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The Impact of Sleep Restriction (Nap Deprivation) On Preschool Children's (Aged 3-5) Emotional Response

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THE IMPACT OF SLEEP RESTRICTION (NAP DEPRIVATION)

ON PRESCHOOL CHILDREN'S (AGED 3-5) EMOTIONAL RESPONSE

by

Hui-Ya Han

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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ABSTRACT

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This study examined the effect of nap restriction on 3- to 5-year-old habitually napping children's emotional responding. It was predicted that the intensity of emotional stimuli would moderate the relationship between nap restriction and the magnitude of emotional responding. Specifically, following nap restriction, the emotional responses to stronger stimuli would be amplified, while the emotional responses to weaker stimuli would be reduced. Emotional stimuli, were classified into four categories: strong negative, weak negative, weak positive, and strong positive. Facial electromyography was measured to reflect preschoolers' emotional responses. The results indicated emotional responses to both strong negative and positive stimuli were amplified following nap deprivation. Planned analyses revealed no differences in emotional responses to weak stimuli with exploratory analyses suggesting actual amplification with nap deprivation. Compensatory increases in attention required by the experimental task may have masked the effect of nap restriction on emotional responses to weak stimuli. Further studies on preschoolers are needed to understand the influence of nap on children's cognitive and emotional behavior.

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INTRODUCTION

The significance of sleep health is now being recognized in modern society. Sleep health is interwoven with overall health status in daily life. Generally, poor sleep health results from insufficient sleep duration, poor sleep quality, or sleeping at biologically inappropriate times. Most adults in America experience poor sleep health at least at times (Bonnet, 2005; Colten & Altevoqt, 2006; Dinges, Roger, & Baynard, 2005). The adverse effects of poor sleep health on human behavioral performance and overall health conditions in adults have been well-documented (Bonnet, 2005; Colten & Altevoqt, 2006; Dinges et al., 2005). Relatively little is known, however, about the consequence of poor sleep health for children.

Sleep Health and Adults

Prevalence of Poor Sleep Health in Adults

According to the 2011 *Sleep in America Poll* (National Sleep Foundation, 2011), adults sleep an average of 6.9 hours per night, well short of the recommended 8 hours of sleep per 24-hour period. Approximately 20% of workers in the US work outside the time period of 7 am to 6 pm. This results in excessive sleepiness and poor sleep quality due to inadequate sleep and misalignment between the biological circadian rhythm and external activities (Monk, 2005; Reid & Zee, 2005). Insufficient sleep and sleep at inappropriate times have been found to be especially common among college students and teens (Buboltz, Brown, & Soper, 2001; Pilcher, Ginter, & Sadowsky, 1997). High prevalence of erratic schedules, less parental supervision, and alcohol or drug misuse are characteristics of the college lifestyle associated with students' irregular sleep-wake patterns, insufficient sleep, and poor sleep quality (Buboltz et al., 2009; Gaultney, 2010; Lund, Reider, Whiting, & Prichard, 2010). Notably, approximately 10% of the general population suffers from sleep disorders such as obstructive sleep apnea syndrome, restless legs syndrome and insomnia (Partinen & Hublin, 2005).

Risk Factors for Poor Sleep Health among Adults

Poor sleep health is associated with predisposing factors such as lifestyle (e.g., long hours on the internet), work (e.g., irregularly scheduled shifts), stressors, psychiatric conditions (e.g., mood disorders), and medical conditions (e.g., obesity, sleep disorders, or chronic painful conditions) (Colten & Altevoqt, 2006). Stress in daily-life is a common precursor to disturbed sleep quality defined as decreased sleep efficiency and increased awakenings (Kim & Dimsdale, 2007). Obesity (Gami, Caples, & Somers, 2003; Young, Peppard, & Taheri, 2005) and weight gain (Lyytikäinen, Rahkonen, Lahelma, & Lallukka, 2011; Watanabe, Kikuchi, Tanaka, & Takahashi, 2011) are also common risk factors for poor sleep health. Additionally, numerous medical conditions change sleep-wake cycles (Colten & Altevoqt, 2006) and are associated with poor sleep health.

Consequences of Poor Sleep Health on Adults

A direct impact of poor sleep health is excessive sleepiness defined as the tendency to fall asleep at inappropriate times. Excessive sleepiness is the quintessential indicator of poor sleep quality. Several epidemiologic studies examining sleep and excessive sleepiness showed a high prevalence of excessive sleepiness (13%~25%) in the United States (Drake, Roehrs, Richardson, & Roth, 2002; Punjabi, Bandeen-Roche, & Young, 2003; Roehrs, Carskadon, Dement, & Roth, 2005). More generally, the adverse effects of poor sleep health include mood disturbance (Pilcher & Huffcutt, 1996), altered sensory perception (Killgore & McBride, 2006; Roehrs, Hyde, Blaisdell, Greenwald, & Roth, 2006), diminished attentional capacity (Epstein, Chillag, & Lavie, 1998), impaired memory performance (Carskadon, Harvey, & Dement,1981a; 1981b; Walker & Tharani, 2009), lower motivation (Dinges & Kribbs, 1991), and poor driving performance (Dinges et al., 2005), as well as physiological changes such as altered hormonal rhythms (Bonnet & Arand, 2003), and immune functioning (Dinges et al., 2005). Chronic sleep restriction and obesity have been shown to have a dose-response relationship; i.e., the shorter the sleep duration, the greater the obesity (Colten & Altevoqt, 2006; Hasler et al., 2004).

The consequences of sleep loss on cognitive performance are well-documented (Durmer & Dinges, 2005; Krueger, 1989; Walker, 2008). Interestingly, one meta-analysis by Pilcher and Huffcutt (1996) revealed that mood may be more influenced by sleep loss than cognitive functions. Pilcher and Huffcutt (1996) compared the magnitude of the effects reported in 19 studies examining the impact of sleep deprivation on driving performance, cognitive function, and mood. Of the three, mood was shown to be most affected by poor sleep health (Pilcher & Huffcutt, 1996).

Sleep Health and Children

Sleep and Development

Sleep is the major activity of the brain during early-stage maturation and is thought to play an important role in early-stage development (Dahl, 1996). Children's sleep undergoes dramatic changes during the first few years of life. These include changes in sleep duration: neonates (15-17 hours daily), 1-year-olds (~14 hours daily), and 5-year-olds (~11 hours daily). The distribution and structure of individuals' sleep-wake patterns change from polyphasic (birth-neonate), to biphasic with morning and afternoon naps (1-2 years), to biphasic with afternoon naps only (2-5 years), to a consolidated, nocturnal, more adult-like sleep architecture (5 years and up) (Anders, Sadeh, & Appareddy, 1995; Crosby, LeBourgeois, & Harsh, 2005; Iglowstein, Jenni, Molinari, & Largo, 2003; Webb & Dinges, 1989; Weissbluth, 1995; Wolfson, 1996). It is likely that these changes in sleep-wake patterns are also tied to maturation of the homeostatic and circadian mechanisms that regulate adults' sleep behavior (Crosby et al., 2005; Webb & Dinges, 1989). Therefore, maintaining good sleep health may be especially important for children during their formative years (Dahl, 1996).

Prevalence of Poor Sleep Health in Children

Mindell and Owens (2003), authors of the book *A Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems*, advocate 11 to 12 hours of sleep (over a 24-hour period) for 3-to 5-year-old preschool children and 10 to 11 hours of sleep for 6- to 12-year-old school-aged children. Data from the 2004 *Sleep in America Poll* (National Sleep Foundation, 2004), however, showed that around 56% of preschool children (ages 3-5) receive less than the recommended hours of a 24-hour sleep period. Supporting this, Ward, Gay, Anders, Alkon, & Lee (2008) found that the majority of preschool-aged children take a diurnal nap when the opportunity is given. Ward et al. noted that this result suggests that most preschoolers need more sleep during the day than they are currently receiving.

Numerous epidemiological studies indicate that sleep problems are common in children and adolescents (Kahn et al., 1989; Mindell, 1993; Mindell & Meltzer, 2008; Owens, Spirito, McGuinn, & Nobile, 2000; Reigstad, Jørgensen, Sund, & Wichstrøm, 2010). The prevalence of sleep problems has been estimated to vary from 5% to around

37% in children and adolescents worldwide (Kahn et al., 1989; Mindell, 1993; Owens et al., 2000; Reigstad et al., 2010). One study by Mindell, Owens, and Carskadon (1999) reported that 20% to 25% of children in the first few years of life who are referred to clinics suffered from some form of sleep disturbance. Another recent epidemiological study by Reigstad et al. (2010) found that 5% of adolescents aged 12 to 18 in Norway have self-reported sleep problems. In addition, Owens et al. (2000) showed 37% of children aged 4 to 11 in the US experienced sleep problems in at least one sleep domain (e.g., bedtime resistance, sleep-onset delay, and short sleep duration), based on reports by their parents. Therefore, poor sleep health may have a significant impact on children's development and functioning, and the issue of poor sleep health needs to be addressed seriously (Dahl, 1996; Dahl, 1999).

Sleep problems in children and adolescents are usually identified by parent- or self-report as opposed to objective measures. Depending on the definition, the phrasing of the questions in the instrument, and the specific ages of the children considered, estimations as to the prevalence of sleepiness in children varies wildly, from 4% (Camhi, Morgan, Pernisco, & Quan, 2000, children ages 3-14 in the U.S.) to 48% (Verhulst et al., 2007, children ages 6-12 in Sri Lanka) (Cairns, LeBourgeois, Crosby, & Harsh, under review). Most epidemiological studies of sleepiness in children heavily rely on a single-item question to assess the sleepiness level of children. Therefore, it is difficult to arrive at a definitive claim as to the epidemiology of poor sleep health in children. However, medical symptoms and/or lifestyle factors leading to poor sleep health were associated with high rates of sleepiness in children (Calhoun et al., 2011). Moreover, the prevalence of sleepiness in children was rated higher if the appearance of tiredness was counted as one manifestation of sleepiness (Cairns et al., under review). Additionally, Liu, Liu, Owens, & Kaplan (2005) proposed that daytime sleepiness was common in 5- to 13-year-old children in both the United States and in China.

Risk Factors of Poor Sleep Health for Children

According to Owens (2005), certain intrinsic and extrinsic risk factors such as difficult temperament, chronic illness, neurodevelopmental delays, maternal depression, or family stress may predispose particular children towards chronic sleep disturbance. One risk factor associated with poor sleep health in children is the requirement to attend school/day care starting early in the morning. Han, Cairns, LeBourgeois, & Harsh (2008) indicated that preschool/daycare attendance, which is associated with early morning start times, is related to poor sleep health. Children attending daycare appeared less able to acquire adequate weekday nocturnal sleep, evidenced by relatively greater difficulty getting out of bed in the morning and more diurnal sleep (Han et al., 2008).

Poor sleep health in children is associated with use of electronic media, including television viewing, surfing the Internet, and playing video games (Cain & Gradisar, 2010; Oka, Suzuki, & Inoue, 2008; Owens et al., 1999; Paavonen, Pennonen, Roine, Valkonen, & Lahikainen , 2006; van den Bulck, 2004). Not only was media use significantly related to shorter time in bed and more self-reported tiredness, but also having media equipment in the bedroom was associated with delayed sleep time and overall level of tiredness (Owens et al., 1999; van den Bulck, 2004). It would appear that watching television, playing video games, and browsing the Internet in the bedroom are potentially negative influences on children and adolescents' sleep health (Owens et al., 1999).

Consequences of Poor Sleep Health in Children

The relationships between poor sleep health during childhood and problematic behavior, including attention problems (Dahl, Pelham, & Wierson, 1991), hyperactivity (Aronen, Paavonen, Fjallberg, Soininen, & Torronen, 2000) and anxiety/depression symptoms (Johnson, Chilcoat, & Breslau, 2000; Ong, Wickramaratne, Tang, & Weissman, 2006), have been well-documented. Abnormal behaviors associated with sleep problems implicate the issue of poor sleep health in the development of childhood psychopathology (Ong et al., 2006). Wolfson and Carskadon (2003) assessed the relationship between sleep health and school performance reported in 14 studies of preadolescent to college students. The authors' conclusions indicated that poor sleep health, including shortened total sleep duration, irregular sleep schedules, delayed sleep phase, and poor sleep quality, is related to poor school performance (Wolfson & Carskadon, 2003).

