleep I've had in a long time*). This subjective information was used primarily to help align actigraph events (i.e., bedtime, etc.).

Participants recorded their subjective level of stress experienced in the past 24 hours on a 5-point Likert scale (1 = *very low* and 5 = *very high*), along with choices of stress category (e.g., work-related, family issues, financial issues, etc.). The instructions were *Please tell us about any stressful events you experienced today by selecting from the categories below (you may choose more than one)*. Comment areas were included. Reliability for this scale was only moderate ($\alpha = 0.56$). For the path analysis, total number of stressful events was multiplied by stress level for the day and mean centered, yielding a measure of total stress.

Mood was assessed using the PANAS-X (described above) using the *today* instruction. The scale showed good reliability for our sample (α levels for positive affect scale = 0.92; negative affect scale = 0.71; guilt subscale = 0.93). Here, too, the guilt subscale was chosen for analyses due to relevance and high correlation with the positive

and negative affect. The guilt subscale was mean centered for use in the path model analysis.

The Stroop task (Gailliot, Schmeichel, & Baumeister, 2006; see Appendix J) was chosen as one daily objective measure of self-regulatory capacity. The Stroop task has been shown to effectively measure self-regulatory capacity by Gailliot and colleagues (2006). Higher response times on incongruent trials are interpreted as indicating lower self-regulatory capacity. To reduce practice effects sometimes reported for the Stroop task, different keys were used to represent red, blue, and green font colors each day. Stroop scores were determined by calculating the mean response time difference in percent between congruent and incongruent trials.

Research (Mischel & Ebbesen, 1970) has shown that choosing larger but delayed rewards rather than smaller and more immediate rewards is an indicator of good self-control. The two-choice impulsivity paradigm (TCIP; Schmeichel & Vohs, 2009; see Appendix J) consists of the presentation of two geometric shapes on a computer screen, a square and a circle. The stated object of the game is to score as many points as possible. Participants can choose either the circle or square by clicking on a selection box under the shape. Choosing the square scores 15 points, but freezes the game for 15 seconds, during which no further action can be taken; choosing the circle scores five points, and the game freezes for five seconds. Participants completed 30 trials for a range of scores from 150 (0%) to 450 (100%). Self-regulatory capacity was calculated by taking the average of the sum of the TCIP percent of full score and the Stroop percent difference between congruent and incongruent trial and centering the result.

The daily diary data entry system was used to collect information regarding eating events (see Appendix J). The following instructions headed the section: *You will be asked to describe each meal, snack or treat ("event"). For each event you report, you will be given a set of questions regarding that meal, snack or treat. For example, if you had 3 meals (breakfast, lunch, supper) and 3 snacks or treats, you would enter the total which would be 6.* Depending on the number the participant entered, Lime Survey prepared a questionnaire for each event (up to 12). The maximum number of eating events entered for a single day by any participant was nine. Subjective control over each eating event (the variable used to indicate binge eating) was assessed with a 5-point scale (0 = *I felt completely in control: I ate because I was hungry*; 1 = *I ate because it was meal/snack time*; 2 = *I felt pretty much in control of how much I was eating*; 3 = *I felt a little out of control and unsatisfied*; 4 = *I felt like I was watching someone else, like my hand was moving by itself*). To produce a measure of binge eating based on feelings of lack of control, the number of eating events rated 3 or 4 each day were multiplied by 3 or 4 respectively and taking the average. For example, if a participant reported three eating events rated at 3 and two eating events rated at 4, the resulting score for that day would be 8.5 (the average of $3*3 + 2*4$).

To measure stigma, a section of the daily diary presented questions based on the MacArthur Foundation Midlife Development in the United States survey (MIDUS; E. M. Friedman, Williams, Singer, & Ryff, 2009; Kessler, Mickelson, & Williams, 1999). Questions from the MIDUS were presented in two contexts: lifetime experience and experienced today. The *lifetime* context section was only completed once, on the first day of the study. The section was headed by *Have you EVER IN YOUR LIFE*

experienced any of the following types of prejudice or discrimination as a result of your identity or the way you look? Eleven possible examples of prejudice or discrimination were presented along with *Other (describe)* and *None of these have ever happened to me*. Participants could select any or all of the choices, examples of which are *hassled by the police; not hired for a job; and denied a bank loan* (see Appendix J for complete listing). If any items were selected, Lime Survey was programmed to then probe the aspect of the participant's identity to which they attributed the prejudice and/or discrimination (e.g., gender/sexual identity, age, weight, religion; see Appendix J for complete listing). Reliability for this scale was good ($\alpha = 0.77$). Two items were not chosen by any participants (*denied scholarship, prevented from renting/buying a home in the neighborhood you wanted*).

The question for the *today* context section of the stigma report is *Did you experience any of the following types of prejudice or discrimination TODAY because of your identity or the way you look?* Eight responses were taken from the MIDUS survey including *you were treated with less courtesy than other people, people acted as if they were afraid of you, and you were called hurtful names or were insulted* (see Appendix J for the complete list of response options). Lime Survey was programmed to provide the same list of possible reasons for the discrimination participants may have experienced (e.g., gender/sexual identity, age, weight, religion; see Appendix J for complete listing). Scale reliability for these data was only moderate ($\alpha = 0.57$) and two items were not chosen by any participants (*you received poorer service than other people at a restaurant or store, and you were threatened or harassed*).

Procedure

Preparation

A follow-up reminder phone call was made by the principal investigator the day before the scheduled appointment to confirm the appointment, provide directions, and answer any questions. During the follow up call, participants were asked to refrain from strenuous physical exertion and to avoid having a heavy meal or consuming caffeine or alcohol for two hours prior to the appointment. This precaution was made to improve the chances of obtaining a stable baseline heart rate for the vagal tone measurement (Sinnreich et al., 1998). Each participant was provided with a username and password for both the purpose-built website and Lime Survey.

Lab protocol

Upon arrival, participants were weighed and their height measured. The informed consent (see Appendix B) and payment documents were given to each participant and time was provided for a thorough reading of them. Although provided with the opportunity to do so, no participants opted out at this stage. Following consent, each participant was given instructions and shown an illustration of the correct electrocardiogram electrode placement (see Appendix K). Participants attached the electrodes in privacy. The experimenter then fitted the respiration sensor and the two electrodermal finger sensors. The instrumentation was checked for operation and scaling with adjustments made as necessary. The participant was instructed to sit comfortably, breathe normally, and watch the first video (a Hawaiian beach scene) on the laptop computer. During the video, the experimenter monitored the participants' baseline heart rate, respiration, and electrodermal response from the control room.

At the conclusion of the relaxation video the experimenter returned to the participant room and offered to answer any questions. To confirm that the participant was watching the video, the experimenter asked if a seal on the beach was observed. All participants reported seeing the seal which is shown approximately two minutes from the start of the video. The experimenter then introduced and started the stress-inducing video (a worker wearing a head-mounted camera climbs a tall radio transmission tower). After starting the video, the experimenter again monitored the signals from the control room. At the end of the video the experimenter returned and set up the relaxation video for its second viewing. After the final video the experimenter returned and instructed the participant in removing the electrodes in privacy.

Participants then were given instructions for completing the questionnaire packet consisting of the baseline measures previously described (see Appendices E – I). After the participant completed the questionnaire the experimenter demonstrated logging in to the daily diary websites, and the Stroop and two-choice impulsivity task. Instructions were provided for completing the daily food diary. Finally, the actigraph was described, fitted, and demonstrated to the participant. If there were no questions, the participant was thanked for their participation and encouraged to contact the principal investigator in the event of any problems or questions regarding anything pertaining to the study. The typical elapsed time for the lab visit was 90 minutes.

Final lab visit

The purpose of the second lab visit was to retrieve the actigraph device, debrief the participant regarding the hypotheses of the study, and to provide a list of resources for counseling, weight loss, the treatment of binge eating disorder, and the diagnosis and

treatment of sleep disorders. Participants were asked to give a short recorded interview during which the researcher asked questions regarding: specific stressors encountered during the monitoring period; difficulties with the study materials; difficulty providing daily information; suggestions for future improvements. This qualitative data was used mainly to verify compliance with the protocol and to uncover difficulties encountered during the monitoring week. Participants were invited to ask questions regarding the study and had any confusing aspects explained to them.

Results

Analysis Plan

Results from the baseline questionnaires were analyzed to establish relevant characteristics of this sample of people who use food to cope with stress (see *Baseline Questionnaire Data Analysis* below; Tables 1 & 2). Baseline questionnaire data and daily diary data were analyzed separately, and each participant's daily diary data points were treated as independent.

Paths and disturbances in the model (Fig. 1) were estimated using AMOS SEM software (Arbuckle, 2006) to test three hypotheses: (H1) sleep has direct effects on stress level, mood, and self-regulatory capacity, and both direct and indirect effects on likelihood of a binge episode; (H2) stress has both a direct effect on binge likelihood and an indirect effect through its effect on self-regulatory capacity; (H3) similarly, mood has both a direct effect on binge eating likelihood and an indirect effect through its impact on stress and self-regulatory capacity. Separate analyses were completed for baseline questionnaire data (see Table 4) and daily diary data. To account for missing data in the daily diary data, ten sets of multiple imputations were run in SPSS. To determine

statistical significance for indirect and total effects in the daily diary data, 5000 bootstrapped samples were analyzed in AMOS for each imputed data set (see Table 5). Standardized total effects, standardized indirect effects, standard errors and bias-corrected two-tailed significance for each path to binge eating were entered into a spreadsheet that pools the standard errors and parameter estimates from each imputed set, resulting in single summary estimates (Schafer, 1997). The unmeasured disturbances in the model (labeled d in Fig. 1) are calculated by $\sqrt{1 - R^2}$.

Multiple regression analysis was used to test two additional, secondary, baseline hypotheses: (H4) that there is a relationship between vagal tone (measured by respiratory sinus arrhythmia), mood, and self-regulatory capacity; (H5) that there is a relationship between body size (determined by BMI), perceived stigma, and stress level. These hypotheses were tested only with the baseline data set.

If binge eating is indeed a way to induce restorative sleep, then some reduction in binge eating behavior should be observed following sleep. In effect, binge eating behavior and sleep would appear to be out of phase with each other when plotted. More than a third of participants' data showed patterns of recovery following improved sleep. These data are presented as case studies for future investigation (see Figures 5-12).

Baseline Questionnaire Data Analysis

Sleep Quality: The study starts with the assumption that participants who use food to cope with chronic stress will report poor sleep. Buysse and colleagues (1989) state that a global score on the Pittsburgh Sleep Quality Inventory (PSQI) > 5.0 separates good sleepers from poor ones. Mean global PSQI rating for the sample was 8.17 ($SD = 3.23$).

Perceived Stress: The Perceived Stress Scale (PSS; Cohen et al., 1983) was used to measure stress level generally, and to test the assumption that participants in the study were in a state of chronic stress. Cohen and Williamson (1988) collected a large national probability sample of over 2300 individuals and found that the mean score on the PSS was 19.6 ($SD = 7.49$). My sample's mean score was over three standard deviations above that level ($M = 46.57$, $SD = 6.02$), indicating at least a higher level of perceived stress compared to the general population.

Mood Level: Generally, scores on the PANAS-X (Watson & Clark, 1994) were below the scale midpoint; my participants were not particularly happy ($M = 2.56$, $SD = 0.80$), unhappy ($M = 1.99$, $SD = 0.55$), or guilty ($M = 1.80$, $SD = 0.71$) over the past few days. However, average mood is not an especially good indicator of the predictive power of mood on binge eating behavior, as results below will indicate (also see Wilson, Laser, & Stone, 1982).

Self-Control: The Brief Self Control scale (Tangney et al., 2004) indicated that participants' assessment of their level of self-control was moderate ($M = 2.76$, $SD = 0.54$). Similar to mood, however, overall impressions of one's self-control may not offer insight into binge eating behavior as it is likely that transient lapses in both mood and self-control are what contribute to binge eating episodes.

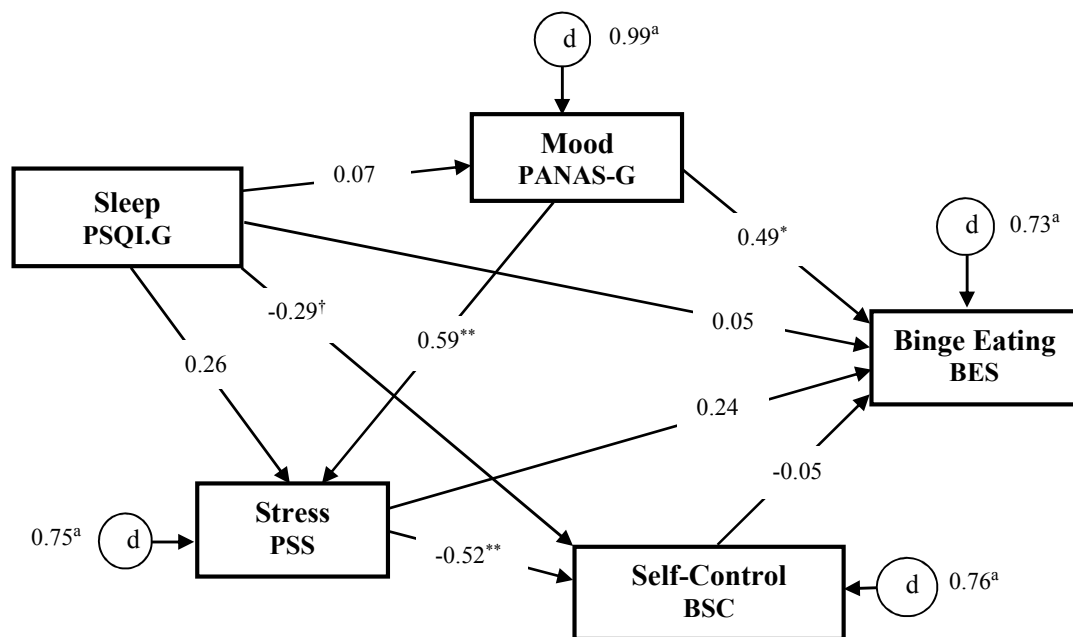
Binge Eating Behavior: The baseline measure of binge eating behavior was the Binge Eating Scale (BES; Gormally et al., 1982). Researchers who have experience with the scale place the cutoffs at 17 for mild or non-binge eaters and 27 for severe binge eaters. The mean for my sample was 21.48. The high standard deviation ($SD = 7.64$) indicates the wide variability in perceptions of binge eating behavior in the sample.

Baseline Path Analysis

Referring to Figure 1, the outcome variable in the baseline model was binge eating (BES; Gormally et al., 1982) and the predictors were sleep quality (PSQI.G; Buysse et al., 1989), perceived stress (Cohen et al., 1983), guilt indicated by the PANAS-X subscale (Watson & Clark, 1994), and self-control (BSC; Tangney et al., 2004). Predictor variables were mean centered prior to analysis.

The model predicts that sleep will have direct effects on stress level, mood, and self-regulatory capacity, and both direct and indirect effects on likelihood of a binge episode (H1). To test this hypothesis, baseline data was analyzed using the path analysis procedure outlined above (see Fig. 2; indirect path betas are shown in Table 4). As the

Figure 2: Path model solved for baseline data (mood predicts stress).



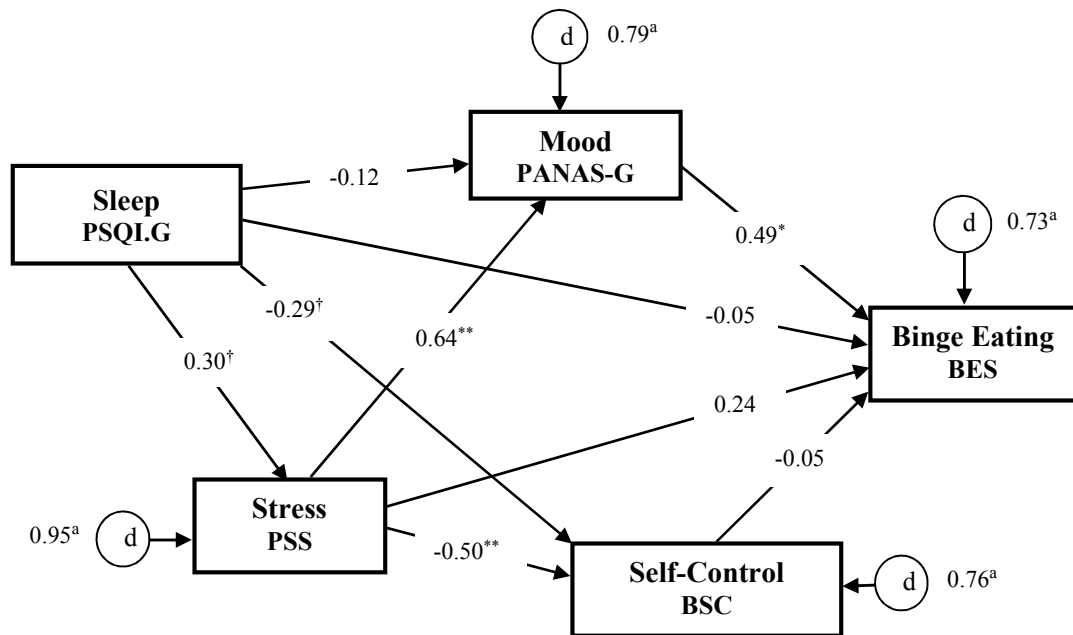
Notes. $n=23$; $** p < 0.01$, $* p < 0.05$, $† p < 0.10$

^a disturbance ($d = \sqrt{1 - r^2}$)

beta weights (shown in the path arrows) and p values show, for the baseline measures H1 was only supported (and then only marginally) in the relationships between sleep quality and self-regulatory capacity. Fit statistics for this model (see Table 5) suggest that the model is a reasonably good fit to the data².

Hypothesis H2 predicts that stress will have direct and indirect effects on binge eating through its effect on self-regulatory capacity. In the baseline analysis, neither the direct nor the indirect path through self-control were statistically significant, although perceived stress did predict self-control. However, when stress was allowed to predict mood (see Fig. 2a, Table 4), the indirect and total effects were statistically significant,

Figure 2a: Path model solved for baseline data (stress predicts mood).



Notes. $n=23$; ** $p < 0.01$, * $p < 0.05$, † $p < 0.10$

^a disturbance ($d = \sqrt{1 - r^2}$)

² Disturbances are unexplained variance in each endogenous variable.

though the direct path was not. Thus for the baseline measures the effect of stress on binge eating was fully mediated, most likely through mood, since the path from self-control to binge eating was not statistically significant.

The model predicts that mood will have a direct effect on binge eating and an indirect effect through stress (H3). Here, too, for the baseline measures, the path from mood-to-stress was tested as well as from stress-to-mood. In both cases, the direct path from mood to binge eating was statistically significant (see Fig. 2, 2a, Table 4, 4a) However, when mood was allowed to predict stress, the indirect path through stress was not statistically significant, supporting both the hypothesis and past research that cites mood as a good predictor of binge eating behavior.

Secondary Baseline Analyses

The first of two secondary hypotheses was tested using multiple regression: (H4) states that there is a relationship between vagal tone (physiological stress response indicated by respiratory sinus arrhythmia (RSA), controlling for participant age), perceived stress, and self-regulatory capacity. Physiological stress response using respiratory sinus arrhythmia was determined by taking the residual after regressing RSA during the stress phase on RSA during the recovery phase of the trial. Multiple regression analyses of vagal tone showed no statistically significant relationship with perceived stress or self-regulatory capacity when controlling for age.

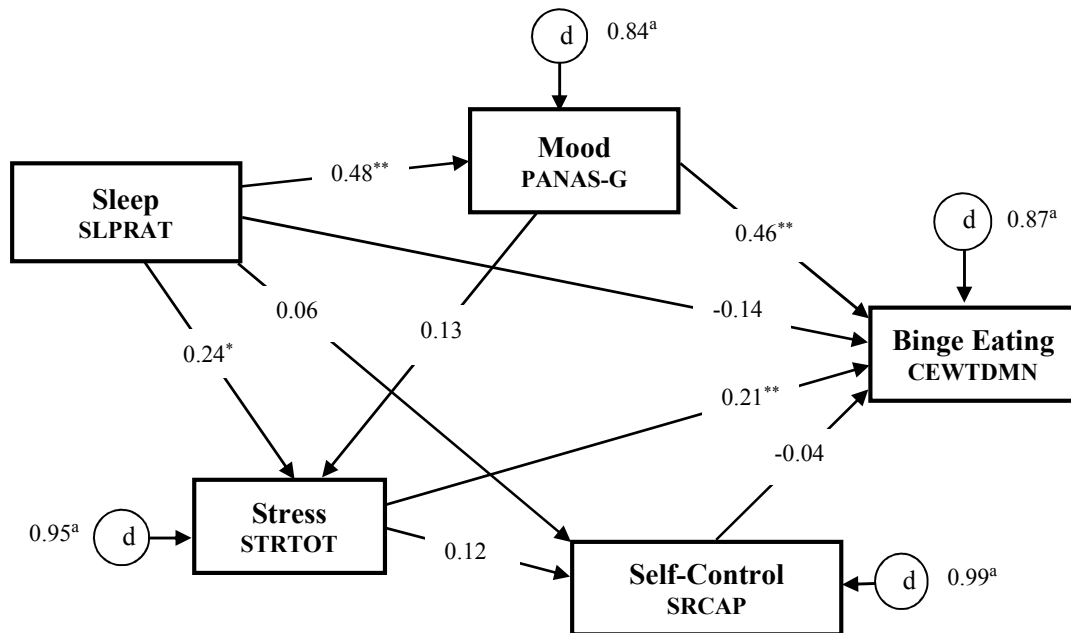
The second of two secondary hypotheses was also tested: (H5) there is a relationship between body size (BMI) and stress level (PSS; Cohen et al., 1983). This hypothesis was tested both at baseline and with the daily diary data using mean-centered

predictors. The baseline showed no significant relationship between BMI and perceived stress: r^2 (PSS) = 0.0, $\beta = -0.13$, $p > .05$.

Daily Diary Path Analysis

The hypotheses suggested by the model (see Fig. 1) were also analyzed using the daily diary data (see Fig. 3, Table 4) and the path analysis procedure described above.

Figure 3: Path model solved for daily diary data.



Notes. $n=139$; $** p < 0.01$, $* p < 0.05$, $\dagger p < 0.10$

^a disturbance ($d = \sqrt{1 - r^2}$)

Each individual participant's daily data points were treated as independent. For the exogenous sleep variable, the objective data collected by means of the motion-sensing actigraph was analyzed to produce a ratio of sleep to wakefulness. To ensure that the objective sleep measure pertained to (and preceded) the daily diary subjective reports, the data was offset and the first day of each participants' self-reports was omitted since the first diary entry was presumably made prior to the first sleep data collection. Although

participants were instructed to complete their daily diary at the end of each day, approximately half of the participants actually completed the tasks the next day at least once during the week of data collection. On average, 75% of the 161 diary entries were completed at the end of each day. One participant always completed the diary the next day.

The stress factor combined both the number of stressors and subjective stress level reported by each participant each day. The self-regulatory capacity measure combined the scores on the two game-like tasks completed each day. The binge eating outcome variable includes the number of events participants reported as lacking control, giving more weight to events that felt more out of control. Only the mood measure was similar to that used for the baseline analysis (i.e., the PANAS-X). Thus the daily diary path model seeks to provide a timelier and perhaps more objective analysis of the factors examined. Fit statistics for this model (see Table 5) also suggest that the model is a reasonable representation of the data.

Compared to the baseline results, the hypothesis that sleep will have direct effects on stress, mood, and self-regulatory capacity, and both direct and indirect effects on likelihood of binge eating (H1) is partially supported using the daily diary data. Sleep ratio predicted both stress and mood, though interestingly not self-control. Sleep was fully mediated through mood; the indirect path was statistically significant and the total effect showed a statistical trend ($p = 0.07$). The hypothesis that stress will have a direct effect on binge eating and an indirect effect through self-regulatory capacity (H2) was also partially supported; stress predicted binge eating, but not self-regulatory capacity.

Mood had a large direct effect on binge eating (H3), but not an indirect effect through stress.

Binge Reduction Following Improved Sleep

One of the underlying themes of this study is that there is a relationship between eating and sleep, and that for people who use food to cope with stress binge eating may be a way to induce restorative sleep. Plotting sleep ratio and binge eating behavior over time should therefore show that relationship. Graphing each participants' sleep ratio data with the binge eating outcome variable provided evidence for the proposed relationship for a third of the participants in this study. Using actigraph data (sleep ratio) and the binge eating outcome variable collected with the daily diary, the following plots (Figures 4 – 11) show out-of-phase behavior such that binge eating behavior is inversely related to sleep ratio: when sleep ratio is high, binge behavior is low. While these patterns were not observed for all participants, it appears that for some, restful sleep reduces the need to binge eat.

Figure 4 – 11: Relationship between actigraph sleep ratio (SR) & binge events (BE)