Sleep problems in early age may be closely related to increased emotional and behavioral problems in mid-adolescent age. One longitudinal study by Gregory and O'Connor (2002) illustrated that sleep problems in 4-year-olds predict depression/anxiety, attention problems, and aggression at the ages 13 to 15 after accounting for the stability of depression/anxiety, gender, and adoptive status. Particularly, the stronger association between sleep problems and depression/anxiety with age suggested a causal relation between sleep problems at earlier ages and behavioral/emotional problems later. Therefore, poor sleep health in childhood could be a prognostic symptom of the psychopathologic disorders later in adults. Moreover, one study by Mindell and Meltzer (2008) reviewed the assessment of behaviorally-based sleep disorders in children and suggested the hyperactivity and difficulties in emotion regulation could be the manifestations of sleep disorders.

While the consequences of total sleep deprivation and sleep restriction have been extensively investigated in adults (Ayas et al., 2003; Colten & Altevoqt, 2006; Dinges et al., 2005; Hasler et al., 2004; Spiegel, Leproult, & Cauter, 1999), laboratory studies of the relationship between sleep and child functioning are sparse (Dahl, 1996; Sadeh, 2007). One early study by Carskadon et al. (1981a) restricted children aged 11-13 to sleep only 4 hours for one night and observed the recovery after the sleep restriction. Relative to adults' recovery progress, the objective results showed greater daytime sleepiness after one night of recovery sleep. This suggested that children are more severely affected by sleep loss and need more time to recover from it (Dahl & Lewin, 2002; Gregory & O'Connor, 2002).

Most parents have experienced the adverse effect of sleep loss on their children's mood. It is generally accepted that sleepy children exhibit crankiness, bad temper, and irritability. Essentially, poor sleep health is thought to tax the ability to stabilize emotional states and control emotional responding (Dahl, 1999). It is proposed that the incidence of primary emotional problems in adolescents and youth, following patterns of poor sleep health, demonstrates the impact of poor sleep health on children's ability to control or modify their emotional responses in such a way as to engage in or maintain benign social interaction with their peers (Dahl, 1999).

Sleep Health and Emotion

"Emotional response" is the important variable in this study; thus the definition and the distinction of emotion from other related terms are elaborated on here. Emotion, affect, and mood are terms which have been used interchangeably often without clear distinctions. According to Davidson (1994), “Moods provide the affective background…. Emotions can be viewed as phasic perturbations that are superimposed on this background activity.” Emotions usually are preceded by distinct events, but moods are not (Davidson, 1994; Gross, 1998). Additionally, emotion can be distinguished from mood in terms of duration. Emotion lasts for a brief period of time, while mood is held longer (Davidson, 1994; Ekman, 1994; Gross, 1998). In addition, William James’s response-tendency perspective indicated that emotions are the tendencies of physiological responses and adaptive behaviors (Gross, 1998). Moods are often regarded as subjective experience (Davidson, 1994). In the current study, emotional response was specifically defined by the measurable physiological responses corresponding to the preceding emotional stimuli.

Emotion and Emotion Regulation

It is a challenge to define the concepts of emotion and emotion regulation clearly, even for researchers in emotion studies (Cole, Martin, & Dennis, 2004). Lack of consensus and the complex concepts of emotion contribute to the arduousness in defining the construct (Bridges, Denham, & Ganiban, 2004; Cole et al., 2004). Yet, in order to distinguish emotion regulation from emotion, the nature of emotion needs to be clarified first. The working definition of emotion and emotion regulation in Cole et al.’s (2004) study was be adopted as my working definition of emotion and emotion regulation here.

In Cole et al.’s (2004) paper, “Emotion regulation as a scientific construct: methodological challenges and directions for child development research,” the authors elaborated on the definition of emotion:

> We assume that emotions are biologically endowed processes that permit extremely quick appraisals of situations and equally rapid preparedness to act to sustain favorable conditions and deal with unfavorable conditions . . . appraisal and action readiness are the wrap and woof that constitute the fabric of emotion. (Cole et al., 2004, p. 319)

In detail, the “appraisal” involved in emotion is defined as the process of evaluating the importance of a situation for individuals. The appraisal also affects the tendencies of being ready to respond in a specific way based on individuals’ desires; this process is called action readiness (Cole et al., 2004) (see Figure 1).

Likewise, the definition of emotion regulation is a perplexing construct that should be elaborated on (Cole et al., 2004; Gross, 1998). Although emotion regulation has been recognized to have a tight relationship with an emotional state, Cole et al. (2004) claimed that emotion and emotion regulation can be clarified and measured independently. These two concepts can be distinguished from each other by defining emotion regulation as an independent process of systematic changes associated with the initial activated emotion (Cole et al., 2004). Specifically, two necessary conditions must exist for emotion regulation to occur: (1) an initial emotional response was activated; (2) a regulatory process occurred independently from the initial emotional response (see Figure 1).

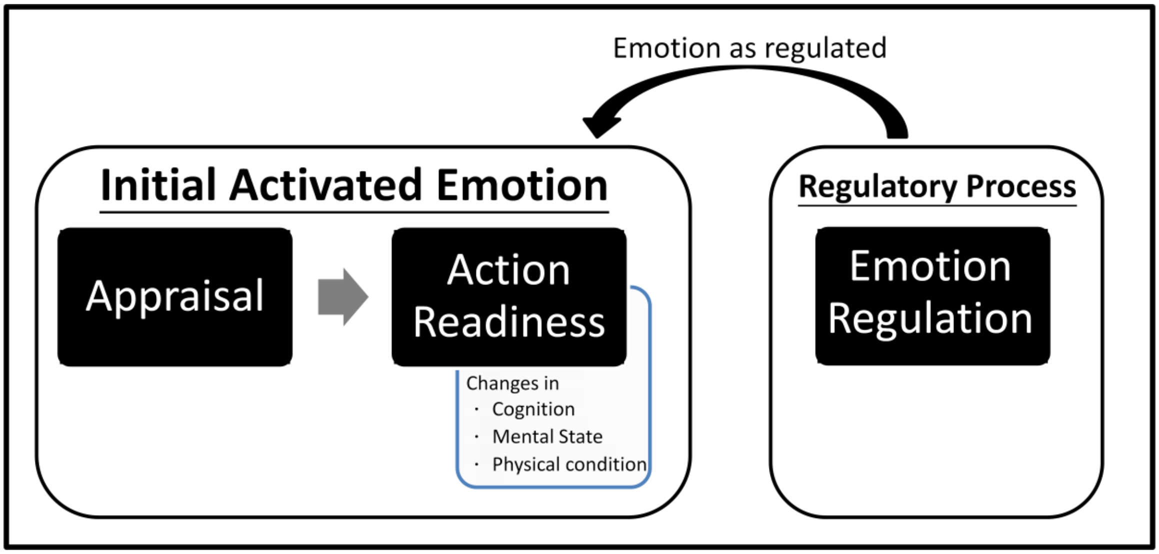

Figure 1. This schematic figure illustrates the process of emotion and the relationship between emotion and emotion regulation.

Both initial emotional responses and emotion regulatory processes are affected by sleep loss (Cole, Michel, & Teti, 1994; Franzen, Buysse, Dahl, Thompson, & Siegel, 2009; van der Helm & Walker, 2010). The impact of sleep loss on emotion regulation may be revealed by poor mediation of regulatory emotional processes (Crossin, Seifer, Carskadon, & LeBourgeois, 2008). Similarly, the consequence of sleep loss on emotion may be reflected by amplified or reduced initial emotional response. In the present study, the emotional responses to emotional stimuli following nap or nap deprivation was measured by facial electromyography. I only focus on the changes in emotional responses to emotional stimuli because of nap deprivation. These changes may reflect either the initial emotional responses and/or the regulated emotional responses.

Sleep Deprivation and Emotion: Inconsistently Altered Emotional Responding following Sleep Loss

Amplified negative and blunted positive emotional responses. The emotional processing system, including mood status and emotional responses to external stimuli, is altered by poor sleep health (Pilcher & Huffcutt, 1996; Zohar, Tzischinsky, Epstein, & Lavie, 2005). Several studies have shown that sleep loss results in greater responses to negative stimuli and reduced responses to positive and neutral stimuli. For example, in Zohar et al.'s (2005) research, medical residents' self-rating of emotional responses toward real-life events were examined in the context of 32-hour work shifts. A total of 78 medical residents received three random phone calls during their work shifts to request completion of a one-page survey. The survey asked about medical residents' emotional responses to events occurring within the preceding 15 minutes. During these work shifts, negative emotional responses to goal-disruptive events were intensified, and emotional responses to goal-enhancing events were attenuated.

Other findings also indicate that sleep loss results in greater emotional responses toward negative stimuli. Walker and Tharani (2009) investigated the impact of sleep deprivation on emotional memory encoding. Subjects learned negative, positive, and neutral words either under 36 hours of sleep deprivation or with no sleep deprivation. Recognition of the words was then examined after two nights of normal sleep. With no sleep deprivation, subjects had greater recall of emotional words (both negative and positive) than neutral words. Sleep loss before learning resulted in a 40% memory impairment of overall words. Interestingly, the recognition of negative words was not impaired even with sleep loss before learning, and relative to positive and neutral counterparts, the recognition of negative words was significantly better. This result indicated the better emotional encoding of negative words and impaired emotional encoding of positive and neutral words following sleep loss (Walker & Tharani, 2009). Further, the past findings supported that greater emotional responses improved the performance of emotional encoding (Cahill & McGaugh, 1995; Mather, 2007; Mathew, 2006). Therefore, the better emotional encoding of the negative words may be a result of the greater negative emotional responses after sleep loss.

An altered processing of emotional stimuli following sleep loss is also indicated by physiological reactivity. The magnitude of pupil diameter is used as an index of emotional arousal and autonomic activation (Bradley, Miccoli, Escrig, & Lang, 2008). Pupillary reactivity is greater when viewing emotionally arousing stimuli. One study by Franzen et al. (2009) selected 45 pictures—categorized into groups of 15 pictures for positive, negative, and neutral emotional valence—from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1999). These pictures were shown to subjects in sleep-deprived and normal sleep groups. Subjects' pupil diameters were measured when passively viewing the pictures. Franzen et al. (2009) found 32-hour acute sleep deprivation magnified the pupil dilation to negative pictures relative to the positive or neutral pictures. This result indicated that sleep-deprived people have greater emotional arousal to negative, but not positive, pictures. These findings are in line with the concept of altered emotional processing following sleep deprivation.

Neural imaging findings are also consistent with the thought of altered emotional processing. For example, in Yoo et al.'s (2007) research, 26 subjects either had 35-hour sleep deprivation or normal sleep conditions. These subjects were instructed to label 100 IAPS pictures in a gradient level from neutral to increasingly negative valence into the negative or the neutral category. While the subjects were categorizing the pictures, their brain activity was recorded by functional magnetic resonance imaging (fMRI). The fMRI results revealed amplified amygdala activity following sleep deprivation accompanied by reduced connectivity from the medial prefrontal cortex. The investigators proposed that the absence of top-down control of the amygdala by the medial prefrontal cortex may lead to contextually inappropriate emotional reactivity (Yoo et al., 2007). Moreover, the behavioral performance in Yoo et al.'s (2007) study also supported altered emotional processing, because the sleep-deprived group rated more pictures as negative compared to the standardized rating.

The above findings generally were in line with the concept of altered emotional processing following sleep deprivation (Franzen et al., 2009; Walker & Tharani, 2009; Yoo et al., 2007; Zohar et al., 2005). Specifically, these above-mentioned results are concordant with the pattern of the greater negative emotional response and attenuated positive emotional responses following sleep loss. However, not all findings have been consistent.