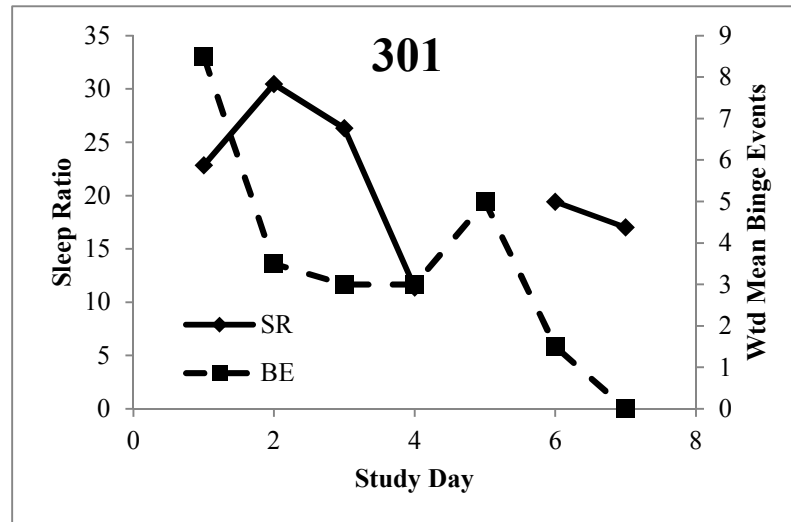


Figure 4: *Participant 301*

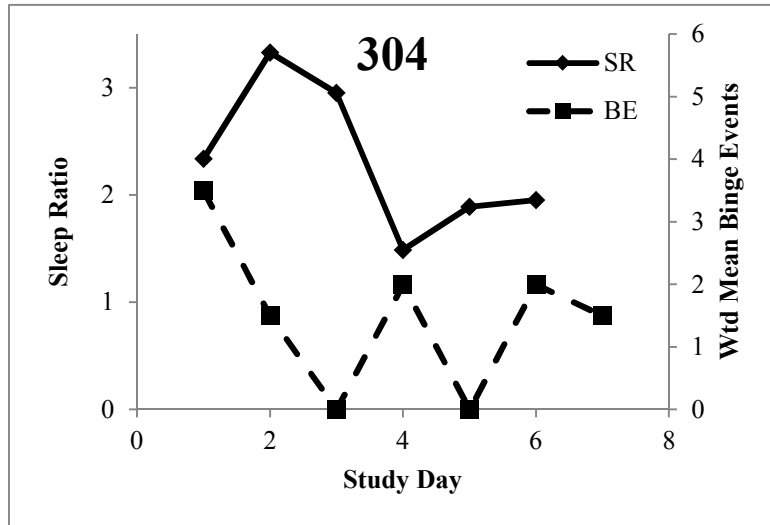


Figure 5: Participant 304

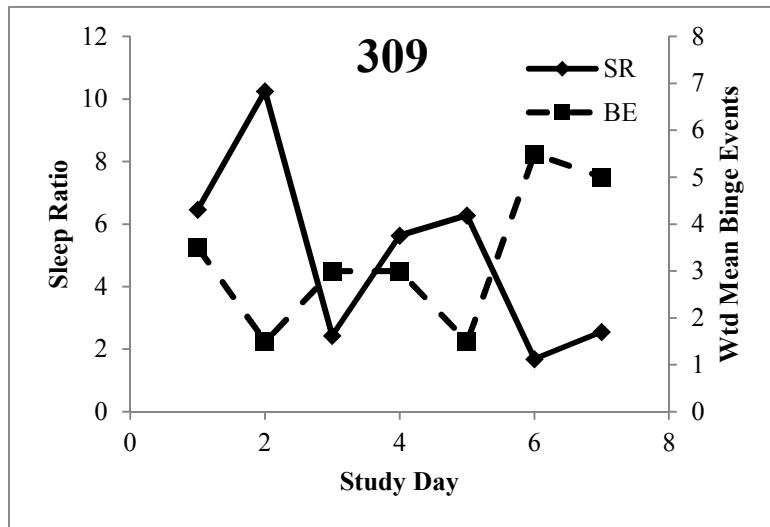


Figure 6: Participant 309

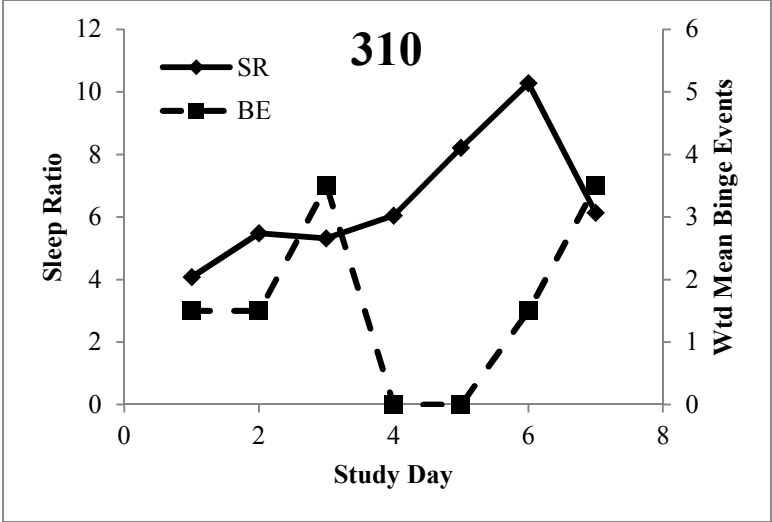


Figure 7: Participant 310

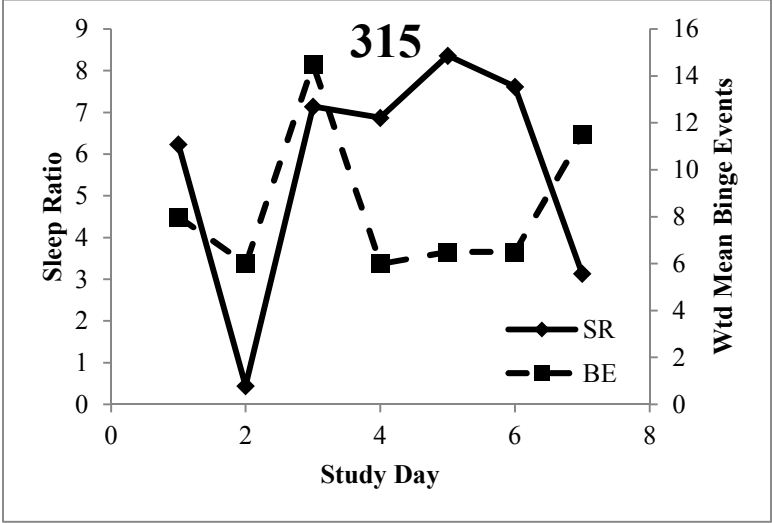


Figure 8: Participant 315

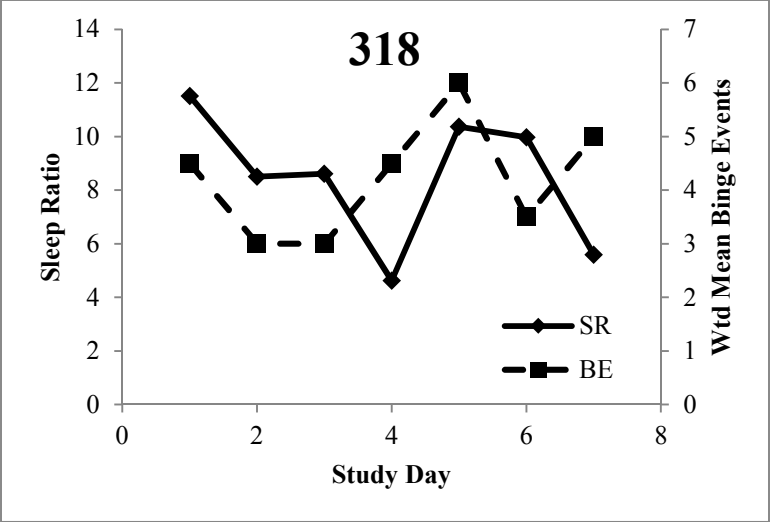


Figure 9: Participant 318

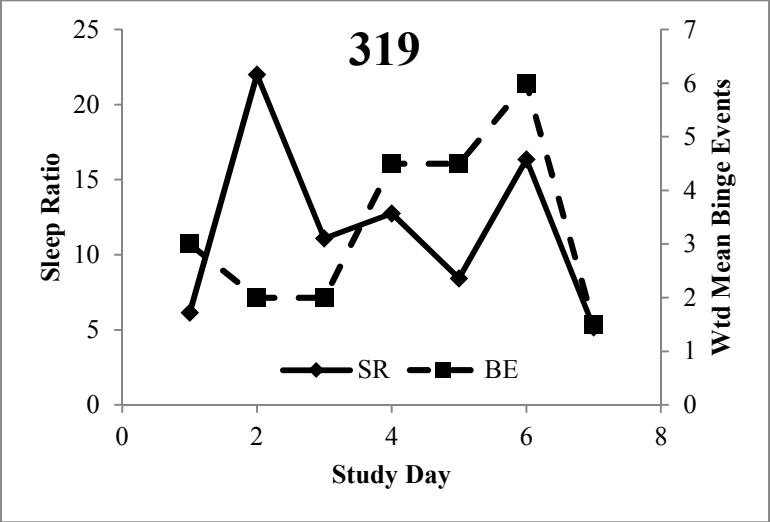


Figure 10: Participant 319

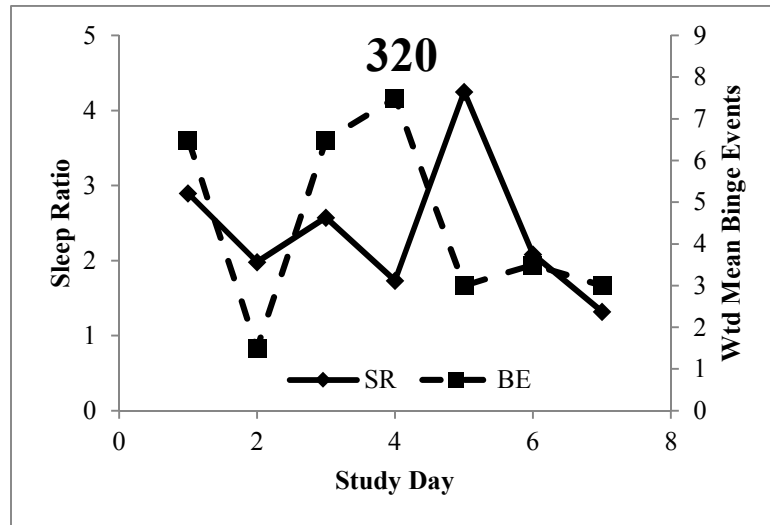


Figure 11: *Participant 320*

Discussion

This research attempts to describe the hypothesized direct relationship between binge eating behavior and sleep, and the indirect effects of sleep on binge eating through chronic stress, mood, and self-regulatory capacity. The research presented here treats poor sleep as an antecedent to binge eating, while acknowledging that sleep can also be, and frequently is, a result of the binge. Data were treated as cross-sectional, so cause and effect are ambiguous.

A review of the literature on sleep, stigma and stress, mood, self-regulatory capacity, and eating, suggested a model that might be useful in describing the interplay between these factors related to cycles of binge eating behavior. Based on the model, three main hypotheses were tested: (H1) sleep has direct effects on stress level, mood, and self-regulatory capacity, and both directly and indirectly affects likelihood of a binge episode; (H2) stress has both a direct effect on binge likelihood and an indirect effect

through its effect on mood and self-regulatory capacity; (H3) similarly, mood has both a direct effect on binge eating likelihood and an indirect effect through its impact on stress.

These hypotheses were tested with two sets of data: a primarily retrospective baseline consisting of self-report survey instruments, and a somewhat more objective and in-the-moment data set consisting of actigraph sleep data, and a self-reported daily diary. The two datasets showed different effects in regards to the hypotheses. For the baseline questionnaire data, the only measurable effect of sleep quality was a trend to predict self-control ($p = 0.09$). Perceived stress predicted mood and self-control and had an indirect effect on binge eating mediated by mood, but not mediated by self-control. Mood was the only direct predictor of binge eating. The diary data tell a different story. As hypothesized, sleep ratio predicted stress and mood but surprisingly not self-control. Sleep also predicted binge eating, mediated by stress and mood. Stress had a direct effect on binge eating but no indirect effects. Total stress in the diary dataset did not predict either mood or self-control. Mood seemed to be the best predictor of binge eating regardless of which data were considered. This result has also been found by a number of researchers (e.g., Greeno et al., 2000; Macht, 2008; Polivy & Herman, 1999).

There are a number of possible reasons for the differences between retrospective self-reported measures of sleep, stress, mood, self-control, and eating behavior and daily measures of the same factors. Although the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) provides a validated measure of overall sleep, actigraphic data collection is arguably a more accurate and objective measure of sleep. Participants completing the PSQI may have had a distorted perception of their overall sleep quality,

perhaps dependent on how they were feeling that day (i.e., mood congruent judgment; Croyle & Uretsky, 1987; Mayer, Gaschke, Braverman, & Evans, 1992).

General perceptions of stress seemed to follow stereotypical relationships in the baseline data: high perceived stress correlated with less self-control, and worse mood. When tracking stress level, self-control, and mood day-by-day, however, those relationships faded, perhaps supporting Wilson, Laser, and Stone's (1982) premise that people are generally not good at differentiating between lay theories and objective measures predicting mood. Also, escape theory (Heatherton & Baumeister, 1991) suggests that the result of a binge is to dampen self-awareness, perhaps leading participants to forget how stressed they were before binge eating in the past. Requiring participants to report stress level closer to the binge eating event may explain the lack of an effect of stress on binge eating in the baseline compared to the robust path in the daily diary dataset.

The data tended to confirm some assumptions about the population of interest. People who use food to cope with stress are likely to report high levels of perceived stress. They report relatively worse sleep than the general population. Also, the data did not seem to show a relationship between binge eating behavior and body size. In addition results from this study offer tantalizing evidence that there may indeed be a set of factors regulating the frequency at which binge eaters indulge in the behavior and that the proposed model, or one similar to it, offers a reasonable first step toward a description of those factors.

After the Binge

In many studies examining binge eating, researchers report that negative mood or changes in mood often lead to a binge episode (Arnow, Kenardy, & Agras, 1992; Chua, Touyz, & Hill, 2004; Dingemans, Martijn, van Furth, & Jansen, 2009; Greeno et al., 2000; Hilbert & Tuschen-Caffier, 2007; Lingswiler et al., 1989; Polivy & Herman, 1999; K. E. Wegner et al., 2002). Few researchers consider what the individual does after the binge episode. The research on mood and binge eating has considered post-binge mood primarily in the context of the previously discussed psychosomatic comfort hypothesis, which states that eating provides comfort and is a coping mechanism that people engage because they believe it will improve their mood (Polivy & Herman, 1999). The same research generally finds that mood is seldom improved following the binge (Hilbert & Tuschen-Caffier, 2007; K. E. Wegner et al., 2002). Often one negative affective state, typically anger, anxiety, or depression is exchanged for another, most frequently self-reproach and guilt (Arnow et al., 1992; Dingemans, Martijn, Jansen, & van Furth, 2009; Hilbert & Tuschen-Caffier, 2007). The data from this study generally support that conclusion and provide evidence for the likely role of guilt.

Heatherton and Baumeister (1991) describe the effects of binge eating as paradoxical, since it is often a counter-productive outcome of dieting, and it fails to improve mood, despite beliefs to the contrary. This led them to propose that escape from aversive cognitions is a primary force driving binge eating behavior. The studies of affective antecedents cited above and the results showing no improvement in mood following a binge episode support this idea. However, if escape from aversive cognitions is the purpose of the binge, what happens after the binge is over? Does the binger simply

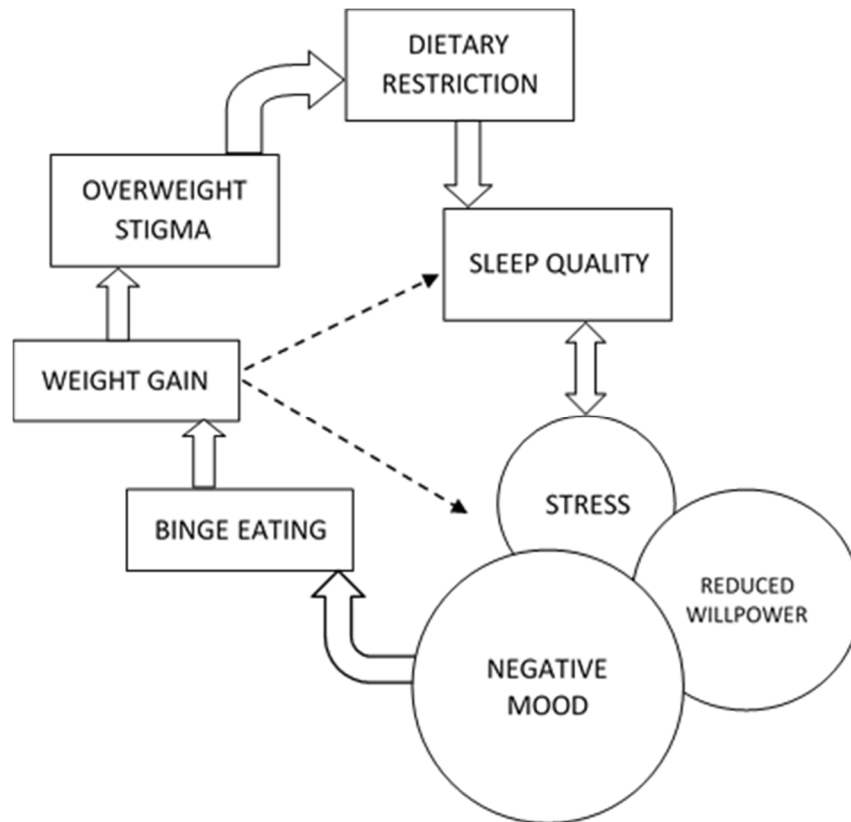
pick up where she left off, with the added burden of guilt, self-reproach, and feelings of failure? If that is the case, what would reinforce binge behavior and make it more likely to occur when the person is next confronted with overwhelming ego threats and stress?