Blunted negative and blunted positive emotional responses. Several studies showed that sleep deprivation caused blunted responses to both negative and positive emotional stimuli (Leotta, 1999; Minkel, Htaik, Banks, & Dinges, 2011; van der Helm, Ninad, & Walker, 2010). In van der Helm et al.'s (2010) study, subjects were required to rate the emotional intensity of different human facial expressions after a 35-hour sleep deprivation. A follow-up rating was obtained after a 13-hour recovery sleep. The faces were displayed randomly in a gradient level from neutral (no emotional facial expression) to distinct emotional facial expressions (e.g. obviously happy face). These emotional stimuli were selected from the Ekman's "Pictures of Facial Affect," a collection of validated emotional representations of human facial expressions, which includes happy, angry, and sad emotions. The emotional intensity of facial expressions was measured by a 4-item scale, composed of four simple descriptions of emotional strength from 1 to 4 (e.g. for happy category, 1: definitely neutral, 2: more neutral than happy, 3: more happy than neutral, and 4: definitely happy).

van der Helm et al.'s (2010) study showed a deficit in recognition of both negative (angry) and positive (happy) facial expressions following sleep deprivation when compared to the rating after recovery sleep. The deficit in the emotional recognition task was reflected by the lower rating of emotional intensity of facial expressions following sleep deprivation. It is possible that sleep deprivation altered cognitive functioning and subsequently may have resulted in weak emotional stimuli becoming even less intense. For example, as suggested by the author, a faint frown or smile may have become an ambiguous expression.

Minkel et al. (2011) videotaped 23 subjects' facial expressions while passive-viewing sets of sad and amusing video clips. Two different sets of emotional video clips were displayed before and after 32 hours of sleep deprivation. A total of 92 video segments were produced from 4 film clips. The facial muscle movements were scored as emotional facial expressions mainly based on the Facial Expression Coding System (FACES; Kring & Sloan, 2007). The FACES was used to categorize different facial expressions regarding the dimensions of emotional experiences (Kring & Sloan, 2007). Overall expressiveness for each film segment was rated by observers on a 5-point scale ranging from 1 as "no emotion" to 5 as "several large displays or lasting small displays." Minkel et al. (2011) found that sleep-deprived subjects showed less facial expressions while passively viewing the video clips across amusing and sad conditions. One possible explanation of the blunted responses to both emotional stimuli, instead of greater responses toward the negative stimuli, is that the intensity of stimuli used was not sufficient to elicit emotional responses.

Leotta (1999) used multiple self-rating scales and the Specific Affect Coding System (SPAFF; facial expression coding system) to measure adolescents' mood and emotional responses to passively viewing emotional pictures after partial sleep deprivation during the previous night. The emotional positive and negative pictures were selected from a set of IAPS validated for adolescents. The results showed significantly reduced positive mood and positive facial expressions with 4-hour nocturnal sleep, compared to 10-hours sleep in the normal sleep condition. In the subsequent experiment of the same study, the author used a similar protocol with only 2-hour nocturnal sleep to measure young adults' mood and self-rating emotional responses but no facial expression. The results of this subsequent experiment continued to be consistent with reduced positive mood and positive emotional responses. Also, the author found increased negative mood and a predicted trend of increased negative emotional responses. After 5 weeks, the young adults returned to the laboratory for a test of recognition of the pictures. However, no evidence was found for superior memory retention of pictures with valences across sleep conditions. Jointly, the results of two aforementioned experiments in Leotta's study showed consistently reduced positive emotional responses after sleep restriction, relative to baseline sleep condition.

Inconsistent patterns of positive emotional responses following sleep loss. From the above reviewed studies, the positive emotional responses consistently showed a pattern of being reduced after sleep deprivation; however, one inconsistent result has been reported recently (Gujar, Yoo, Hu, & Walker, 2011). The study by Gujar et al.

(2011) illustrated an unexpected positive bias in healthy adults when judging stimuli after 32-hours of sleep loss. The authors also argued that this behavioral positive bias was accompanied by the neuroimaging evidence of increased reward-relevant activity in mesolimbic regions of the brain while viewing the most positive pictures set. The mesolimbic rewarding region includes amygdala, ventral tegmental area, fusiform gyrus, left putamen, and left insular.

In the Gujar et al. (2011) study, 27 subjects were given the binary option to categorize the valence of 100 IAPS pictures as either “pleasant” or “neutral” following sleep deprivation. The pictures ranged in a gradient of valence from neutral to increasingly positive. The fMRI was used to measure the brain reactivity corresponding to the performance of the appraisal tasks. For the forced-choice appraisal task, Gujar et al. (2011) calculated the “positive bias score” by subtracting the percentage of pictures labeled as “neutral” from the percentage of pictures labeled as “pleasant.” Behaviorally, the sleep-deprived group categorized more pictures as positive than the rested group. The positive bias was reflected by a higher positive bias score in the sleep-deprived group than in the rested group. In response to the top 25% positive pictures based on the normative rating after sleep loss, the fMRI results showed physiologically amplified reactivity in the mesolimbic rewarding region of the brain.

Gujar et al. (2011) argued that the changes in the mesolimbic region of the brain were accompanied by a positively biased judgment of emotional pictures following sleep deprivation. The behavioral positive bias when judging an entire set of pictures may not be simply explained by amplified neural reactivity of the top 25% positive pictures. The mechanism of behaviorally positive bias following sleep deprivation is unclear with the limited information of the stimuli characteristics in Gujar et al.'s (2011) study. However, the neuroimaging data indeed helps us to understand the amplified positive emotional response to strong stimuli.

Most of the studies reviewed above showed blunted positive emotional responses following sleep loss; however, the greater positive emotional responses after sleep loss in Gujar et al.'s (2011) study provides for an alternative perspective. The amplified positive emotional response to top 25% positive pictures supports the working model of altered positive as well as negative emotional responses to strong stimuli following sleep loss (see Figure 3). Jointly, the reviewed literatures supports that there is an amplified positive emotional response to strong positive stimuli (Gujar et al., 2011) and a blunted positive emotional response to weak stimuli (Franzen et al., 2009; Leotta, 1999; Minkel et al., 2011; Zohar et al., 2005) following sleep loss.

Role of Hypoactivation of the Prefrontal Cortex in Emotional Responding following Sleep Deprivation

The prefrontal cortex is influenced adversely by sleep loss (Muzur, Pace-Schott, & Hobson, 2002). Neural networks of the prefrontal cortex involved in executive functions, such as attention, inhibition, and memory, are vulnerable to sleep deprivation (Goel, Rao, Durmer, & Dinges, 2009; Harrison & Horne, 2000; Muzur et al., 2002). Past findings showed decreased brain activities in the prefrontal cortex were corresponded with impaired executive functions after one night of sleep deprivation (Drummond, Brown, Stricker, Buxton, Wong, & Gillin, 1999; Muzur et al., 2002; Petiau et al, 1998; Thomas et al., 2000). For example, decreased glucose metabolic rate during an attention-demanding task has been found in the prefrontal cortex after sleep deprivation, and this decrease is associated with deficits in attentional performance (Goel et al., 2009; Wu et al., 1991).

Among executive functions, attention is often regarded as a basis to access higher-level cognitive processing and is particularly susceptible to sleep loss (Goel et al., 2009; Lim & Dinges, 2008). The hypoactivation of the prefrontal cortex with deficits in attention capacity after sleep deprivation may be related to deterioration in subsequent cognitive and emotional processes. Supporting this possibility, Pessoa, Gutierrez, and Ungerleider (2002) showed that no differential reactivity in the amygdala to emotional valence of facial expressions was found while attention was reduced by a distraction task. The result implies that the deficit in attention associated with hypoactivation in the prefrontal cortex after sleep deprivation may influence the recognition of emotional stimuli and corresponding emotional processing which are dominated by the amygdala.

In contrast, the vulnerability of the prefrontal cortex to sleep loss may directly involve the hyperactivation of the amygdala which is associated with amplified emotional responses after sleep deprivation. The extensive interconnections between the prefrontal cortex and the amygdala implicate that these two brain regions participate in the integration of emotional and cognitive process (Barbas, 2000; Nomura et al., 2004). Specifically, one lesion study in rats of Morgan, Romanski, and LeDoux (1993) showed lesions of part of the prefrontal cortex extended a conditioned aversive response. This result suggested the prefrontal cortex plays a major role in modulating emotional activity in the amygdala (Affective & affective style; Morgan, Romanski, & LeDoux, 1993). Supporting the modulated relationship, neuroimaging studies examining depressed patients showed that increased amygdala responses accompanied reduction in the activity of the prefrontal cortex in response to emotional stimuli relative to the healthy control group. The finding implies that decreased prefrontal activity may be associated with a failure of top-down regulation of activity in amygdala. The authors also suggested that biased emotional processing may be explained by the hypoactivation of prefrontal reactivity and the hyperactivation of amygdala responses (Zhong et al., 2011). Consistently, another neuroimaging result of patients with pediatric bipolar disorder showed that reduction in activity of the prefrontal cortex was associated with increased activation in the amygdala. (Pavuluri, O'Connor, Harral, & Sweeney, 2008). This result suggests that a dysfunctional prefrontal cortex may reduce inhibition of amygdalar activity and result in an associated amplified emotional response.

Following sleep deprivation, a pattern of hyperactivation in the amygdala and reduced functional connectivity between the amygdala and the medial prefrontal cortex to both positive and negative stimuli has been found (Gujar et al., 2011; Yoo et al., 2007). Consistent with bipolar disorder, the pattern of reactivity in the amygdala and the prefrontal cortex following sleep deprivation may reflect the underlying mechanism of irregular neural activity leading to altered emotional processing.

A working model of altered emotional responses following sleep loss. The findings on emotional responses following sleep loss are inconsistent among the reviewed studies. After sleep deprivation, some studies showed amplified emotional responses (Franzen et al., 2009; Gujar et al., 2011; Yoo et al., 2007; Zohar et al., 2005) and other studies reported attenuated emotional responses (Leotta, 1999; Minkel et al., 2011; van der Helm & Walker, 2010). To account for this inconsistency, I propose a working model of the altered emotional responses following sleep loss, which describes the modulating effect of sleep loss on the relationship between the intensity of stimuli and the magnitude of emotional responses for both negative valence (see Figure 2) and positive valence (see Figure 3).

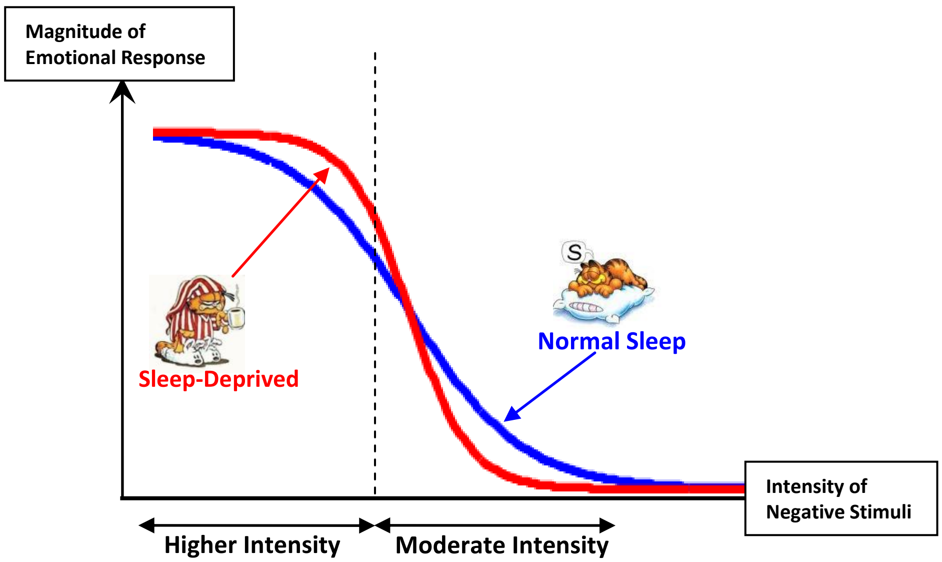

Figure 2. The figure depicts the magnitude of the negative emotional responses in relation to the intensity of negative emotional stimuli in rested and sleep-deprived conditions. The x axis represents the intensity of negative emotional stimuli, and the y axis represents the magnitude of the emotional responses. The red and blue lines represent sleep-deprived and rested states, respectively.

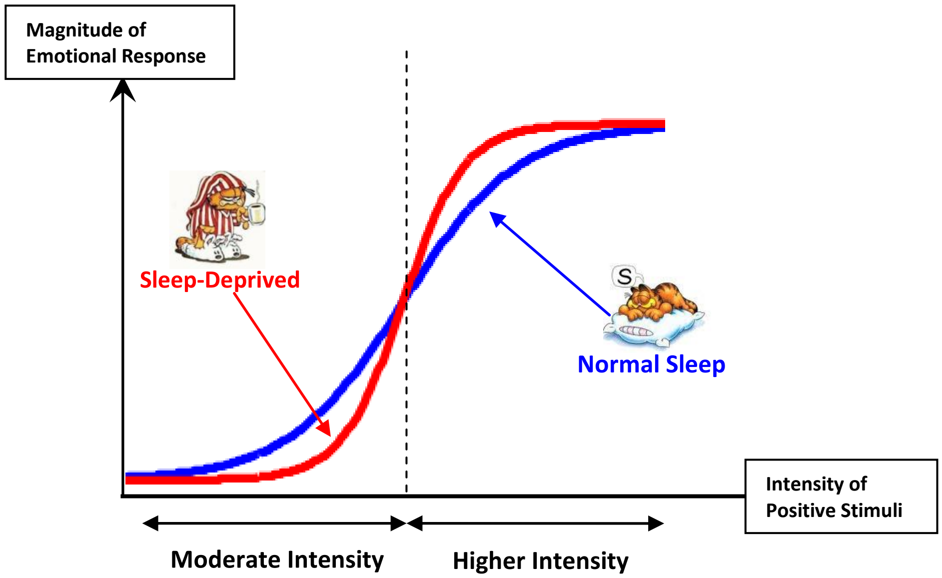

Figure 3. The figure depicts the magnitude of the positive emotional responses in relation to the intensity of positive emotional stimuli under rested and sleep-deprived conditions. The x axis represents the intensity of negative emotional stimuli, and the y axis represents the magnitude of the emotional responses. The red and blue lines represent sleep-deprived and rested states, respectively.

The working model proposes that the intensity of emotional stimuli may play a vital role in the change in the relationship between emotional response and stimulus intensity after sleep loss. Specifically, according to the hypothesis of the working model, the response to weak emotional stimuli following sleep deprivation is blunted in relation to the normal sleep condition while an amplified emotional response to strong stimuli is observed after sleep deprivation (see Figure 2 & Figure 3). Therefore, the inconsistent results of emotional responding in the past findings may be attributed to the characteristic of stimuli associated with the hypoactivation of prefrontal cortex after sleep deprivation.

In the working model, the hypoactivation of the prefrontal cortex was argued as the core concept to explain the incongruous results of emotional responding after sleep loss. For a weak emotional stimulus, the attenuated emotional response after sleep deprivation may relate to a deficit in executive function (e.g., attention and cognitive processing) associated with the hypoactivation in the prefrontal cortex. One early study of Hockey (1970) examining the attention deployment under sleep deprivation illustrated that attention was allocated more to high priority stimulus and less to low priority stimulus (weak emotional stimulus) in order to maintain efficiency on essential task performance. Furthermore, the past finding showed low attentional resources cannot support neural network in the amygdala to distinguish different types of facial expressions. The result implies that sufficient attention is necessary for amygdala processing valences of emotional stimuli differentially (Pessoa et al., 2002). Supported by the result of van der Helm and Walker's (2010) study, sleep deprivation selectively impairs the recognition of weak facial expressions. Therefore, a deficit in attention resources after sleep deprivation may be associated with altered reactivity in the amygdala and lead to blunted emotional response.

Additionally, impaired cognitive function, one domain of executive functions, is associated with reduced activity in the prefrontal cortex which is vulnerable to sleep loss (Drummond et al., 1999; Horne, 1988). It is reasonable to consider that weak stimuli require more cognitive processing to be recognized as having emotional significance relative to strong (salient) stimuli. The more that task performance involves cognitive processing, the greater impact of sleep loss is expected to be. Thus, the deficits in cognitive processing following sleep deprivation imply impaired emotional processing of weak stimuli. Taken together, the hypoactivation of the prefrontal cortex associated with deficits in attention and impaired cognitive processing may contribute to more attenuated emotional responses to weak emotional stimuli after sleep deprivation. This explanation may provide the further understanding of the blunted emotional response after sleep deprivation was found in some past studies.

Alternatively, some other studies examining emotional responses after sleep loss claimed the amplified response to emotional stimulus is the manifestation of the consequence of sleep deprivation (Gujar et al., 2011; Yoo et al., 2007). In my working model, the elevated emotional response may be the behavioral outcome of the increased activity of the amygdala with a reduced control by the prefrontal cortex after sleep deprivation. The hypoactivation of the prefrontal cortex associated with the hyperactivation in the amygdala has been found in the patients of major depressive disorder and pediatric bipolar disorder, one of the commonalities of these disorders is altered emotional responses relative to normal health people (Pavuluri et al., 2008; Zhong et al., 2011). The abnormally greater emotional responses in psychiatric disorders are inferred as a dysfunctional prefrontal top-down regulation of the amygdala (Pavuluri et al., 2008; Zhong et al., 2011).

People who experienced 35-hours of sleep deprivation also showed the similar pattern of neural reactivity in the prefrontal cortex and amygdala (Gujar et al., 2011; Yoo et al., 2007). Yoo et al. (2007) showed the increased activity in the amygdala to the 25% most negative valence of pictures set used in the experiment while sleep-deprived people were passively viewing the pictures. Likewise, Gujar et al. (2011) also revealed the amplified activity in the amygdala in response to top 25% positive valence of emotional pictures while the sleep-deprived people categorized the pictures with positive bias. Both these sleep-deprived studies found that the reduced functional connectivity between the prefrontal cortex and amygdala and suggested that the deficit in top-down control of the prefrontal cortex on the amygdala. Therefore, the reasonable explanation supporting amplified emotional response after sleep deprivation is that reduced activity in the prefrontal cortex may be linked to a failure to inhibit the elevated reactivity in the amygdala involved in the exaggerated emotional responses.

Back to the working model, for strong emotional stimuli, once the intensity of the emotional stimuli is strong enough to draw the attention and fit the cognitive evaluation, the amygdala would be ready for carrying out the emotional processing. However, the decreased activity in prefrontal cortex following sleep deprivation may be associated with the increased activity in the amygdala and the corresponding amplified emotional responses due to a lack of top-down modulation from the prefrontal cortex (see Figure 2 and Figure 3).

A real-life environment is a complex context composed of negative, neutral, and positive stimuli. For a further understanding of altered emotional responses following sleep loss, the patterns of negative and positive emotional responses is integrated into one symmetrical working model (see Figure 4). In the model, the magnitudes of emotional responses change as a function of intensity of negative and positive emotional stimuli following conditions of sleep loss or normal sleep. The stimuli in the neutral spectrum locate at the middle part between two ends of negative and positive valences along the x axis. Along the y axis, two rising curves stem from the neutral valence (vertex) which stretch to two sides of negative and positive valence and then form a basin-shape curve (see Figure 4). The magnitude of positive and negative emotional responses increases as a gradual slope following intensity of the emotional events. When the intensity of both negative and positive emotional stimuli increases to a certain high level, even though the level of intensity continues to increase, the emotional responses plateau (see Figure 4, the maximum response).

Under a sleep-deprived state (see Figure 4, the red line), toward weak emotional stimuli and neutral stimuli, people exhibit more blunted responses in comparison with rested group (see Figure 4, for the red line). However, following increased emotional intensity, the emotional response to stronger negative or positive stimuli becomes even greater relative to rested people. In sum, compared to individuals in rested states, sleep-deprived individuals show the blunted responses to neutral, weak negative, and weak positive stimuli. In contrast, sleep-deprived individuals show greater responses to strong negative and positive stimuli. Specially, emotional stimuli with stronger intensity elicit greater emotional responses following sleep deprivation in contrast to the responses in a rested state. This integrated working model is a parsimonious explanation for the inconsistent and consistent research results of the impact of sleep deprivation on emotional response, the dose-response empirical data is needed to further support the working model.

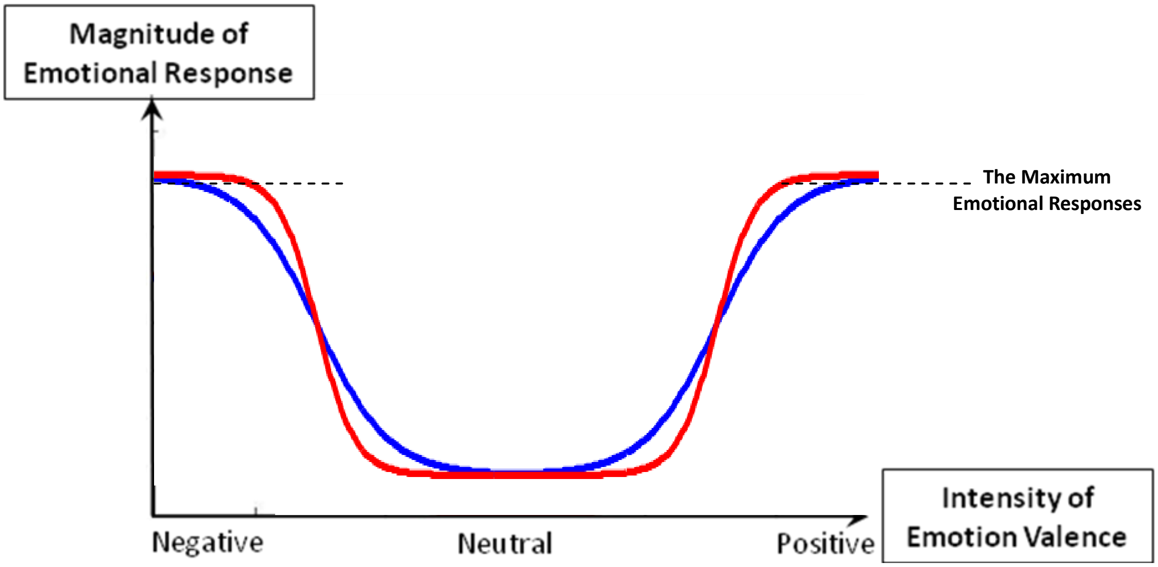

Figure 4. A full-scale view of the function relates the magnitude of emotional responses and intensity of positive and negative events following sleep loss or normal sleep conditions.

The working model is built according to the adults' emotional responses following sleep loss. We know little about the pattern of emotional responses after sleep loss in other age groups, especially lack of experimental data in early aged children. In the proposed study, the impact of sleep loss on preschoolers' emotional responses was examined. The young children's emotional responses following sleep loss is predicted to be consistent with my working model built on adults' data. Regarding that children aged 3 to 5 may not be capable to subjectively report and distinguish their emotional responding, the objective measures was mainly used to detect children's emotional responses. Therefore, children's emotional responding was assessed by using facial electromyography (fEMG).

Measuring Emotional Responses: Facial Electromyography

Darwin (1872) postulated that an individuals' emotional state can be recognized through facial expressions, and that facial displays can therefore reveal information about individuals' emotion states. Accepting the truth of this premise, an objective method used to measure physiological arousal corresponding to emotional responses to stimuli is facial EMG (fEMG) (Hazlett & Benedek, 2007; Magnée, de Gelder, van Engeland, & Kemner, 2007). fEMG measures subtle changes in the electrical activity of facial muscles as individuals display different facial expressions (Hazlett & Benedek, 2007; Magnée et al., 2007). Past findings (Cacioppo, Martzke, Petty, & Tassinary, 1988; Cacioppo, Petty, Losch, & Kim, 1986; Hazlett & Benedek, 2007; Magnée et al., 2007) have established the association between activity in specific facial muscle groups, individuals' emotional responses, and the valence of emotional stimuli.

For example, increased activity in the zygomaticus major, a muscle in the cheek associated with smiling, has been related to positive mood states as well as to reactions to positive emotional stimuli (Hazlett & Benedek, 2007; Magnée et al., 2007). Regarding negative moods and emotional reactions, the corrugator supercilli, a muscle in the eyebrow which activates during frowning, has been correlated with negative mood states and reactions to negative emotional stimuli (Cacioppo et al., 1988).