The guiding hypothesis of my study is that binge eating is an attempt by the brain's glucose-depleted executive processing center to both regulate (i.e., increase) glucose levels and induce restorative sleep. Restorative sleep results in some amount of recovery (Eidelman, 2002). By definition, recovery results in improved mood, increased self-regulatory capacity, and thus may reduce the likelihood of another binge episode in close temporal proximity to the sleep-induced recovery (Baumeister et al., 1998; Gujar, Yoo, Hu, & Walker, 2011). This hypothesis is supported by the observed relationship between sleep ratio and binge eating behaviors seen in Figures 4 – 11. For some participants, binge eating and sleep ratio are out of phase: when sleep ratio is high, binge eating events are low. As sleep ratio deteriorates over time, binge eating events increase.

The research reported here can be considered part of a larger question, and problem, concerning restrictive dieting. The model shown below (Fig. 12) illustrates a complex self-perpetuating feedback loop sustained primarily by chronic stress, partly as a result of dietary restriction and its general inability to result in sustained weight loss (Baumeister & Tierney, 2011). In this model, sleep is a key element: it may be that chronic lack of restful sleep leads to binge eating, as suggested by the current study. One purpose for this uncontrolled eating may be to bring on needed restful sleep, restoring willpower and temporarily providing resources to resist stressors. However, this behavior is not sustainable. Continued over-eating inevitably leads to overweight, which

increases stigma and adds to the chronic stress the person is attempting to deal with. So, while restful sleep is a desirable outcome, a more lasting solution would seem to require a reduction in stress level.

Figure 12: Hypothesized relationship between dieting, sleep, stress, willpower, and overweight stigma.



The Failure of Self-Regulatory Capacity to Predict Binge Eating

Perhaps the most surprising result in this study is the inability of established measures of self-regulatory capacity (Gailliot et al., 2006; Schmeichel & Vohs, 2009) to predict binge eating behavior. Although technical issues with the website where participants completed the Stroop task and the Two Choice Impulsivity Paradigm are

perhaps partly to blame for this failure, the Brief Self-Control questionnaire (Tangney et al., 2004) also failed to predict scores on the Binge Eating Scale instrument (Gormally et al., 1982). Together these results suggest that, at least for this sample, binge eating is not necessarily a failure of self-control, but is motivated by some other factors. In the models presented here, those factors are sleep quality, stress, and mood – specifically guilt. The implication then is that regulating mood and stress level by maintaining good sleep hygiene is a more effective remedy against binge eating behavior than is strengthening willpower.

Limitations and Future Directions

Some of the factors hypothesized to contribute to cycles of binge eating may be impossible to measure effectively. For example, it is conceivable that there is no baseline equivalent to self-regulatory capacity, that it is a dynamic dimension that is not well characterized by a questionnaire measure like the Brief Self-Control scale (Tangney et al., 2004). Daily diary measures are also difficult to obtain reliably. Ironically, asking someone to keep track of their behavior, perhaps especially eating behavior, often results in modification of typical patterns – the very patterns we are most interested in as researchers. For example, even though the word “binge” was never used in any part of the study, participants often provided the word unprompted in their exit interview, either in recognition of the true purpose of the study or in denying that they engaged in the behavior.

The study is also limited by the small sample size. The decision to treat participants’ daily data points as independent is partly a result of the limitations imposed by small sample size. One effect of treating observations as independent is a moderately

high intraclass correlation and therefore higher variance than would be found using repeated measures with a larger sample.

There also were some methodological issues which had an impact on data collection. Although told at the start of the study that they could complete the daily diary the next day if necessary, participants were encouraged to complete it each evening. As a result of these instructions, self-report items were subject to memory of the previous day for 25% of the data. This delay also likely had a negative influence on the reliability of the Stroop task and Two Choice Impulsivity Paradigm for half of the participants, who sometimes waited to complete the daily tasks. The actigraph instruments also presented minor problems: three participants apparently removed the device before bed some or all nights of the study, one of the actigraphs was lost while in the possession of a participant, and two units malfunctioned resulting in missing sleep data. With the exception of the lost unit, participants provided an additional week of data, minimizing the impact of the problems with the instruments.

A logical next step in this research would be to collect a larger sample and to modify the procedure to ensure more reliable and consistent data collection, especially of self-regulatory capacity. The question of the relationship between respiratory sinus arrhythmia and self-control would benefit from a larger age-matched sample. The study has uncovered some interesting connections between several factors that regulate the interval between binge eating events for people who use food and eating as a coping mechanism. The data suggest that mood and stress are predictors of binge eating behavior, and offer evidence of a link between sleep ratio and binge eating. From a prevention and therapeutic perspective, it seems a reasonable conclusion that people who

periodically binge eat would benefit from healthier means of obtaining restorative sleep and that both psychoeducation in sleep hygiene and stress reduction techniques could reduce binge eating behavior.

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Table 1: *List of Measures and Instruments*

Baseline Measures					
Variable	Construct	Reliability (α)	Mean	Std Dev	Appendix
PSQI	Sleep quality	0.77	8.17	3.23	E
PSS	Perceived stress	0.77	46.57	6.02	F
PANAS-X	Positive affect (Past few days)	0.91	2.56	0.80	G
	Negative affect (Past few days)	0.75	1.99	0.55	G
	Guilt (Past few days)	0.93	1.80	0.71	G
BSC	Self-control	0.74	2.76	0.54	H
BES	Binge eating	0.85	21.48	7.64	I
RSA	Stress responsiveness				K
EDR	Stress responsiveness				
Daily Measures					
PANAS-X	Positive affect (today)	0.92	2.35	0.83	G
	Negative affect (today)	0.71	1.52	0.41	G
	Guilt (today)	0.93	1.63	0.86	G
Self-Control	Self-Regulatory Capacity: mean of TCIP and Stroop		0.57	0.22	J
Sleep ratio	Time asleep : Time awake		5.83	5.29	
Total Stress	Subjective stress x Events		5.46	4.65	J
Eating events	Out of control eating		2.11	2.32	J

Table 2: *Baseline Correlations*

		Sleep Quality (PSQI)	Perceived Stress (PSS)	Positive Mood (PAN-P)	Negative Mood (PAN-N)	Guilt (PAN-G)	Self- Control (BSC)	Binge Eating (BES)
Sleep quality (PSQI)	<i>r</i>	1						
	Sig							
	<i>n</i>	23						
Perceived Stress (PSS)	<i>r</i>	0.30	1					
	Sig	0.17						
	<i>n</i>	23	23					
Positive Mood (PAN-P)	<i>r</i>	-0.17	-0.67**	1				
	Sig	0.45	<0.001					
	<i>n</i>	23	23	23				
Negative Mood (PAN-N)	<i>r</i>	0.08	0.55**	-0.49*	1			
	Sig	0.71	0.006	0.02				
	<i>n</i>	23	23	23	23			
Guilt (PAN-G)	<i>r</i>	0.07	0.60**	-0.39†	0.51*	1		
	Sig	0.74	0.002	0.06	0.01			
	<i>n</i>	23	23	23	23	23		
Self- Control (BSC)	<i>r</i>	-0.44*	-0.59**	0.52*	-0.29	-0.50*	1	
	Sig	0.04	0.003	0.01	0.18	0.02		
	<i>n</i>	23	23	23	23	23	23	
Binge Eating (BES)	<i>r</i>	0.08	0.55**	-0.43*	0.28	0.66**	-0.42*	1
	Sig	0.72	0.006	0.04	0.20	0.001	0.05	
	<i>n</i>	23	23	23	23	23	23	23

** Correlation is significant at the $p < 0.01$ level (2-tailed)

* Correlation is significant at the $p < 0.05$ level (2-tailed)

† Correlation is significant at the $p < 0.10$ level (2-tailed)

Table 3: *Daily Diary Correlations*

		Sleep Ratio	Stress Total	Positive Mood (PAN-P)	Negative Mood (PAN-N)	Guilt (PAN-G)	Self-Control	Binge Event
Sleep Ratio	<i>r</i>	1						
	Sig							
	<i>n</i>	142						
Stress Total	<i>r</i>	0.27**	1					
	Sig	0.001						
	<i>n</i>	141	160					
Positive Mood (PAN-P)	<i>r</i>	-0.16 [†]	-0.16*	1				
	Sig	0.06	0.042					
	<i>n</i>	141	160	160				
Negative Mood (PAN-N)	<i>r</i>	0.19*	0.32**	-0.13	1			
	Sig	0.02	<0.001	0.11				
	<i>n</i>	141	160	160	160			
Guilt (PAN-G)	<i>r</i>	0.46**	0.25**	-0.37**	0.68**	1		
	Sig	<0.001	0.001	<0.001	<0.001			
	<i>n</i>	141	160	160	160	160		
Self-Control	<i>r</i>	0.07	0.16 [†]	-0.13	0.07	0.25**	1	
	Sig	0.49	0.09	0.15	0.44	0.006		
	<i>n</i>	107	121	121	121	121	160	
Binge Event	<i>r</i>	0.19*	0.26**	-0.36**	0.41**	0.46**	0.07	1
	Sig	0.03	0.001	<0.001	<0.001	<0.001	0.42	
	<i>n</i>	142	160	160	160	160	121	160

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

[†] Correlation is significant at the 0.10 level (2-tailed)

Table 4: *Standardized Direct, Indirect, Total Effects of Factors on Binge Eating*

Baseline Data		Mood Predicts Stress			Stress Predicts Mood		
<u>Variable</u>	<u>Direct</u>	<u>Indirect</u>	<u>Total</u>	<u>Direct</u>	<u>Indirect</u>	<u>Total</u>	
BSC	-0.05	--	-0.05	-0.05	--	-0.05	
PANAS-G	0.49*	0.16	0.65*	0.49*	--	0.49*	
PSS	0.24	0.03	0.27	0.24	0.34 [†]	0.58**	
PSQI.G	-0.05	0.13	0.08	-0.05	0.13	0.08	
Daily Diary Data		Mood Predicts Stress			Stress Predicts Mood		
<u>Variable</u>	<u>Direct</u>	<u>Indirect</u>	<u>Total</u>	<u>Direct</u>	<u>Indirect</u>	<u>Total</u>	
Self-Control	-0.04	--	-0.04	-0.04	--	-0.04	
PANAS-G	0.46**	0.03	0.48**	0.46**	--	0.46**	
Stress Total	0.21**	-0.01	0.20*	0.21**	0.04	0.25**	
Sleep Ratio	-0.14	0.28**	0.14 [†]	-0.14	0.28**	0.14 [†]	

** Significant at the $p < 0.01$ level (2-tailed, bias corrected)

* Significant at the $p < 0.05$ level (2-tailed, bias corrected)

[†] Significant at the $p < 0.10$ level (2-tailed, bias corrected)

Table 5: *Model Fit Statistics for Path Models*

Model	χ^2	p	SRMR	CFI	TLI	RMSEA (90% CI)
Baseline	1.97	0.16	0.05	0.96	0.68	0.21 (0.0 – 0.65)
Diary	2.30	0.13	0.03	0.98	0.74	0.09 (0.0 – 0.27)

Note: No differences in fit for mood predicts stress vs. stress predicts mood.

Appendix A

Sample advertising text

ELIGIBLE PARTICIPANTS CAN EARN UP TO \$80

RESEARCH STUDY



Do you use food to cope with the stress of daily life?

Do you ever feel like you are unable to control your eating once you get started?

If so, you may be eligible to participate in a research study examining eating and sleep patterns of people who use food as a tool to cope with stress.



SOCIAL PSYCHOLOGY RESEARCH
PROTOCOL # B13-066

To participate you must be:

- Age 18 or older
- A non-smoker
- Willing to commit to a seven day study and two 1-hour lab visits

For more information about this study, send an email with the words "Factors Study" in the subject line to sbrl@uvm.edu

Or complete a confidential, on-line survey at:
<http://tinyurl.com/factorstudy> to see if you qualify!

Research Study:

Email SBRL@uvm.edu or visit <http://tinyurl.com/factorstudy>

- Stress & Eating Research Study
Email SBRL@UVM.edu
<http://tinyurl.com/factorstudy>
- Stress & Eating Research Study
Email SBRL@UVM.edu
<http://tinyurl.com/factorstudy>
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- Stress & Eating Research Study
Email SBRL@UVM.edu
<http://tinyurl.com/factorstudy>

Appendix B

Informed Consent

Title of Research Project: Factors in the regulation of eating behaviors

Principal Investigator: Andrew Knapp, MA

Faculty Sponsor: Carol T. Miller, Ph.D.

You are being invited to take part in this research study because you are an adult at least 18 years of age and have indicated that you use food to cope with stress.