Researchers (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Dimberg, 1982) have shown that individuals passively viewing positive stimuli (e.g., happy faces) show increased activity in the zygomatic muscle group whereas individuals passively viewing negative stimuli (e.g., angry faces) show increased activity in the corrugator supercilli muscle group. The past finding (Cacioppo et al., 1986) have demonstrated that fEMG is sensitive to and capable of measuring facial muscle activity in response to weakly evocative emotional stimuli, even when the Facial Action Coding System (FACS) displays no observable reactions. FACS, developing by Ekman and Friesen (1978), is a coding system of emotional facial expressions by observers. Facial EMG can detect minute facial muscle movement, which may not be recognized by the naked eye (Cacioppo, Bush, & Tassinary, 1992; de Wied, van Boxtel, Posthumus, Goudena, & Matthys, 2009; Hazlett & Hazlett, 1999).

The validity of the facial EMG as an emotion-measure has been demonstrated in studies of young children. Children's facial EMG responses to emotional stimuli are similar to adults' response patterns (Hazlett, 2006; de Wied et al., 2009; McManis, Bradley, Berg, Cuthbert, & Lang, 2001). One study by McManis et al. (2001) illustrated that 7- to 10-year-old children's facial EMG responses corresponded to positive and negative IAPS pictures. Another study by Hazlett (2006) showed that children aged 9 to 15 displayed the different facial EMG patterns corresponding to negative and positive events while playing the video games. However, few studies have used facial EMG techniques to assess emotional responding in children under age 7. The result of Soussignan and Schaal's (1996) study showed 5-year-old childrens' different facial expressions to odors measured by FACS may be counted as an indirect evidence to support the effectiveness of facial EMG in very young children.

In Soussignan and Schaal's (1996) study, the negative odors (fishy and fecal) stimuli and positive odors (fruity and floral) were presented to a group of 5- to 12-year-old children. The children's facial expressions to different olfactory stimuli were recorded by a video camera and coded by FACS at later time. It was found that children showed negative facial expressions to fecal and fishy odor stimuli, and positive facial expressions to fruity and floral odor stimuli. If the facial muscle movement of children as young as 5-year-old can be observed by the naked eyes and then coded by the FACS

(Soussignan & Schaal, 1996), then fEMG may be an appropriate method for measuring the emotional responses of 3- to 5-year-old preschool children who may lack the mature cognitive ability to reflect and distinguish, or report, their own emotional experiences accurately.

Research Question

Question: How does nap restriction affect 3- to 5-year-old children's emotional responding?

In the present study, habitually napping children were randomly assigned to two groups: Nap-Deprived or Nap group. Both groups of children were exposed to emotional stimuli consisting of a visual cue followed by positive and negative pictures and associated sounds. Children's emotional responses to pictures of different emotional valence were compared.

Hypothesis 1a. Habitually napping children would have greater responses to *strong* negative emotional stimuli when they are deprived of a nap (Δ1 in Figure 5, the difference between Response 1 and Response 2).

Hypothesis 1b. Habitually napping children would have reduced responses to *weak* negative emotional stimuli when they are deprived of a nap (Δ1 in Figure 5).

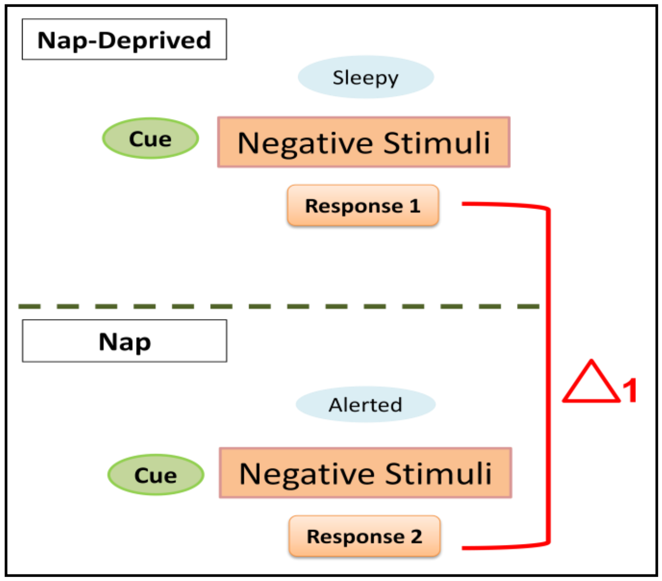

Figure 5. Simplified Diagram of Experimental Design (Hypothesis 1).

Hypothesis 2a. Habitually napping children would have greater responses to *strong* positive emotional stimuli when they are deprived of a nap (Δ2 in Figure 6, the difference between Response 3 and Response 4).

Hypothesis 2b. Habitually napping children would have reduced responses to *weak* positive emotional stimuli when they are deprived of a nap (Δ2 in Figure 6).

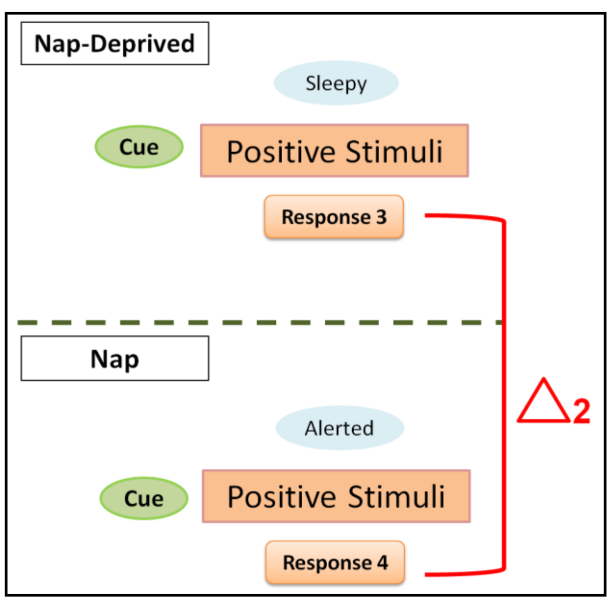

Figure 6. Simplified Diagram of Experimental Design (Hypothesis 2)

CHAPTER II

METHODOLOGY

This is a repeated-measure design experiment in which facial electromyography (fEMG) was used to detect the physiological responses of habitually-napping children who were exposed to emotional stimuli (pictures and associated sounds). Participating children attended three laboratory appointments (Introductory Appointment, The First Test Day, and The Second Test Day) over two weeks. After the first week of stabilization, children were randomly assigned to napping or nap-deprived conditions on the first test day in the following week. Children in the nap-deprived condition first were nap restricted on the first test day that week and allowed to nap normally on the second test day that week. Children in the napping condition first were allowed to nap normally on the second test day that week and were nap restricted on the second day that week. Before and between laboratory appointment days, participating children's sleep schedules were monitored via actigraphic device (Actiwatch, motion-sensing monitor to record the sleep-wake schedule, detailed discuss in the "Material" section, page 36) and caregiver sleep diaries. (see Figure 7, the detailed procedure will be discussed later in "Procedure" section, page 39).

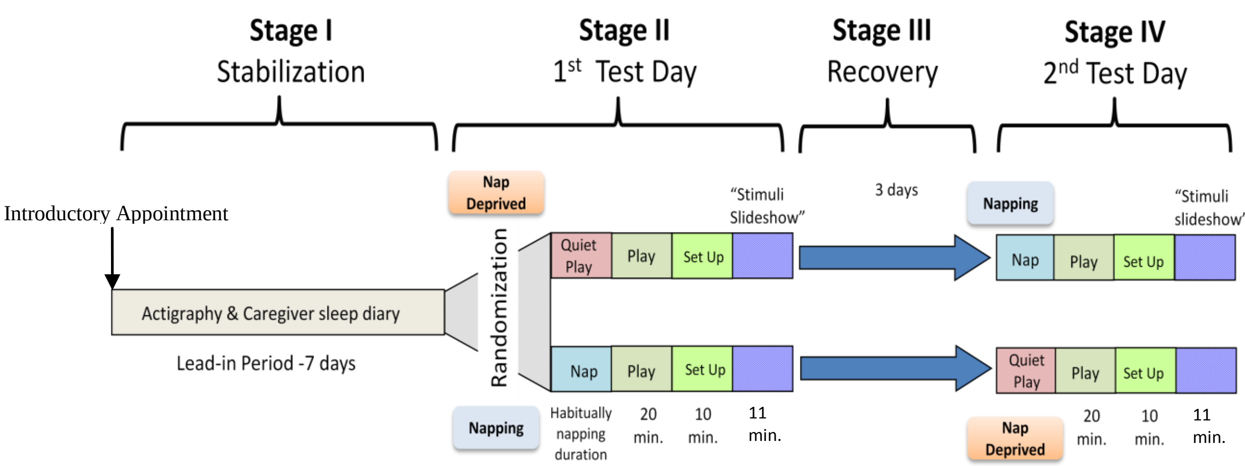

Figure 7. Procedure: Timeline

Participants

Participants in this study were seventeen 3- to 5-year-old preschool children (average 50 ± 10.0 month old; 53.0 % female, 64.7% Caucasian) of families in a tri-county area of southern Mississippi meeting inclusion and exclusion criteria (see below). Participating families were recruited using multiple strategies (flyers, face-to-face interactions, media advertisement, and snowball sampling) aimed at recruiting a heterogeneous group of children. Following the Kish procedure (Kish, 1949) to eliminate within-sampling error, only one child was accepted for inclusion from any family unit. Data from a total of 14 children (50.0% female, 71.4% Caucasian) were included in the present analyses. Three children were excluded from the analyses because they stopped participating.

Inclusion and Exclusion Criteria

Inclusion in this study required that children have a biphasic sleep-wake pattern (one nighttime sleep period and one daytime nap of at least 45 minutes time), napping at least 4 days per week (defined as habitually napping children in this study). This cut-off criterion was selected based on the result of Crosby et al.'s (2005) study. Crosby and his colleagues investigated the napping and nighttime sleep pattern of 2- to 8-year-olds from southern Mississippi. The result showed that the average of napping day per week is from 4 to 6 days on aged 2 to 5 children (the target population in the present study). Therefore, I used 4 napping days per week to define the habitually napping children. According to the self-report of main caregivers of the fourteen children, the average nap day per week was 5.3 $\pm$ 0.9 days, and the average nap duration was 114.6 $\pm$ 21.7 minutes.

Additionally, all 14 participating children met the following situations based on the information provided by the main caregiver on the Pre-screening Questionnaire, Demographic, Developmental, and Health Questionnaire, General Sleep Information Questionnaire, and Children's Sleep-Wake Scale:

- No physical handicap that would interfere with testing (blindness, deafness), developmental disabilities (pervasive developmental disorder, mental retardation, autism, etc.), chronic medical conditions (asthma, diabetes, cancer, etc.), neurological disorders (epilepsy, etc.), metabolic disorders, infectious illness, or lead poisoning.
- No parental-report that the child's sleep schedule varied by more than two hours in the stabilization period (the week before the first test day).
- No travel across more than two time zones within two months prior to the study period.
- No sleep problems (sleep walking, enuresis, night terrors, obstructive sleep apnea, sleep onset association disorder, limit setting disorder, etc.) indicated by parents on the pre-screening questionnaire.

- No medication affecting the sleep-wake cycle, daytime sleepiness-alertness, or the circadian system.
- No allergies, fever, illness, or symptoms involving respiratory infection during the study period.
- No history of head injury leading to loss of consciousness.
- No family history of diagnosed (first degree) psychosis, bipolar disorder, or narcolepsy.

Recruitment and Retention

Recruiting Period. Researchers visited allied childcare centers to solicit caregivers and children interested in participating in the study. Caregivers who expressed interests were contacted by the researchers by phone to confirm their interest, to be given a more detailed explanation of the study, to take a preliminary screening questionnaire, and to set a date for the introductory appointment, for a caregiver and the child, at the laboratory.

Introductory Appointment. Caregivers and children visited the laboratory to fill out the consent forms and screening questionnaires and to become familiar with the researchers, the lab environment, the home protocols (sleep diaries), the study equipment (actigraphy, facial EMG), the study protocols (via a training video), and the research schedule. At this time the first facial EMG session was scheduled, one week after the initial home-monitoring begins. The caregivers were given contact information for the researchers, in case they have questions or encounter problems with the actigraphy.

Home-Observation Periods. After the introductory appointment, this experiment consists of a preliminary home observation period of seven days, followed by two in-lab facial EMG appointments. Following the first test day, participating children were monitored at home during three-day recovery periods. During all home-observation periods (the first stabilization week and the three-day recovery periods between the first and second test day), caregivers kept sleep diaries of the study children's sleep-wake schedule, and the children wore Actiwatch (motion-sensing monitor to record the sleep-wake schedule). Because both facial EMG assessments are performed in the laboratory, it is critical that caregivers follow research protocols and keep scheduled appointments. Because the appointments are crucial, the research team regularly contacted participating families by phone, email, and text, to remind them of appointments and to offer reassurance or answer questions about equipment or protocols.

Families were contacted by phone two days before each laboratory appointment, and contacted by text and email on the day before each appointment. Additionally, two days after the introductory appointment, during the seven-day Stabilization period, the research team contacted each family by phone a) to thank them for their participation, b) to offer to answer any questions, and c) to remind them of the next appointment date.

Compensation. As an additional method to promote cooperation by caregivers for the entire duration of the study, participating families received total $50.00 upon completion of the second Facial EMG Appointment ($25.00 for the second time to visit the laboratory, another $25.00 for the last time to visit the laboratory).

Screening

Screening participants for participation involves three steps: a) a recruitment interview delivered onsite at daycare facilities, b) a preliminary telephone interview with the parent/primary-caregiver, and c) administration of parent/primary-caregiver questionnaires (listed below) that more thoroughly assess inclusion and exclusion criteria. After these three steps, eligible participants then enter the study.

Materials

This study utilizes a number of survey instruments and questionnaires, as well as electronic equipment such as Actiwatch and facial EMG.

1. *Pre-screening Questionnaire.* Primary caregivers are given an explanation of the study and administered a telephone interview that focuses on inclusion and exclusion criteria.
2. *Demographic, Developmental, and Health Questionnaire.* Primary caregivers complete this form to provide demographic, medical, and health information about the family and child. This questionnaire addresses exclusion criteria previously discussed.
3. *General Sleep Information Questionnaire (GSI).* This 26-item questionnaire asks primary caregivers about their child's sleep quantity, sleeping arrangements, weekday/weekend sleep schedules, and morning/evening preference.
4. *Children's Sleep-Wake Scale (CSWS).* This 26-item sleep quality questionnaire was finished by a primary caregiver. The CSWS is designed to assess five behavioral dimensions of sleep behavior in preschooler and early school-aged children (2- to 8- years-old). The five subscales are: Going to Bed, Falling Asleep, Maintaining Sleep, Reinitiating Sleep, and Returning to Wakefulness. Subscale scores range from 1 to 6, with higher scores indicating better sleep quality. In LeBourgeois and Harsh's (2004) validation results, the

correlation between CSWS subscale scores and sleep diary and actigraphic data showed that the CSWS is an effective research instrument with adequate construct validity (LeBourgeois & Harsh, 2004).

5. *Sleep-Wake Diary.* The 15-item Sleep-Wake Diary is designed to allow primary caregivers to fill in daily information about children's bedtimes, wake times, and naps, as well as information about particular events related to sleep, and activities that take place while the Actiwatch is off. Previous research (Gaina, Sekine, Chen, Hamanishi, & Kagamimori, 2004) showed correlation coefficients between the Sleep-Wake Diary and Actiwatch data of 0.49 for sleep latency, 0.99 for sleep onset time, 0.99 for wake time, and 0.97 for total sleep duration. These results are sufficient to justify use of the Sleep-Wake Diary as a confirmatory instrument to screen children's sleep habits while participating in the current study.
6. *Actigraphy (Actiwatch).* Actigraphy utilizes a wristwatch-like device, worn on the wrist of the non-dominant hand, to record motor activity. Compared to conventional methods such as polysomnography (PSG), actigraphy is a less invasive method which allows researchers to obtain a continuous recording of individuals' sleep-wake schedules. A validation study (Sadeh, Lavie, Scher, Tirosh, & Epstein, 1991) found that the total agreement rate between conventional PSG and actigraphic monitoring was 85.3% overall, subdivided into 76.9% for wake minutes and 87.7% for sleep minutes. This study utilizes Actiwatch 64 Actigraphy System (Respironics, 1999), with an accelerometer sensitivity of 0.05g, a sampling rate of 32 Hz, and possible sampling epoch

lengths of 0.25, 0.5, 1.0, 2.0, 10.0, and 15.0 minutes. Actigraphic data from participants' Actiwatch was downloaded into a laboratory computer, where Actiware Software (v.5) (Respironics, 2005) was used to categorize sleep-wake periods according to movement amplitude criteria. Movement amplitudes above a particular threshold caused a given epoch to be scored as awake. This study utilized actigraphy to monitor the stability of participants' sleep-wake schedules before the initial test day and between subsequent test days.

7. *Facial EMG.* Facial Electromyography (fEMG) refers to the technique of measuring facial muscle activity by detecting and subsequently amplifying electrical impulses generated when muscle fibers contract (Larsen, Norris, & Cacioppo, 2003). fEMG focuses on two facial muscle groups, the corrugator supercilli, a muscle in the eyebrow which is associated with frowning and whose activity correlates with negative emotional reactions and mood states, and the zygomaticus major, a muscle in the cheek associated with smiling and whose activity is correlated with positive emotional reactions and mood states (Magnée et al., 2007). fEMG has been utilized in past studies (McManis et al., 2001; Shackman, 2009; Tassinary, Cacioppo, &Vanman, 2007) as a tool to measure emotional reaction in a way that is a) precise, b) sensitive, c) and non-invasive, and which d) does not heavily rely on subjects' memory, cognitive ability, or accuracy in self-reporting emotional responses.

Measures

Electromyography was used to record levels of muscle reactivity by bipolar montage over two locations: the corrugator supercilli and zygomaticus major. Activity over the muscle of corrugator supercilli has been shown to be an index of positive emotion responses and activity over the zygomaticus major muscle has been also shown to be a marker of negative emotion responses (Cacioppo et al., 1986). Standard EMG electrode preparation and placement procedures were followed (Tassinary, Cacioppo, & Green, 1989; de Wied et al., 2009; Tassinary, Cacioppo, Vanman, 2007). First, the skin over the muscle group was wiped with alcohol swaps and gently abraded with NuPrep Gel. Electrodes were Gereonics 2mm plastic electrodes. Muscle activity was continuously recorded using a Grass Model 7P51. Activity over each muscle was recorded at a sampling rate of 60 Hz with a 10 Hz to 500 Hz bandpass filter. All raw EMG data were rectified and then transformed by square-root to correct for positive skewed as the processed data (Larsen & Norris, 2009).

Data were collected with the children seated on the lap of an undergraduate assistant or seated alone (depends on the body size of the child) in front of a computer screen approximately 30 cm away. An undergraduate assistant read to children to shift their attention while the experimenter placed electrodes for approximately 10 minutes. During testing, children were instructed to focus on pictures presented on the computer screen with corresponding sounds. The duration of the total 32-trial emotional stimuli task was approximately 11 minutes. Upon finishing the task, children received snacks as a reward. The complete procedure of stimuli displaying was described in Stimulus section (See Figure 8).

Procedure

This repeated-measure study involved at-home monitoring and subsequent in-lab testing of physiological and behavioral measures for control (napping) and experimental (nap-deprived) conditions. The study protocol includes a) an in-home training session with children to ensure they perform, accept, and enjoy the study procedures, b) daily caregiver monitoring of children's sleep and behavior via sleep diaries, c) use of Actiwatch to acquire objective data on children's' sleep-wake patterns, including sleep schedule variability, sleep quantity and quality, and daytime activity patterns, and d) family cooperation in scheduling and complying with one introductory appointment and two in-lab experiments. For each participant, participation after initial recruitment took place during a one-week period (see Figure 7). Each child was assigned into both Nap-Deprived Condition and Napping Condition in a counterbalanced design.

Introductory Appointment Day: The Beginning Day

Once the qualified caregivers and the children agree to participate in the study during the phone recruitment, they would be invited to visit the Sleep Laboratory in the Psychology Department at the University of Southern Mississippi. On this Introductory Appointment Day, caregivers and children were asked to fill out consent forms and screening questionnaires. In order to make the participants familiar with the researchers, lab environment, and the equipment, the researcher introduced the procedure with the caregiver and played some interactive games (e.g., colored the coloring books or played the Lego game together) with the children.

Stabilization: Home-Observation Period

Followed by the introductory appointment, participating children underwent a 7-day period of stabilization in which their caregivers promoted and encouraged a sleep schedule consisting of 11-12 hours of sleep in each 24-hour period. Schedule compliance was verified by caregiver sleep diaries, actigraphy, and periodic contact with the caregivers and children. The stabilization period was important because it serves to minimize the children's sleep restriction and to stabilize the children's circadian rhythm in the daily schedule.

During this stage participants were encouraged to sleep in their own homes, in their accustomed beds, with the lights off or dimmed to the family's usual sleeping levels, and with no distractions such as television or music playing during the sleeping period. Participating caregivers were urged to encourage children to stay in bed during their scheduled sleeping hours and to avoid letting the children consume caffeine or other substances that may alter their circadian rhythms or otherwise affect their sleep.

After the stabilization period ends, participating families visit the sleep laboratory after children's accustomed afternoon nap time. The research team greeted the children and caregivers and discussed the children's sleep schedule in the *Stabilization* week. Following that, participating children were assigned into Nap-Deprived Condition or Napping Condition. Both conditions include 1st Test Day (1st Facial EMG Appointment), Recovery Period, and 2nd Test Day (2nd Facial EMG Appointment).

Nap-Deprived Condition

1st Test Day (1st Facial EMG Appointment). Participating children who were assigned into Nap-Deprived Condition were instructed to have quiet play for their habitual nap duration at home. The activity of quiet play was verified by actigraphic data. Children in the Nap Condition had a habitual nap at home. Following the quiet play or nap time at home, children in both groups were brought into the laboratory of the Psychology Department at USM by caregivers. When the children and the caregiver arrived, the experimenters introduced themselves and played with the children for 20 minutes. The research team members played with the children for a time before applying the fEMG for a short while, such that the children have an opportunity to grow used to the fEMG equipment. Interactive play time may make children more comfortable and familiar with the environment and the research team. After play, the children were brought to the room where the experimenter attaches electrode leads on children for conducting facial EMG. When finishing 10-minute EMG attachment, the children were exposed to a stimuli presentation consisting of cue images followed by positive and negative stimuli images and associated sounds. The emotional stimuli were displayed in a counterbalanced order, with each emotional stimuli proceeded by the cue. The emotional stimulus slideshow lasted approximately 11 minutes.

After the emotional stimuli, the fEMG electrode leads were removed, the caregivers were invited to ask questions, and the research team reminded the caregivers about the actigraphy and sleep diary monitoring procedures to be maintained during the recovery period between two test days.

Between Test days: Recovery Period. After the 1st test day in Nap-Deprived Condition or Nap Condition, participating children underwent a 3-day period of recovery in which their caregivers promote and encourage a sleep schedule consisting of 11-12 hours of sleep in each 24-hour period. Schedule compliance was verified by caregiver sleep diaries and actigraphy. The recovery period is important because it serves to minimize the children's sleep restriction and to stabilize the children's circadian rhythm after the disruptions which may have occurred during a test day for some of the participating children.