The study is being conducted by researchers in the Department of Psychology at the University of Vermont. You are encouraged to ask questions and have discussions with anyone who you feel can help you make an informed decision about whether you should participate in this study. The information provided on this form and by the Principal Investigator should also help you decide whether you would like to freely and voluntarily choose to participate.

Why is this research being conducted?

We are interested in sleeping and eating patterns among people who use food as a coping mechanism. This research may be used to inform professionals in the health care and mental health fields regarding sleeping and eating patterns. The results of this study may help professionals develop a better understanding of how to increase healthy behaviors especially in people who use food to cope with stress.

How many people will take part in the study?

Approximately 30 men and women will take part in the study.

What is involved in the study?

Initial Screening (via telephone/on-line): Prior to your arrival at the lab today, you participated in an initial screening via telephone or by completing an on-line screening and you meet the eligibility requirements for the study. The information collected during the initial screening may be used as part of this study.

First Lab Visit (today): Today we will take some preliminary measurements. We expect that this session will take less than an hour. We will measure the regularity of your heart beat, your skin conductance, height, and weight. Skin conductance is a measure of your responsiveness to anxiety. You will watch a short video while we take the measurement. We are interested in the variability of your heart beat because it is an indicator of your general stress level. You will also fill out some questionnaires asking about your mood, sleep history, eating behaviors and levels of stress and stigma. We will give you instructions for completing a daily on-line diary and fit you with a motion monitor which we would like you to wear for the duration of the study (i.e., for the next seven days). The motion monitor is designed to record your movement, particularly when you are sleeping. It is waterproof and requires no special care or attention on your part. There may be times you wish to remove the device for a short time. You are free to do so, of course. We would simply ask that you remember to put it on again and also take note of when the device

was not being worn. At the end of the study you will return the device to us and we will download the data stored on it. This data is vitally important to our study, so if you feel you are not able to commit to wearing the device and returning it at the end of the study you may wish to reconsider your participation in the study. If you encounter any problems with the device, please contact the Principal Investigator as soon as practicable (see contact information below).

For the next 7 days: For the next seven days you will go about your normal daily activities. Sometime each evening or night you will log on to the daily diary and complete the measures you will find there. There will be two game-like activities (which you will also see today), and space to record specifics about your last night's sleep, your food intake/meals for the day, general stress, and any incidents of discrimination. We expect that completion of the daily diary will take less than one hour. If you miss a day, you can enter the information the next day by logging in once for the previous day, logging off, and logging back in for the current day. We ask that you do your best to complete the daily diary at the end of each day so that the day's events are fresh in your mind.

Final lab visit: At the end of the seven days, we ask that you return to the lab to return the motion monitor and participate in an interview regarding your experiences during the week. With your permission we will record this interview and later transcribed for research purposes. We will also provide you more information about the study. The final lab visit is expected to take approximately 30 minutes. In the event that you are unable to complete the study for any reason the Principal Investigator will arrange a time and place to pick up the motion monitor device at your convenience. If prior commitments or scheduling difficulties delay the final visit, it can be scheduled for a later date. Monitoring and diary completion, however, will cease after 7 days.

What are the risks and discomforts of the study?

Participating in the study presents minimal risks. There is a chance that the motion monitor will become a nuisance or be uncomfortable. If that occurs you are urged to contact the Principal Investigator to discuss the issues.

Answering some of the questions regarding sleep, stress, stigma, and eating habits may feel intrusive or make you feel uncomfortable. Your answers will be kept completely confidential, so we encourage you to answer honestly. You do not have to answer any questions that you do not feel comfortable answering. The Principal Investigator will be available to meet with you to discuss any concerns that you might have. In addition, we will provide references to professionals for you should you find that the study has revealed issues with sleep, eating, or stress that might benefit from a therapeutic intervention.

Although every effort will be made to protect your confidentiality, the risk for accidental breach of confidentiality cannot be eliminated. You are also free to discontinue your participation at any time by contacting the Principal Investigator. We ask that you return the motion monitor and arrangements will be made to pick it up at your convenience.

What are the benefits of participation in the study?

You may not benefit directly from your participation in the study. Your responses to the questionnaires, information on your eating and sleeping behaviors and other data collected from you during the study will add to our understanding of the relationships between stress, eating and

sleep. This improved understanding may lead to better treatment for people struggling with issues related to these factors.

What other options are there?

At present there are two studies with similar purposes being conducted in the Psychology Department at the University of Vermont. You may be a better fit for the other study. If so, the principal investigator will inform you of that fact so that you can choose which study to participate in. It is also possible that you could participate in both studies.

Are there any costs?

There are no costs for you to participate in the study other than your time and effort.

What is the compensation?

Participants will receive \$5 for each of two lab visits plus \$10 for each day of the 7-day study for a possible total of \$80. The compensation will be made in the form of a check paid at the completion of your participation. Participants are required by the University of Vermont to provide their social security number for accounting purposes prior to being paid. Your social security number, as well as all of the data we collect from you will be kept completely confidential at all times.

Can you withdraw or be withdrawn from the study?

You may discontinue your participation in the study at any time by contacting the principal investigator and returning the motion monitoring device. In the event that you do not complete the seven days of the study, we may use any completed data up to the point that you discontinue your participation. The Principal Investigator reserves the right to determine the validity of data collected and may choose to discard some or all of the data you provide.

What about confidentiality?

We are very sensitive to the fact that the information you are providing us is personal. All information you provide as part of this study will be confidential and will be protected to the fullest extent provided by law. Information that you provide and other records related to this study will only be accessible to those persons directly involved in the study. All of the data will be stored in a password-protected digital format accessible only to the Principal Investigator and his faculty advisor.

Your research data will be collected, assessed, and maintained separately from your signed consent form, and your contact information. All forms with contact or other personal information will be kept in a locked file cabinet in our locked laboratory space. All other survey data will be labeled with a randomly assigned participant number, so your name will not be attached to your data.

If you consent to digital audio recordings of your end-of-study interview, any recordings will be destroyed after they are transcribed into electronic form. Potentially identifying information (e.g., names, places, etc.) will not be part of the permanent transcriptions. You will be identified only by your participant number on the transcriptions.

Contact Information:

You may contact Andrew Knapp, the Principal Investigator at (802) 355-6402 or his supervisor, Dr. Carol T. Miller at (802) 656-4158 for more information about this study. If you have questions about your rights as a participant in a research project or for more information on how to proceed should you believe that you have been injured as a result of your participation in this study, you may contact Nancy Stalnaker, the Director of the Research Protections Office at the University of Vermont at (802) 656-5040.

Statement of consent:

You have been given and have read or have had read to you a summary of this research study. Should you have any further questions about the research, you may contact the person conducting the study at the address and phone number given below. Your participation is voluntary and you may refuse to participate or withdraw at any time without penalty or prejudice.

You agree to participate in this study and you understand that you will be given a signed copy of this consent form.

This form is only valid if the Committees on Human Research current stamp of approval is shown below.

Please check one:

Yes, you may digitally record the end-of-study interview.

No, you may not digitally record the end-of-study interview.

Signature of Participant

Date

Name of Participant Printed

Signature of Principal Investigator or Designee

Date

Name of Principal Investigator or Designee Printed

Principal Investigator: Andrew Knapp, MA
Department of Psychology
University of Vermont
John Dewey Hall, 2 Colchester Ave
Burlington, VT 05405-0134
Phone: (802) 355-6402

Supervisor: Carol T. Miller, Ph.D.
Department of Psychology
University of Vermont
John Dewey Hall, 2 Colchester Ave
Burlington, VT 05405-0134
Phone: (802) 656-4158

Appendix C

Exclusion Criteria and Lime Survey Self-Screening

Exclusion criteria

- Adult Males, and Females who are not currently pregnant
- Between the ages of 18 and 70
- Not currently using appetite suppressants
- No diagnosis of clinical depression, anxiety, agoraphobia
 - Or with a diagnosis controlled with use of prescription medication in use for more than 30 days
 - Not currently treated with prescription benzodiazepines
- No diagnosis of sleep-related disorder (e.g. apnea)
- Non-smoker
- No to moderate use of alcohol
- No use of a prescription or OTC sleep aid in the past 30 days
- No diagnosis of bulimia nervosa or anorexia nervosa

Lime Survey Program for Self-Screening

NOTE: Items in [] are variables and/or calculations used by Lime Survey

The following confidential screening survey will determine your eligibility to participate in a 7-day study of adult sleeping and eating patterns.

Thank you for your interest in participating in our research study sponsored by the Psychology Department at the University of Vermont. Please read the information that follows before going on; it contains important information about the purpose of the study, what is involved if you qualify for the study, the risks, benefits and confidentiality measures, so you are informed. Your consent to answer these screening questions is implied upon the completion of this survey. If you qualify, you will be required to read and sign a consent document before the start of your actual participation.

Why is this study being conducted? We are interested in sleeping and eating patterns among people who use food as a coping mechanism. This research may be used to inform professionals in the health care and mental health fields regarding sleeping and eating patterns. The results of this study may help professionals develop a better understanding of how to increase healthy behaviors especially in people who use food to cope with stress.

How many people will take part in the study? Approximately 30 women and men will take part in the study. You must be at least 18 years old to participate.

What is involved in the study? There are four parts to the study. Part one is the part you are now reading, the initial screening to determine eligibility, which will take approximately 15 minutes to complete. Should you qualify, part two is a lab visit of approximately one hour where you will meet with the Principal Investigator who will explain the study and give you a consent document to read and sign. If you agree to participate, you will then complete a few computerized surveys, and have some physiological measurements taken (heart rate, for example). The third part consists of a seven-day monitoring period during which we will keep track of your sleep patterns using a motion detector that you will wear for the seven days of the study. During this phase you will also complete a daily diary where you will record stressful events, answer questions about your sleep and eating, and complete a pair of computerized tasks related to the study. The time requirement for part three is estimated to be an hour per day or less, for a total of approximately 7 hours. In part four you will make another short visit (one hour or less) to the lab where you will be interviewed regarding your participation. We will collect the motion detector at that time and you will be compensated for your participation. Your total time commitment for the entire study is expected to be 9 hours.

What are the risks and discomforts of the screening process? Participating in this computerized screening presents minimal risk. Some of the questions are sensitive and personal in nature, but are required for the purposes of the study. Because we are trying to determine your eligibility you cannot skip any questions. You can, of course, choose not to complete the screening. We are very concerned about your privacy and will keep anything you reveal to us completely confidential. The online screening survey is operating on a secure network. You may at any time stop taking the screening by simply closing your browser window. Doing so will result in our deleting any answers you provided up to the point when you stopped answering, including your name. You may also complete the screening in more than one sitting by selecting the "save for later" block located on each page of the screening survey. If you complete the screening and don't qualify for the study, we will only retain your name and the fact that you did not qualify - the specific answers to the questions you entered will not be saved. If you do qualify, we will keep your answers to the screening questions as they may provide data relevant to the purposes of the study.

What are the benefits of participating in the study? You may not benefit directly from your participation in the study. Should you qualify to participate in the study, your responses to the questionnaires, information on your eating and sleeping behaviors and other data collected from you during the study will add to our understanding of the relationships between stress, eating and sleep. This improved understanding may lead to better treatment for people struggling with issues related to these factors. While you may not benefit directly, your participation will contribute to our understanding of people in situations similar to yours.

What other options are there? At present there are two studies with similar purposes being conducted in the Psychology Department at the University of Vermont. You may be a better fit

for the other study. If so, the principal investigator will inform you of that fact so that you can choose which study to participate in. It is also possible that you could participate in both studies.

Are there any costs? There are no costs to you for participating in the study other than your time and effort, and possibly transportation to the lab site.

What is the compensation? You will be compensated at the rate of \$5 for each of the two lab visits plus \$10 per day for the 7 days of your participation for a possible total of \$80. The compensation will be made in the form of a check paid at the completion of your participation. Participants are required by the University of Vermont to provide their social security number for accounting purposes prior to being paid. Your social security number as well as all of the data we collect from you will be kept completely confidential at all times. If you choose to stop your participation prior to the seventh day, you will be paid for the days that you completed. There is no compensation for completing the screening phase.

Can you withdraw or be withdrawn from this screening phase of the study? You may discontinue your participation in this screening at any time by simply closing your browser window. In the event that you do not complete the screening, we will not save any of the information you provided, including your name. In order to be considered for participation you must complete the screening, however. Assuming you qualify, you may also choose to discontinue your participation in the study at any time by contacting the Principal Investigator and arranging for the return of the study equipment.

What about confidentiality? The survey program, called Lime Survey assigns a unique ID to each person who starts the survey. We will also ask for your name, email address, and phone number if you qualify for the study so that we can contact you to set up your first lab visit. The data collected from the screening survey is stored at the web location scripts.uvm.edu. The data is password protected, and is encrypted with high grade encryption (AES-256, 256 bit). This encryption makes it difficult for unauthorized people to view information traveling between computers and/or over a network. The screening survey is confidential. However, we cannot guarantee that the secure storage will not be hacked or otherwise compromised. We believe that the security measures in place utilize the maximum security available to us. The results of this study may eventually be published, but your answers will only appear in aggregate form with other participants' responses. That is, your individual answers will not be published, but will be combined with other participants' responses to report an overall picture of the data collected from this study. For example, your responses may be grouped with those of other participants who share your gender, or your ethnicity, or age. Or, your responses may be grouped with others' who share your attitudes, beliefs, and habits.

Contact Information: You may contact the Principal Investigator, Andrew Knapp at fknapp@uvm.edu. If you have questions about your rights as a participant in a research project or for more information on how to proceed should you believe that you have been injured as a result of your participation in this study you should contact Nancy Stalnaker, the Director of the Research Protections Office at the University of Vermont at (802) 656-5040.

STATEMENT OF CONSENT: You have read the preceding descriptions and information and agree to undergo the screening procedure that follows. You understand that you may stop at any time by simply closing your browser window and that any answers you provide are strictly confidential. Should you have any questions regarding this screening procedure you may contact the Principal Investigator at the email address shown above.

Continuing with the screening survey at this time by clicking "NEXT" implies your consent.

There are 43 questions in this survey

Screening Questions

This section contains the screening questions used to determine eligibility for the study.

1 [Name] Please enter your first and last name.