2nd Test Day: 2nd facial EMG Appointment. After three recovery days end, participating families had the 2nd Test Day starting with the nap or quiet play at home. During the 2nd facial EMG Test Day, the children who took naps on the 1st Test Day were assigned to Nap-deprived condition; On the contrary, the children who didn't take naps on the 1st Test Day were assigned to Nap condition. The following procedure of the quiet play, active play, and the procedure culminating in the hook-up of the facial EMG was identical to those outlined in 1st Test Day: 1st facial EMG appointment. After facial EMG attachment, the children were exposed to the second set of stimuli pairs. The first and second set of stimuli pairs were matched in stimuli valence and arousal dimensions based on the normative ratings. Procedures culminating in the hook-up of the facial EMG were identical to those outlined in 1st Test Day: 1st facial EMG appointment. The remaining procedures of 2nd Test Day were identical to the procedures utilized in 1st Test Day. At the end of 2nd Test Day, participating families received the compensation and the appreciation from the research team.

Napping Condition

In Napping Condition, the children had the opportunity to take a nap at home during their habitually napping time and the Actiwatch was applied to confirm the nap. This is the only different procedure than in Nap-Deprived Condition. The active play after the habitually napping time serves to allow children who had just been napping time to recover from the sleeping state. The rest of procedures in Napping Condition were the same as in the Nap-Deprived Condition.

Recovery Period between Conditions

When the child switched from Nap-Deprived Condition to Napping Condition or from Napping Condition to Nap-Deprived Condition in a counterbalance design, 3-day recovery period was applied to the transition time between two conditions to eliminate the possible carry-over effect from the previous condition.

Stimulus

Visual stimuli consisted of positive and negative pictures, and each was paired with an appropriate positive and negative. In order to elicit children’s emotional responses, both the visual and the auditory stimuli were selected on the basis of adequate normative ratings of valence and arousal. For this study, each visual stimulus was paired with an appropriate auditory stimulus (i.e., a positive picture was paired with a positive sound: e.g., a friendly cat along with the sound of softly meowing). These pairings of visual and auditory stimuli were *fixed* for the duration of the study. In other words, each unique visual stimulus was always be shown accompanied by a unique and matching auditory stimulus. Each pairing of stimuli was evaluated and screened by a panel of research assistants. Based on the feedback of a panel, the selection and composition of pairing of visual and auditory stimuli was adjusted.

Each trial lasted for 11 seconds, starting with the fixation, and then the presentation of cue, followed by one stimuli pair presentation (7 seconds; see Figure 8). Each pairing of stimuli was preceded by a cue. Cue is a cross in the center of the white-background screen with the sound. For preschool-aged participants, the purpose of the cue is a signal to prepare participants to be ready for upcoming stimuli. Considering the experimental design, the duration of the fixation (see Figure 8) is used to reduce the potential of the carry-over effect from the previous stimuli. A two-second blank frame with a cue was followed by a female or male voice of a theme or object name for two seconds which indicated the following stimuli. (e.g., "Light bulb" was spoken out and then the participant would see the picture and hear the corresponding sounds paired with the stimulus of light bulb).

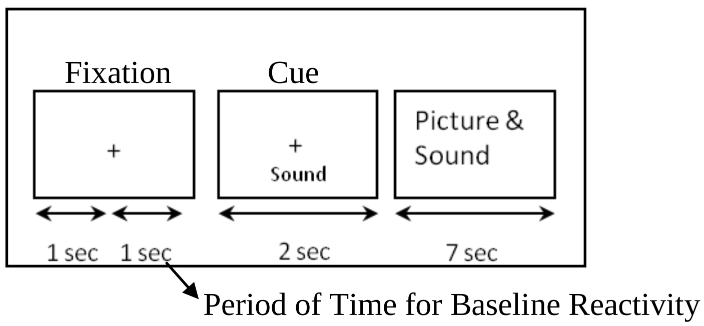

Figure 8. Simplified Diagram of Experimental Protocol of Stimuli Presentation.

The visual stimuli utilized came from the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention [CSEA], 1999; Lang, Bradley, & Cuthbert, 1999; McManis et al., 2001; Sharp, van Goozen, & Goodyer, 2006). The selected pictures based on the chosen pictures from several past findings, which illustrated that the pictures were able to elicit children's differentiated emotional responses. Part of the particular IAPS pictures selected were the same utilized in the second experiment (Experiment 2) from the 2001 study by McManis et al. (2001), which demonstrated that the pictures in experiments elicited emotional responses, as measured by EMG activity, in 7 to 10-year-old children. Additionally, other particular IAPS pictures were selected from the particular pictures used in numerous studies (Sharp et al., 2006). The auditory stimuli accompanying the pictures were selected from the International Affective Digitized Sounds (IADS) database (Bradley & Lang, 1999). The normative valence of the IAPS emotional pictures and IADS emotional sounds were obtained on Self-Assessment Manikin (SAM) scale. The SAM scale assesses two dimensions of emotional responses to stimuli, hedonic valence, and arousal dimension. Hedonic valence dimension has the rating item from 1 (unhappy: negative valence) to 9 (happy: positive valence), and 5 is the midpoint (neutral); similarly for arousal dimension, rating items are from 1 (calmed) to 9 (aroused), and 5 is the midpoint (neutral) as well.

This present study considers the emotional responses of children under two conditions: napping and nap deprivation. All participating children were exposed to a total of 64 unique visual and auditory stimuli pairings. For each condition, a total of 32 visual-auditory stimuli pairs were utilized. The 32 stimuli pairs were selected based on the normative ratings on hedonic valence dimension: 8 as strong negative stimuli (extremely negative value in hedonic valence 1~2), 8 as strong positive stimuli (extremely positive value in hedonic valence value 8~9), 8 as weak negative stimuli (mildly negative value in hedonic valence 4~5), and 8 as weak positive stimuli (mildly positive value in hedonic valence 5~6).

Analyses

This study explores the research question: "How does nap restriction affect children's emotional responding?" by using the following analyses.

All analyses were performed with the aid of SPSS (v. 15). Prior to analyses, all paper-and-pencil questionnaires and sleep diaries were double-entered and checked for data integrity by the research team. Exploratory data analyses consisted of explorations of bivariate and univariate distributional characteristics. In order to view extreme scores, descriptive statistics were computed for every variable. Outliers (scores $\geq$ 3 standard deviations from the mean) were identified and removed. A one-tailed repeated-measure t-test was used to examine the dependent variable in hypotheses 1a and 1b, which is the facial EMG data reflecting the negative emotional responses between both conditions (see Figure 5). Another one-tailed repeated-measure t-test was adopted to test the dependent variable in hypothesis 2a and 2b, which is the facial EMG data reflecting the positive emotional responses between both conditions (see Figure 6). For Exploratory analysis, a 2 (Nap: yes or no) x 2 (Emotional Intensity: strong or weak) x 2 (Valence of stimuli: negative or positive) repeated-measures analysis of variance (ANOVA) was used to examine the impact of nap deprivation on emotional responses to stimuli.

Planned Comparisons

One of the major interests of this study is driven by the past findings. Essentially, the previous findings have demonstrated that, for adults who are sleep restricted, the responses to strong emotional stimuli are amplified, while responses to weak stimuli are reduced. Based on these previous empirical supports, this study attempts to ascertain whether or not these patterns of effect hold true with preschool children and match the working model, through planned comparisons between nap-deprived and napping conditions:

Hypothesis 1a. Habitually napping children would have greater responses to strong negative stimuli when they are deprived of a nap, compared to when they are not deprived.

Hypothesis 1b. Habitually napping children would have reduced responses to weak negative stimuli when they are deprived of a nap, compared to when they are not deprived.

Statistical analysis for Hypothesis 1a and 1b: One-tailed repeated measure t-test was adopted to test the difference in objective measure facial EMG signal to strong and weak negative stimuli between Nap Condition and Nap-deprived Condition.

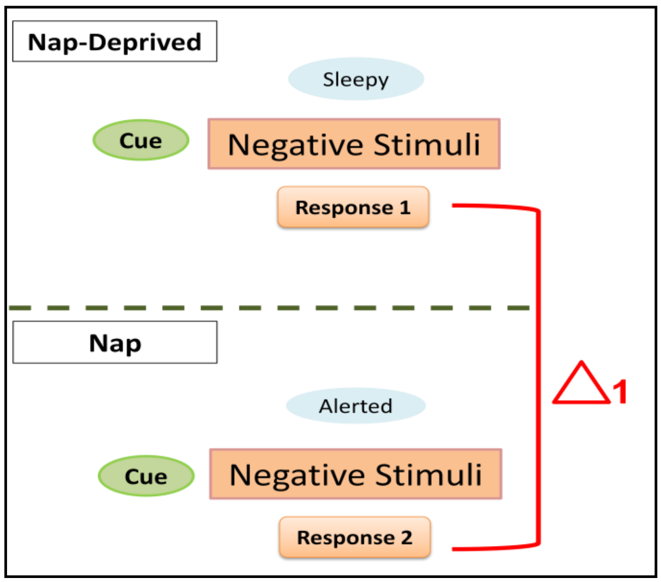

Figure 5. Simplified Diagram of Experimental Design (Hypothesis 1).

Hypothesis 2a. Habitually napping children would have greater responses to strong positive stimuli when they are deprived of a nap, compared to when they are not deprived.

Hypothesis 2b. Habitually napping children would have reduced responses to weak positive stimuli when they are deprived of a nap, compared to when they are not deprived.

Statistical analysis for Hypothesis 2a and 2b: One-tailed repeated measure t-test was adopted to test the difference in facial EMG signal to strong and weak positive stimuli between Nap Condition and Non-nap Condition.

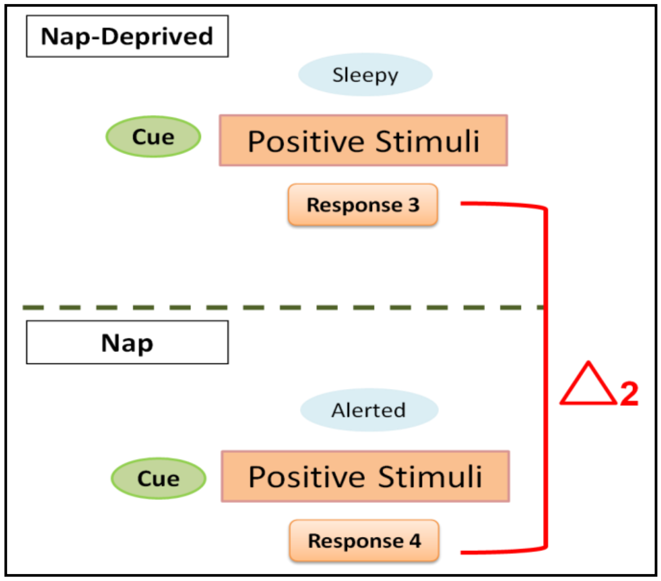

Figure 6. Simplified Diagram of Experimental Design (Hypothesis 2).

Sample Size Estimation

Differences in the emotional responses of sleep restricted (nap-deprived) and rested (napping) preschoolers, measured through fEMG, has not been attempted in the past. However, drawing a) on previous research by Crossin et al. (2008), examining the impact of nap-deprivation on the preschoolers' emotional responding reflecting by using the alternative and coping strategies, the range of the effect size is from 0.5 to 2.0. b) on research by de Wied et al. (2009), using fEMG data to examine 8 to 12-year-old boys' emotional responses to emotion-inducing film clips; the range of the effect size is from 0.53 to 0.82. And c) on research by McManis et al. (2001), demonstrating that the fEMG responses of 7 to 10-year-old children to emotional stimuli was similar to that of adults; therefore, an effect size of 0.80 was adopted to estimate required sample size in the power analysis for this study.

A power analysis using G*Power Software (v 3.0.10) (Erdfelder, Faul, & Buchner, 1996) was adopted to calculate the required sample size for a repeated measure *t*-test design (one-tailed test, alpha level = 0.05, power = 0.80). The differences in facial EMG signals between Nap-deprived and Nap conditions was examined. The result of power analysis indicated that total 12 subjects are necessary to reach an effect size of 0.80 (actually power is 0.829), which represents the effect of nap deprivation on preschoolers' emotional responses.