Please write your answer(s) here:

First?

Last?

2 [Sex] What is your sex, [participant's first name inserted by program]?

Please choose only one of the following:

Female

Male

3 [Age] How old are you?

[Each answer must be at least fixnum(18)]

Please write your answer here:

4 [Height] The last time you checked, what was your height, [participant's first name inserted by program]?

[Each answer must be at most fixnum(11)]

Please write your answer(s) here:

Feet?

Inches?

5 [Height_inches](Height_SQ1*12)]

6 [Height_total](Height_inches + Height_SQ2)]

7 [Weight] What is your weight in pounds?

[Each answer must be between fixnum(50) and fixnum(500)]

Please write your answer here:

8 [BMI](Weight/(Height_total * Height_total))*703]

9 [Birth] Have you ever given birth to a child or been pregnant?

[Only ask this question if the following conditions are met:]

[Sex == "F"]

Please choose only one of the following:

Yes

No

10 [Pregnant] Are you pregnant now, [participant's first name inserted by program]?

[Only ask this question if the following conditions are met:]

[Birth == "Y"]

Please choose only one of the following:

Yes

No

11 [Dieting] Are you currently trying to lose weight by dieting or other methods?

Please choose only one of the following:

Yes

No

12 [Suppressants] Do you regularly use an over-the-counter or prescription appetite suppressant?

[Only ask this question if the following conditions are met:]

[Dieting == "Y"]

Please choose only one of the following:

Yes

No

13 [Depression] Have you ever been diagnosed with major depressive disorder, or clinical depression?

Please choose only one of the following:

Yes

No

14 [Dep_Drug] Is your depression treated with a prescription medication, [participant's first name inserted by program]?

[Only ask this question if the following conditions are met:]

[Depression == "Y"]

Please choose only one of the following:

Yes

No

15 [Dep_Drug_Dur] Have you been taking the medication at the current dose for at least one month?

[Only ask this question if the following conditions are met:]

[Dep_Drug == "Y"]

Please choose only one of the following:

Yes

No

16 [Anxiety] Have you ever been diagnosed with an anxiety disorder or agoraphobia?

Please choose only one of the following:

Yes

No

17 [Anx_Drug] Is your anxiety treated with a prescription medication, [participant's first name inserted by program]?

[Only ask this question if the following conditions are met:]

[Anxiety == "Y"]

Please choose only one of the following:

Yes

No

18 [Anx_Drug_Dur] Have you been taking the anxiety medication at the same dose for at least one month?

[Only ask this question if the following conditions are met:]

[Anx_Drug == "Y"]

Please choose only one of the following:

Yes

No

19 [Anx_Drug_How] Do you take your anxiety medication daily or only as needed?

[Only ask this question if the following conditions are met:]

[Anx_Drug == "Y"]

Please choose only one of the following:

Daily or multiple times per day

As needed

20 [Anx_Drug_Which] Is the prescription drug you take for anxiety on this list, [participant's first name inserted by program]?

Valium

Xanax
Serax
Ativan
Klopidin
Estazolam
Flurazepam
Doral
Restoril
Halcion

[Only ask this question if the following conditions are met:]

[Anx_Drug == "Y"]

Please choose only one of the following:

Yes

No

21 [Anx_Drug_Specify] If you know the name of the prescription drug you take, please type it in below. If you don't know the name of the drug off hand, you may leave the block blank and continue. If you qualify for the study the researcher will ask you for the name of the drug at your first lab visit.

[Only ask this question if the following conditions are met:]

[Anx_Drug == "Y", Anx_Drug_Which == "N"]

Please write your answer here:

22 [Diabetes] Do you currently have a diagnosis of Diabetes controlled with insulin?

Please choose only one of the following:

Yes

No

23 [Apnea_Susp] Do you suspect or has a sleep partner ever indicated that you may have sleep apnea?

Please choose only one of the following:

Yes

No

24 [Apnea] Have you ever been diagnosed with sleep apnea and do you use a CPAP machine or similar device when you sleep?

[Only ask this question if the following conditions are met:]

[Apnea_Susp == "Y"]

Please choose only one of the following:

Yes

No

25 [Cigarettes] Do you currently smoke cigarettes, cigars, or use any tobacco products?

Please choose only one of the following:

Yes

No

26 [Eating] Have you ever had a diagnosis and/or are you currently being treated for an eating disorder such as bulimia nervosa or anorexia nervosa?

Please choose only one of the following:

Yes

No

27 [Sleep] Do you regularly use an over-the-counter or prescription sleep aid?

Please choose only one of the following:

Yes

No

28 [Sleep_drug] If you use a prescription sleep aid is the medication you use on this list?

Valium

Xanax

Serax

Ativan

Klopidin

Estazolam

Flurazepam

Doral

Restoril

Halcion

[Only ask this question if the following conditions are met:]

[Sleep == "Y"]

Please choose only one of the following:

Yes

No

29 [Sleep_freq] Do you use the sleep aid less often than once a month?

[Only ask this question if the following conditions are met:]

[Sleep == "Y"]

Please choose only one of the following:

Yes

No

30 [Sleep_last] Has it been at least a month since you last used the prescription or over-the-counter sleep aid to get to sleep?

[Only ask this question if the following conditions are met:]

[Sleep == "Y"]

Please choose only one of the following:

Yes

No

31 [BES_A] Do you ever feel that you can't control what or how much you eat?

Please choose only one of the following:

Yes

No

32 [BES_B] Do you often eat, within any 2-hour period, what most people would regard as an unusually large amount of food, [participant's first name inserted by program]?

Please choose only one of the following:

Yes

No

33 [BES_C] Has this been as often, on average, as once a week or more for at least the last three months?

[Only ask this question if the following conditions are met:]

[BES_B == "Y" or BES_A == "Y"]

Please choose only one of the following:

Yes

No

34 [BES_E] In the last 3 months have you often done any of the following in order to avoid gaining weight [participant's first name inserted by program]?

Please choose all that apply:

Made yourself vomit?

Took more than twice the recommended dose of a laxative?

Fasted by not eating anything at all for at least 24 hours?

Exercised strenuously for more than an hour specifically to avoid weight gain after overeating?

I have not done any of these things in the last 3 months.

35 [ETOH1] Do you ever drink alcohol in any form (including beer and/or wine)?

Please choose only one of the following:

Yes

No

36 [ETOH2] In the past month, have you ever drunk alcohol even though a doctor suggested you stop drinking because of a problem with your health?

[Only ask this question if the following conditions are met:]

[ETOH1 == "Y"]

Please choose only one of the following:

Yes

No

37 [ETOH3] In the past month, have you used alcohol as a way to get to sleep, [participant's first name inserted by program]?

[Only ask this question if the following conditions are met:]

[ETOH1 == "Y"]

Please choose only one of the following:

Yes

No

38 [DQEQ]if(BMI >= "35", "0", if(Pregnant == "Y", "0", if(Suppressants == "Y", "0", if(Dep_Drug_Dur == "N", "0", if(Anx_Drug_Dur == "N", "0", if(Anx_Drug_Which == "Y", "0", if(Diabetes == "Y", "0", if(Apnea == "Y", "0", if(Cigarettes == "Y", "0", if(Eating == "Y", "0", if(Sleep_drug == "Y", "0", if(Sleep_freq == "N", "0", if(Sleep_last == "N", "0", if(BES_A == "N" and BES_B == "N", "0", if(BES_C == "N", "0", if(ETOH2 == "Y", "0", "1"))))))))))))))))

39 [DQ] Please send an email to SBRL@uvm.edu to find out if you qualify [participant's first name inserted by program]. I will review your answers and let you know if you are eligible. As stated at the start of this survey, if you do not qualify we will not save any of the data you provided here. Your confidentiality is important to us and we will not share or reveal any of the information we collect.

You may [if(DQEQ=="0", "qualify", "also qualify")] for another study sponsored by the Psychology Department at the University of Vermont. To find out, please contact "Eating Study" at www.uvm.edu/~eating or call (802) 656-9890.

40 [eMail] If you qualify for our study we need a way to get in touch with you. If you want me to contact you instead of sending an email to SBRL@uvm.edu, please enter your email address below.

Please write your answer(s) here:

Enter email address

Re-enter email address

41 [Phone] If you would prefer to be contacted by phone, please enter your phone number (including area code) below. Please use this format: ###-###-####

[Only ask this question if the following conditions are met:]

[DQEQ == "1"]

Please write your answer here:

42 [Msg] Is it OK for us to leave you a voice message about scheduling your participation in our study?

[Only ask this question if the following conditions are met:]

[DQEQ == "1"]

Please choose only one of the following:

Yes

No

43 [Phone_when] Please let us know the best time to call you to set up your first lab visit.

[Only ask this question if the following conditions are met:]

[DQEQ == 1]

Please write your answer(s) here:

Please call me between the hours of

And

Thank you for your time and input. The principal investigator will review your answers and contact you at the email address you provided to tell you whether you are eligible. If you are eligible, you will be contacted within the next few days to set up an appointment for your first lab visit. If you do not qualify for this study we invite you to contact the Eating Study at www.uvm.edu/~eating and/or calling (802) 656-9890 to set up an appointment with them. If you have questions regarding the screening procedure and the specific reasons you did not qualify, please contact the Principal Investigator (Andrew Knapp) at fknapp@uvm.edu

Submit your survey.

Thank you for completing this survey.

Appendix D

Scheduling Script

Hello is this _____? My name is Andy Knapp. I'm calling from the Social Behaviors Research Lab at the University of Vermont. I would like to tell you some more about my study and schedule your first of two lab visits. Is this a good time to talk? I'll be reading this, so it might sound a little weird.

The study is examining stress, sleep, and eating patterns in people who use food as a coping tool. The first lab visit serves several purposes. First I want to meet you and personally explain the study to you. You will have a chance to give your consent to everything we will be asking you and also have any questions you have about the study answered.

First I will collect your height and weight. Since I am interested in how people respond to stress I will be making measurements using instruments that measure your stress response. Have you ever had an electrocardiogram at a doctor's office or in the hospital? That's where electrodes are attached to your chest and an instrument measures your heart beat. I will be collecting that kind of data from you during your first lab visit. Unlike at the doctor's office, you'll be fully clothed and sitting in a chair while we take the readings. I will have you attach the electrodes in privacy after I show you how. I will be making a measurement of your breathing with an instrument that you wear like a belt under your armpits and how your skin responds to stress by attaching a couple of sensors to your fingers. The measurements are painless but do take a few minutes to set up.

After those measurements are completed, I will demonstrate a daily diary website. Every evening during the 7 day monitoring period you'll be asked to log in and answer questions about your day, the level of stress, when and how you slept the previous night, and a to give a general report of meals and snacks you had. There are also two game-like tasks that you will complete each evening. The daily diary takes around 15 or 20 minutes per day. I will also fit you with a motion monitor that will help me to determine your level of activity during the day and also provides data on your sleep. You wear it like a wrist watch. You will be asked to wear the device pretty much all the time for 7 days. Would that be acceptable to you?

Do you have any questions so far? OK, so can we schedule your lab visit? Because I share the lab our available times are limited to Tuesday and Thursday mornings between 9 and 11 am. I can also do any time on Sundays. I could do (day, date, time)

The lab meeting takes around ninety minutes. What time would work best for you?

Do you have any questions about your appointment? I will send you an email with the address. You will be able to park here when you arrive and I will meet you at the back door. OK, so I will see you on _____ at _____

Appendix E

The Pittsburgh Sleep Quality Index

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, what time have you usually gone to bed at night?

BED TIME _____

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

NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

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 spent 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	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

- b) Wake up in the middle of the night or early morning

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

c) Have to get up to use the bathroom

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

d) Cannot breathe comfortably

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

e) Cough or snore loudly

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

f) Feel too cold

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

g) Feel too hot

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

h) Had bad dreams

Not during the past month	_____	Less than once a week	_____	Once or twice a week	_____	Three or more times a week	_____
---------------------------------	-------	-----------------------------	-------	----------------------------	-------	----------------------------------	-------

i) Have pain

Not during the past month	_____	Less than once a week	_____	Once or 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 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 to help you sleep) prescribed or “over the counter”)?

Not during the past month	_____	Less than once a week	_____	Once or 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 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 _____

Appendix F

Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein; 1983)

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate. For each question choose from the following alternatives:

0. Never
1. Almost never
2. Sometimes
3. Fairly often
4. Very often

1. In the last month, how often have you been upset because of something that happened unexpectedly?
2. In the last month, how often have you felt that you were unable to control the important things in your life?
3. In the last month, how often have you felt nervous and "stressed"?
4. * In the last month, how often have you dealt successfully with irritating life hassles?
5. * In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?
6. * In the last month, how often have you felt confident about your ability to handle your personal problems?
7. * In the last month, how often have you felt that things were going your way?
8. In the last month, how often have you found that you could not cope with all the things that you had to do?
9. * In the last month, how often have you been able to control irritations in your life?
10. * In the last month, how often have you felt that you were on top of things?
11. In the last month, how often have you been angered because of things that happened that were outside of your control?
12. In the last month, how often have you found yourself thinking about things that you have to accomplish?
13. * In the last month, how often have you been able to control the way you spend your time?
14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

* Scored in the reverse direction.

Appendix G

Positive and Negative Affect Scale (PANAS-X; Watson, et al, 1988, 1994)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent [INSERT APPROPRIATE TIME INSTRUCTIONS HERE]. Use the following scale to record your answers.

1 very slightly or not at all	2 a little	3 moderately	4 quite a bit	5 extremely
_____ cheerful	_____ sad	_____ active	_____ angry at self	
_____ disgusted	_____ calm	_____ guilty	_____ enthusiastic	
_____ attentive	_____ afraid	_____ joyful	_____ downhearted	
_____ bashful	_____ tired	_____ nervous	_____ sheepish	
_____ sluggish	_____ amazed	_____ lonely	_____ distressed	
_____ daring	_____ shaky	_____ sleepy	_____ blameworthy	
_____ surprised	_____ happy	_____ excited	_____ determined	
_____ strong	_____ timid	_____ hostile	_____ frightened	
_____ scornful	_____ alone	_____ proud	_____ astonished	
_____ relaxed	_____ alert	_____ jittery	_____ interested	
_____ irritable	_____ upset	_____ lively	_____ loathing	
_____ delighted	_____ angry	_____ ashamed	_____ confident	
_____ inspired	_____ bold	_____ at ease	_____ energetic	
_____ fearless	_____ blue	_____ scared	_____ concentrating	
_____ disgusted with self	_____ shy	_____ drowsy	_____ dissatisfied with self	

This study used PANAS-X with the following time instructions:

Today (you have felt this way today)

Past Few Days (you have felt this way during the past few days)

Appendix H

Brief Self-Control Scale (Tangney et al., 2004)

Using the scale provided, please indicate how much each of the following statements reflect how you typically are.

	Not at all			Very Much	
1. I am good at resisting temptation.	1	2	3	4	5
2R. I have a hard time breaking bad habits.	1	2	3	4	5
3R. I am lazy.	1	2	3	4	5
4R. I say inappropriate things.	1	2	3	4	5
5R. I do certain things that are bad for me, if they are fun.	1	2	3	4	5
6. I refuse to do things that are bad for me.	1	2	3	4	5
7R. I wish I had more discipline.	1	2	3	4	5
8. People would say I have iron self-discipline.	1	2	3	4	5
9R. Pleasure and fun sometimes keep me from getting work done.	1	2	3	4	5
10R. I have trouble concentrating.	1	2	3	4	5
11. I am able to work effectively toward long-term goals.	1	2	3	4	5
12R. Sometimes I can't stop myself from doing something, even if I know it is wrong.	1	2	3	4	5
13R. I often act without thinking through all the alternatives.	1	2	3	4	5

Appendix I

Binge Eating Scale (BES; Gormally et al.; 1982)

Eating Habits Checklist

Instructions: Below are groups of numbered statements. Read all of the statements in each group and mark on this sheet the one that best describes the way you feel about the problems you have controlling your eating behavior.

#1

1. I don't feel self-conscious about my weight or body size when I'm with others.
2. I feel concerned about how I look to others, but it normally does not make me feel disappointed with myself.
3. I do get self-conscious about my appearance and weight which makes me feel disappointed in myself.
4. I feel very self-conscious about my weight and frequently, I feel intense shame and disgust for myself. I try to avoid social contacts because of my self-consciousness.

#2

1. I don't have any difficulty eating slowly in the proper manner.
2. Although I seem to "gobble down" foods, I don't end up feeling stuffed because of eating too much.
3. At times, I tend to eat quickly and then, I feel uncomfortably full afterwards.
4. I have the habit of bolting down my food, without really chewing it. When this happens I usually feel uncomfortably stuffed because I've eaten too much.

#3

1. I feel capable to control my eating urges when I want to.
2. I feel like I have failed to control my eating more than the average person.
3. I feel utterly helpless when it comes to feeling in control of my eating urges.
4. Because I feel so helpless about controlling my eating I have become very desperate about trying to get in control.

#4

1. I don't have the habit of eating when I'm bored.
2. I sometimes eat when I'm bored, but often I'm able to "get busy" and get my mind off food.
3. I have a regular habit of eating when I'm bored, but occasionally, I can use some other activity to get my mind off eating.
4. I have a strong habit of eating when I'm bored. Nothing seems to help me break the habit.

#5

1. I'm usually physically hungry when I eat something.
2. Occasionally, I eat something on impulse even though I really am not hungry.
3. I have the regular habit of eating foods, that I might not really enjoy, to satisfy a hungry feeling even though physically, I don't need food.

4. Even though I'm not physically hungry, I get a hungry feeling in my mouth that only seems to be satisfied when I eat a food, like a sandwich, that fills my mouth. Sometimes, when I eat the food to satisfy my mouth hunger, I then spit the food out so I won't gain weight.

#6

1. I don't feel any guilt or self-hate after I overeat.
2. After I overeat, occasionally I feel guilt or self-hate.
3. Almost all the time I experience strong guilt or self-hate after I overeat.

#7

1. I don't lose total control of my eating when dieting even after periods when I overeat.
2. Sometimes when I eat a "forbidden food" on a diet, I feel like I "blew it" and eat even more.
3. Frequently, I have the habit of saying to myself, "I've blown it now, why not go all the way" when I overeat on a diet. When that happens I eat even more.
4. I have a regular habit of starting strict diets for myself, but I break the diets by going on an eating binge. My life seems to be either a "feast" or "famine."

#8

1. I rarely eat so much food that I feel uncomfortably stuffed afterwards.
2. Usually about once a month, I eat such a quantity of food, I end up feeling very stuffed.
3. I have regular periods during the month when I eat large amounts of food, either at mealtime or at snacks.
4. I eat so much food that I regularly feel quite uncomfortable after eating and sometimes a bit nauseous.

#9

1. My level of calorie intake doesn't go up very high or go down very low on a regular basis.
2. Sometimes after I overeat, I will try to reduce my caloric intake to almost nothing to compensate for the excess calories I've eaten.
3. I have a regular habit of overeating during the night. It seems that my routine is not to be hungry in the morning but overeat in the evening.
4. In my adult years, I have had week-long periods where I practically starve myself. This follows periods when I overeat. It seems I live a life of either "feast" or "famine."

#10

1. I usually am able to stop eating when I want to. I know when "enough is enough."
2. Every so often, I experience a compulsion to eat which I can't seem to control.
3. Frequently, I experience strong urges to eat which I seem unable to control, but at other times I can control my eating urges.
4. I feel incapable of controlling urges to eat. I have a fear of not being able to stop eating voluntarily.

#11

1. I don't have any problem stopping eating when I feel full.

2. I usually can stop eating when I feel full but occasionally overeat leaving me feeling uncomfortably stuffed.
3. I have a problem stopping eating once I start and usually I feel uncomfortably stuffed after I eat a meal.
4. Because I have a problem not being able to stop eating when I want, I sometimes have to induce vomiting to relieve my stuffed feeling.

#12

1. I seem to eat just as much when I'm with others (family, social gatherings) as when I'm by myself.
2. Sometimes, when I'm with other persons, I don't eat as much as I want to eat because I'm self-conscious about my eating.
3. Frequently, I eat only a small amount of food when others are present, because I'm very embarrassed about my eating.
4. I feel so ashamed about overeating that I pick times to overeat when I know no one will see me. I feel like a "closet eater."

#13

1. I eat three meals a day with only an occasional between meal snack.
2. I eat three meals a day, but I also normally snack between meals.
3. When I am snacking heavily, I get in the habit of skipping regular meals.
4. There are regular periods when I seem to be continually eating, with no planned meals.

#14

1. I don't think much about trying to control unwanted eating urges.
2. At least some of the time, I feel my thoughts are pre-occupied with trying to control my eating urges.
3. I feel that frequently I spend much time thinking about how much I ate or about trying not to eat any more.
4. It seems to me that most of my waking hours are pre-occupied by thoughts about eating *or* not eating. I feel like I'm constantly struggling not to eat.

#15

1. I don't think about food a great deal
2. I have strong cravings for food but they last only for brief periods of time.
3. I have days when I can't seem to think about anything else but food.
4. Most of my days seem to be pre-occupied with thoughts about food. I feel like I live to eat.

#16

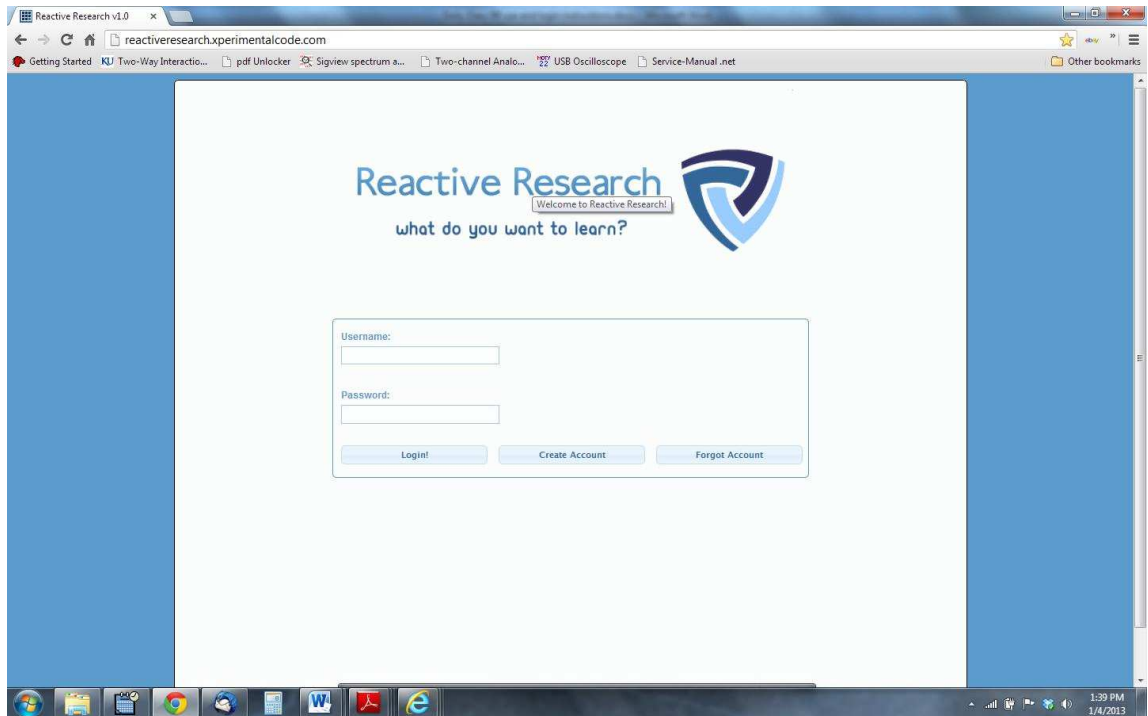
1. I usually know whether or not I'm physically hungry. I take the right portion of food to satisfy me.
2. Occasionally, I feel uncertain about knowing whether or not I'm physically hungry. At these times it's hard to know how much food I should take to satisfy me.
3. Even though I might know how many calories I should eat, I don't have any idea what is a "normal" amount of food for me.

Appendix J

Daily Diary Report

This appendix lists question and response items that appear on a purpose-built website and Lime Survey. Each heading represents an area on the website that participants will see to provide their daily diary information.

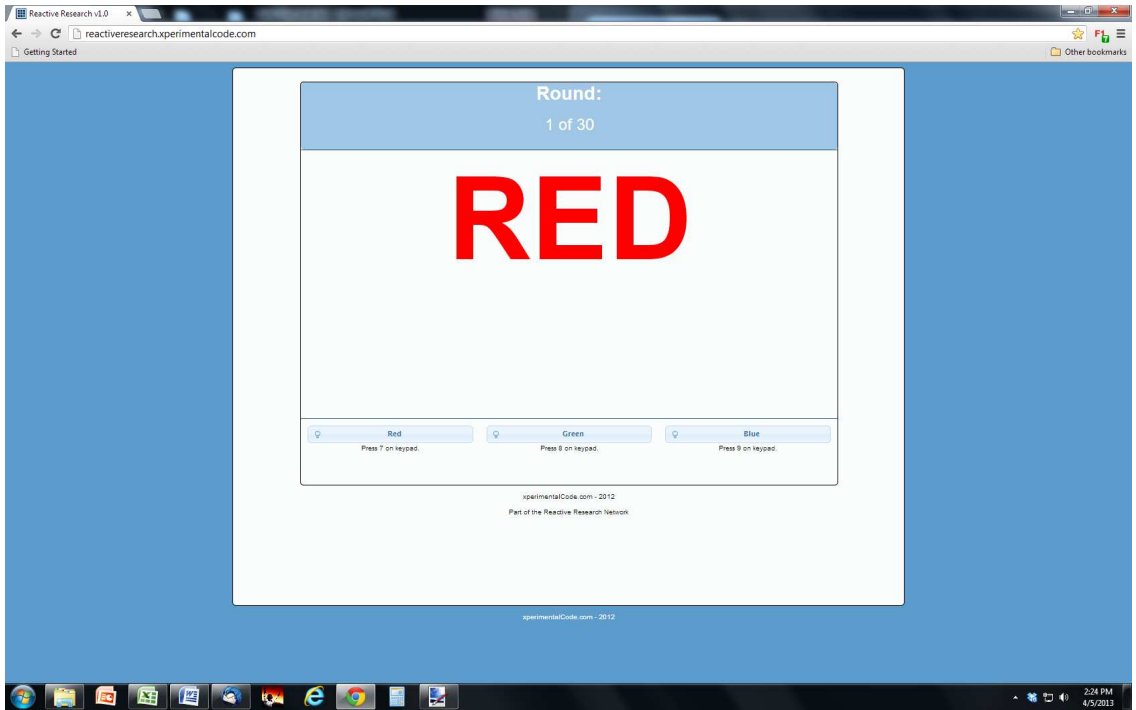
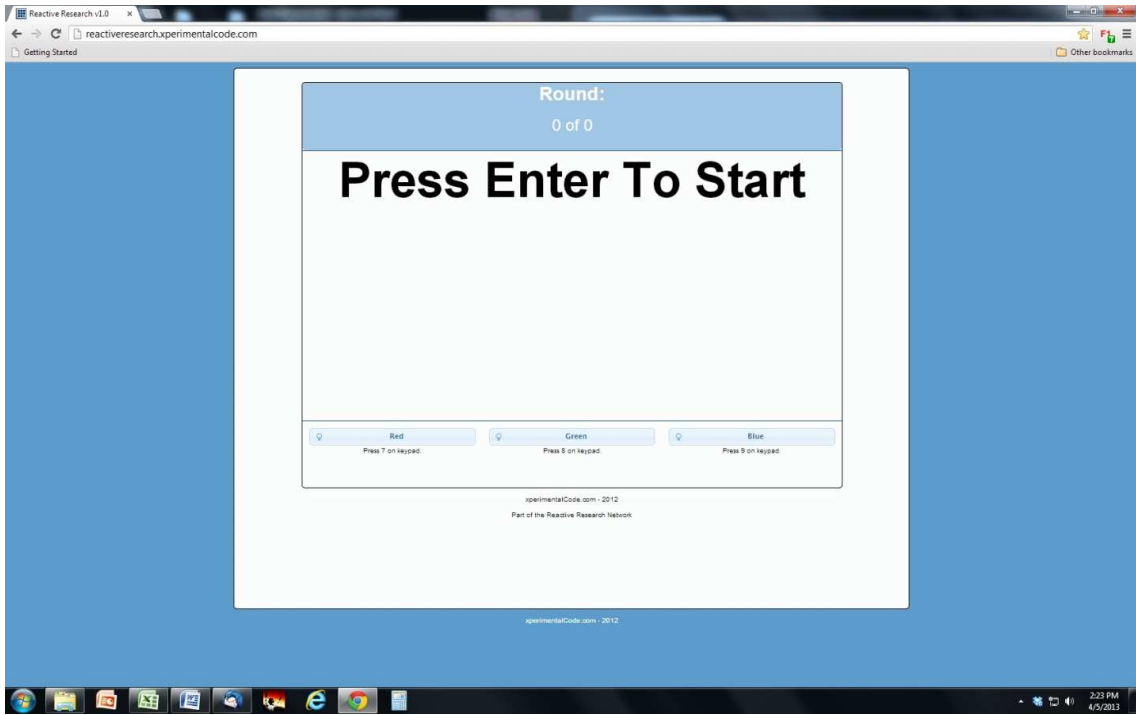
Reactive Research website



After login, participants see these instructions:

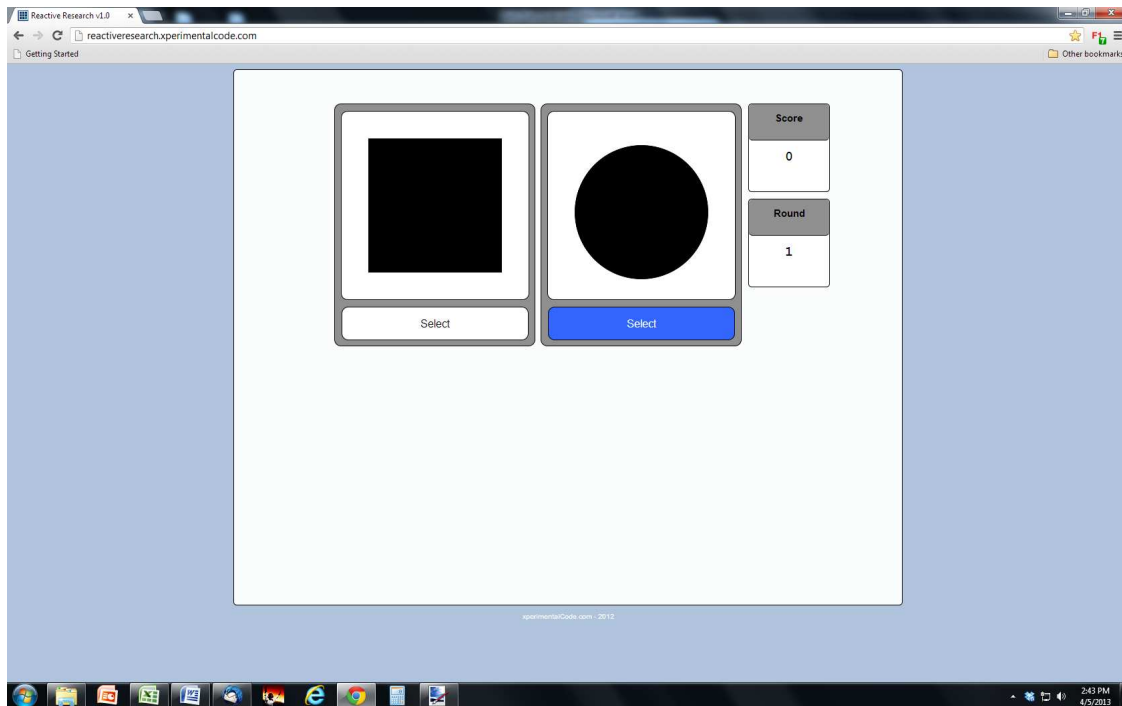
In order to complete the following test press the # key that corresponds to the color of the text. There are 30 rounds to complete.

The Stroop task consists of 3 parts: 30 rounds of color/name agreement, 60 rounds of random color/name, 30 rounds of color/name agreement. After each section, number keys used to indicate colors can change.



Two-Choice Impulsivity Procedure

Following the Stroop task, participants see this screen. Instructions are provided during the first lab visit.



Lime Survey Daily Diary

Dear Participant

Welcome to your personal and confidential daily diary. For the next 7 days we would like you to complete the sections you will find here. You may only enter one day's data for each time you log in. In the event that you forget to complete the diary on a given day, you can log in twice on the following day. The first time you log in will be for the previous day and the second time you log in will be for the current day. Please contact the Principal Investigator Andy Knapp at sbri@uvm.edu or by calling (802) 355-6402 if you encounter any difficulty with the diary or if you anticipate having to discontinue the study for any reason.

Log-in

1. Please enter your 3 digit participant number. This is the same number as your login for Reactive Research without the leading zeroes. For example, if your log in for Reactive Research is 000399 your 3 digit participant number would be 399. You can find your number on the papers we filled out at your first lab visit. If you have lost your participant number, please send an email to sbrl@uvm.edu and I will send it to you.
2. Please enter the date that this daily diary refers to. Generally you should enter today's date, unless you forgot to enter data for yesterday. If this diary is for yesterday, enter yesterday's date.
3. Please select which day of your daily diary you are completing now (1 - 7)

Feelings and emotions (PANAS – X)

1. This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the past 24 hours.
2. Indicate the extent to which you have felt this way in the past 24 hours. (60 adjectives rated on 5 point scale: Very slightly or not at all to Extremely).

Sleep Report

In the items below, please fill in numbers that appropriately answer each question. Pressing the tab key on your keyboard will take you to the next question or you may use the mouse to click the next block.

1. Enter the number of naps you took today. If none, enter '0' (zero).
2. Enter the duration (in minutes) of any naps you took today. If you took more than one nap, enter the average number of minutes for a typical nap.
3. Thinking about sleeping last night, please answer the following questions. You can use the tab key on your keyboard to advance to the next block or use your mouse to select the next block.
 - a. Enter your bedtime using 4 digits (hhmm)
 - b. Approximately how long did it take to fall asleep? (enter minutes)
 - c. How many times did you get up out of bed last night?
 - d. How many times were you awakened during the night?
 - e. Altogether, how many hours did you spend in bed?
 - f. Estimate the number of hours you were asleep
4. Please rate the sleep you got last night using the scale shown. You may also comment on your sleep last night in the area provided.

- a. Terrible - I barely slept at all
- b. Poor - Tossed & turned but finally got to sleep
- c. OK - Neither good nor bad
- d. Good - felt rested when I awoke
- e. Great - Best sleep I've had in a long time

Stress Report

1. Please tell us about any stressful events you experienced today by selecting from the categories below (you may choose more than one). You can also leave a comment about the event in the area provided.
 - Transportation (traffic, weather, car trouble, public transportation hassles, etc.)
 - Work (interpersonal relationships with coworkers, workload, work/family conflict, etc.)
 - Family/Home (interpersonal relationships with partner/spouse, child(ren), etc.)
 - Financial (specific problem with bill(s), money worries, unexpected expense, etc.)
 - Housing (landlord/neighbor problems, moving stress, etc.)
 - Medical Issues (pain, interpersonal relationships w/doctor(s), medical staff, etc.)
 - Technology (TV/cable, computer, internet, cell phone, etc.)
 - Other (enter information in comment area)
 - None of these, it was a perfect day!
2. Please rate your level of stress during the past 24 hours according to the scale provided. (5 point scale: Very low to Very high)

Stigma Report (Items from MIDUS survey)

1. Have you EVER IN YOUR LIFE experienced any of the following types of prejudice or discrimination as a result of your identity or the way you look? (Day 1 of Daily Diary only.)
 - a. Denied a scholarship
 - b. Discouraged by a teacher or advisor from seeking higher education
 - c. Not hired for a job
 - d. Not given a promotion
 - e. Fired

- f. Prevented from renting or buying a home in the neighborhood you wanted
 - g. Prevented from remaining in a neighborhood because neighbors made life uncomfortable
 - h. Hassled by the police
 - i. Denied a bank loan
 - j. Denied or provided inferior medical care
 - k. Denied or provided inferior service by a plumber, car mechanic, or another service provider
 - l. Other (explain in comments section)
 - m. None of these have ever happened to me
2. If you experienced any of the above situations, what do you believe was the main reason for the behavior you experienced? You may select as many as apply. You may also leave a comment in the area provided.
- a. Gender/sexual identity
 - b. Age
 - c. Race
 - d. Height
 - e. Weight
 - f. Ethnicity or nationality
 - g. Religion
 - h. Physical disability
 - i. Some other aspect of your appearance or identity (explain in comment area)
3. Did you experience any of the following types of prejudice or discrimination TODAY because of your identity or the way you look? You may also provide a comment in the area provided. (Daily including Day 1 of Daily Dairy.)
- a. You are treated with less respect than other people
 - b. You are treated with less courtesy than other people
 - c. You receive poorer service than other people at restaurants or stores
 - d. People acted as if they were afraid of you
 - e. People acted as if they thought you were dishonest
 - f. People acted as if they thought you are not as good as they are
 - g. You were called hurtful names or insulted
 - h. You are threatened or harassed
 - i. Other (explain in comments section)
 - j. I didn't experience any prejudice or discrimination today
4. If you experienced any of the above situations, what do you believe was the main reason for the behavior you experienced? You may select as many as apply. You may also leave a comment in the area provided.

- a. Gender/sexual identity
- b. Age
- c. Race
- d. Height
- e. Weight
- f. Ethnicity or nationality
- g. Religion
- h. Physical disability
- i. Some other aspect of your appearance or identity (explain in comment area)

Food Report (Program produces up to 12 event questionnaires, based on item 2 below)

1. You will be asked to describe each meal, snack or treat ("event"). For each event you report, you will be given a set of questions regarding that meal, snack or treat. For example, if you had 3 meals (breakfast, lunch, supper) and 3 snacks or treats, you would enter the total which would be 6.
2. Thinking back over the past 24 hours, how many separate and distinct meals or snacks/treats did you have? Each meal or snack/treat should have had a definite start and stop. Enter the total number of meals and snacks/treats in the space provided.
3. Answer the following questions regarding your [first – twelfth] meal, snack, or treat of the day.
 - a. Using the categories below, please describe the FIRST meal or snack/treat of the day. You may add a comment regarding this meal or snack/treat in the comment section. [Help: Examples of comments you may wish to include: feelings and emotions, how hungry you felt, how satisfying the meal or snack/treat was, etc.]
 - i. Breakfast
 - ii. Lunch
 - iii. Dinner
 - iv. Snack/treat
 - b. Think about the meal or snack/treat you just selected only. About how much did you eat? You may also enter comments about this in the space provided. [Help: Examples of comments you may wish to include: feelings and emotions, how hungry you felt, how satisfying the meal or snack/treat was, etc.]
 - i. Much less than most people would eat
 - ii. Less than most people would eat

- iii. About the same as most people would eat
 - iv. More than most people would eat
 - v. Much more than most people would eat
- c. How would you describe or characterize this meal or snack/treat? You may also provide comments in the space provided. [Help: Examples of comments you may wish to include: feelings and emotions, how hungry you felt, how satisfying the meal or snack/treat was, etc.]
 - i. Regular meal prepared at home with fresh ingredients
 - ii. Fast food/Commercially prepared meal (take-out, frozen, microwave, etc.)
 - iii. Meal eaten at a restaurant (not fast food)
 - iv. Healthy snack (veggies, fruit, yogurt, etc.)
 - v. Sweet snack (candy, ice cream, cookies, cakes, etc.)
 - vi. Salty snack (chips, peanuts, crackers & cheese, etc.)
 - vii. Combination snack (snack consisting of more than one of the above categories)
- d. Thinking of the meal or snack/treat you just described, what was the level of control you felt over how much you ate? You may provide comments in the space provided.
 - i. I felt completely in control: I ate because I was hungry
 - ii. I ate because it was meal/snack time
 - iii. I felt pretty much in control of how much I was eating
 - iv. I felt a little out of control and unsatisfied
 - v. I felt like I was watching someone else, like my hand was moving by itself
- e. How long had it been since your last meal, snack, or treat? [Help: Think back to the meal, snack, or treat you had before this one. How many hours or minutes had it been since that event?]
 - i. Hours
 - ii. Minutes
- f. Where were you when you ate this meal or snack?
 - i. At home
 - ii. At work
 - iii. In a restaurant
 - iv. In the car
 - v. At a friend's house
 - vi. Other (explain in comments section)
- g. Was anyone else with you when you ate this meal or snack?
 - i. Yes

- ii. No
 - h. Think about the very next time you slept (include short and long naps, as well as going to bed for the night). How soon after this meal or snack did you sleep?
 - i. Less than 30 minutes after this meal or snack
 - ii. 30 minutes to 1 hour after this meal or snack
 - iii. 1 to 2 hours after this meal or snack
 - iv. More than 2 hours after this meal or snack
4. (Questionnaires repeat until all are filled out.)

End Message (Daily)

Thank you for your participation in this study. Because anonymity is a critical principle of this research, you are assured that what you share will be held in confidence. This provides the safety you need to share your experiences honestly. Your answers are very valuable to us. We are interested in sleeping and eating patterns among people who use food as a coping mechanism. This research may be used to inform professionals in the health care and mental health fields regarding sleeping and eating patterns. The results of this study may help professionals develop a better understanding of how to increase healthy behaviors especially in people who use food to cope with stress. Be sure to log in again tomorrow to complete the diary again. If this was your 7th day, please contact Andy Knapp at sbri@uvm.edu or by calling (802) 355-6402 to make an appointment for your final lab visit.

Appendix K

Electrocardiogram Electrode Placement