CHAPTER III

RESULTS

Napping

Fourteen habitually napping children as the samples of target population were recruited in the present study. The qualifications of habitually napping pattern (at least 4 napping days per week, and average napping duration should be more than 45 minutes) were verified by (1) the Pre-screening Questionnaires (What is the duration of napping time?) self-reported by participating parents and (2) Actiwatch and sleep diaries during Home-Observation Periods (the stabilization period before the second laboratory visit). On the Pre-screening Questionnaires, parents reported the average 5.29 $\pm$ 0.87 napping days per week. Based on the collected data by sleep diary and Actiwatch, the average napping day per week was 5.36 $\pm$ 1.15 napping days per week. The results indicated no difference between these two sources of information, $t(13) = 0.268$, $p > .05$. Separately, all 14 participating children were confirmed to match the criterion of napping days per week for being habitually napping children in this study.

Nap Timing and Duration

Based on the collected data from self-reported Pre-screening Questionnaire, the average nap duration was 114 minutes (1 hour and 54 minutes) $\pm$ 21.6 minutes. During the Home-Observation Periods, the average napping duration of all total 14 participating children was 102.36 minutes (1 hour and 42.35 minutes) $\pm$ 19.03 minutes according to the record by Actiwatch and sleep diaries. On average, the daytime nap started from 1:13pm (SD = 42 minutes) to

2:55pm (SD = 42 minutes). All napping durations of 14 children were longer than 45 minutes. Due to the malfunction of Actiwatch devices and neglect of filling sleep diaries, two participating children had missing data for two days during 7-days home observation periods, however, other days in the same week indicated that they did have 4 napping days, each napping duration was at least 45 minutes, and stable sleep-wake pattern; therefore, these two participating children were still considered as qualified participants.

Nocturnal Sleep Timing and Duration

The average 11 to 12 hours of sleep (over a 24-hour period) is recommended for 3- to 5-year-old preschool children (Mindell & Owens, 2003). The 14 participating children in the study showed the corresponding sleep-wake pattern and nocturnal sleep duration. On average, their nocturnal sleep duration was 9 hours and 39 minutes (SD = 30.50 minutes), which was from nocturnal bedtime as 9:55pm (SD = 1.13 hours) to wake-up time in the morning as 7:33am (SD = 1.17 hours).

Muscle Reactivity as Emotional Responses

Facial electromyography (fEMG) was used to measure two groups of facial muscle reactivity, the zygomaticus major and the corrugator supercilli, reflecting positive and negative emotional responses towards stimuli respectively (Magnée et al., 2007). The raw fEMG data was electric activity generated during facial muscle contractions corresponding to emotional stimuli set (Hess, 2009). The basic unit of electric activity collected from two groups of muscle in this study was volt (v). The processed EMG data (see Measure section) during stimulus presentation was adopted as the emotional responses towards each stimulus set. Likewise, the processed EMG data during one-second pre-stimulus presentation (one second before the sound; see the sequence of stimulus display; Figure 8.) was adopted as the baseline EMG reactivity. Visual inspection of video recordings was conducted to identify stimulus-irrelevant facial muscle movement (e.g., talk, cough, sneeze, or hand touching face) and bodily movement (e.g., turn head away from screen or swing body) during baseline and picture display. Following the visual inspection, the average 19.64% of baseline reactivity and the average 3.57% of pictures for each child were removed. Then, the processed EMG data three standard deviations above or below was considered outliers and removed from the subsequent analysis. The EMG reactivity toward each stimulus as changed percentage scores from baseline activity was calculated for each participant (Larsen & Norris, 2009).

Planned Comparisons Corresponding to Specific Hypotheses

Four hypotheses were designed in this study to support the working model of altered emotional responses following sleep loss. Here are the hypotheses and the corresponding statistical results.

Hypothesis 1a stated that habitually napping children have greater responses to strong negative stimuli when they are deprived of a nap, compared to when they are not deprived. Consistent with this prediction, habitually napping children demonstrated greater emotional responses to strong negative pictures when they were deprived of nap ($M = 25.84$, $SD = 20.18$), compared to when they were not deprived ($M = 13.47$, $SD = 10.08$), $t(13) = 1.949$, $p < .05$, Cohen's $d = 0.52$; Figure 9.

Hypothesis 1b stated that habitually napping children have reduced responses to weak negative stimuli when they are deprived of a nap, compared to when they are not deprived. Inconsistent with this prediction, the emotional responses of habitually napping children in nap condition (M = 18.26, SD = 17.50) were not reduced when they were nap-deprived (M = 27.21, SD = 22.31), t (13) = -1.110, p> .05; Figure 9.

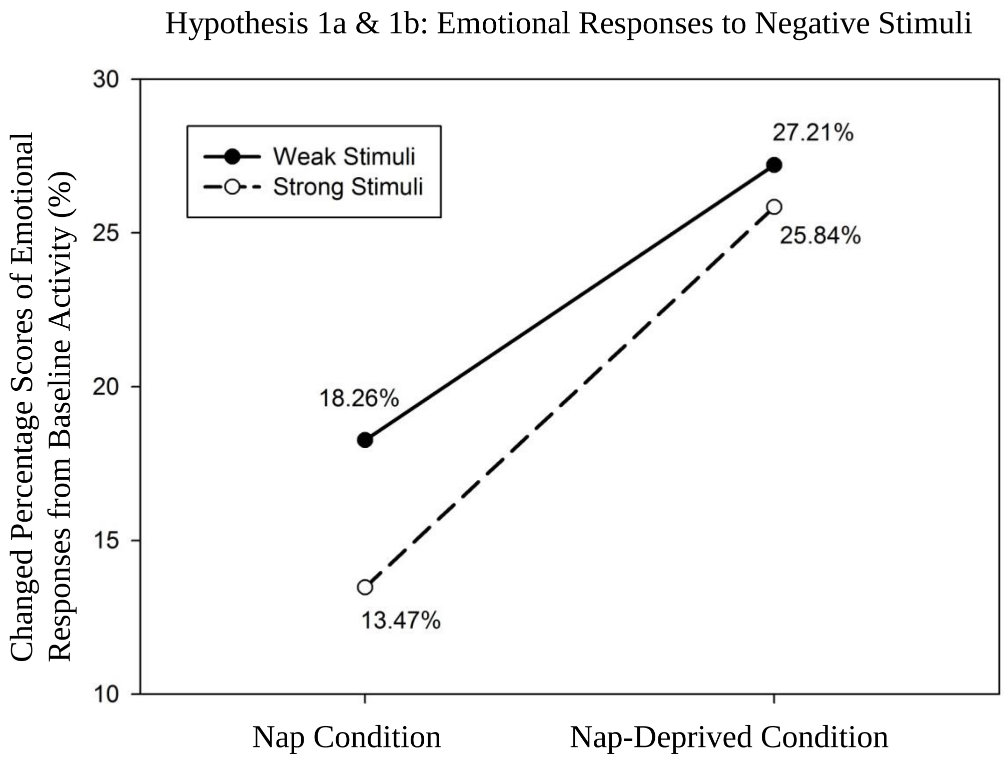

*Figure 9.*Hypothesis 1a and 1b predicted that habitually napping children have greater emotional responses to strong negative stimuli and blunted responses to weak negative stimuli following nap-deprivation condition. Our results supported that the amplified emotional responses to strong negative not weak negative stimuli after nap-deprivation. Dependent variable (scores on y axis) is the changed percentage score (%) from baseline activity. * p < .05.

Hypothesis 2a stated that habitually napping children have greater responses to strong positive stimuli when they are deprived of a nap, compared to when they are not deprived. A one-tailed repeated-measure t test was conducted to test Hypothesis 2a. The hypothesis indicated that the positive emotional responses toward strong positive pictures in nap-deprived condition (M = 45.15, SD = 27.97) were greater than in nap condition (M = 28.86, SD = 23.99), t (13) = 2.125, p< .05, Cohen's d = 0.57; Figure 10.

Hypothesis 2a & 2b: Emotional Responses to Positive Stimuli

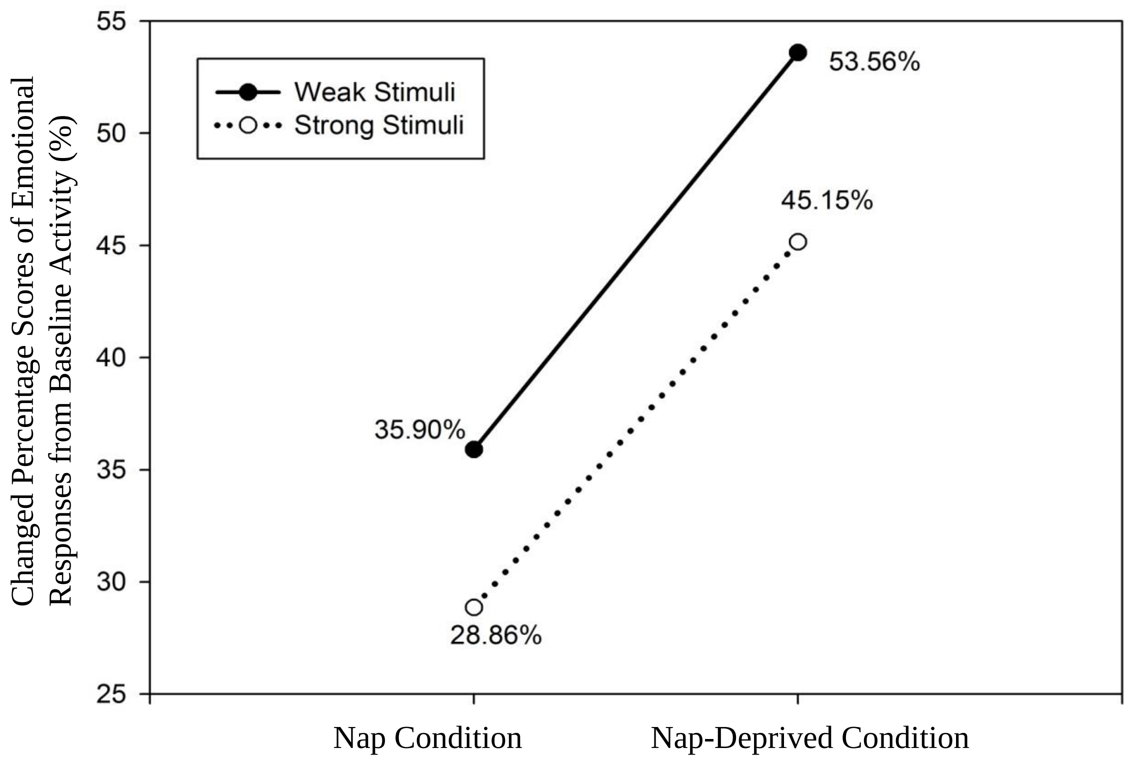

*Figure 10.*Hypothesis 2a and 2b predicted that habitually napping children will have greater emotional responses to strong positive stimuli and blunted responses to weak positive stimuli following nap-deprivation condition. Our results supported that the amplified emotional responses to strong positive not weak positive stimuli after nap-deprivation. Dependent variable (scores on y axis) is the changed percentage score (%) from baseline activity. * p < .05.

Hypothesis 2b stated that habitually napping children have reduced responses to weak positive stimuli when they are deprived of a nap, compared to when they are not deprived. This hypothesis was not supported. A reduction in emotional responses towards the emotional pictures between nap condition (M = 35.90, SD = 24.86) and nap-deprived condition (M = 53.56, SD = 73.83), t (13) = -1.045, p = 0.315; Figure 10.

Exploratory Analysis

A 2 (Nap: nap or nap-deprived) x 2 (emotional valence of stimuli: negative or positive) x 2 (emotional intensity of stimuli: strong or weak) completely repeated-measure analysis of variance (ANOVA) was adopted as part of exploratory analysis of the findings. Results supported that the emotional responses of 3- to 5-year-olds toward stimuli were affected by nap deprivation. The analysis yielded a main effect of nap-deprivation $F(1, 13) = 7.597$, $p < .05$, $eta^2 = .369$, with greater emotional responses in nap-deprived condition ($M = 37.9$) than in nap condition ($M = 24.1$) (see Figure 11). Another main effect of valence of emotional stimuli indicated $F(1, 13) = 5.228$, $p < .05$, $eta^2 = .287$, with greater emotional reactivity towards positive stimuli ($M = 40.9$) than towards negative stimuli ($M = 21.2$) (see Figure 12). None of interactions between variables had been found.

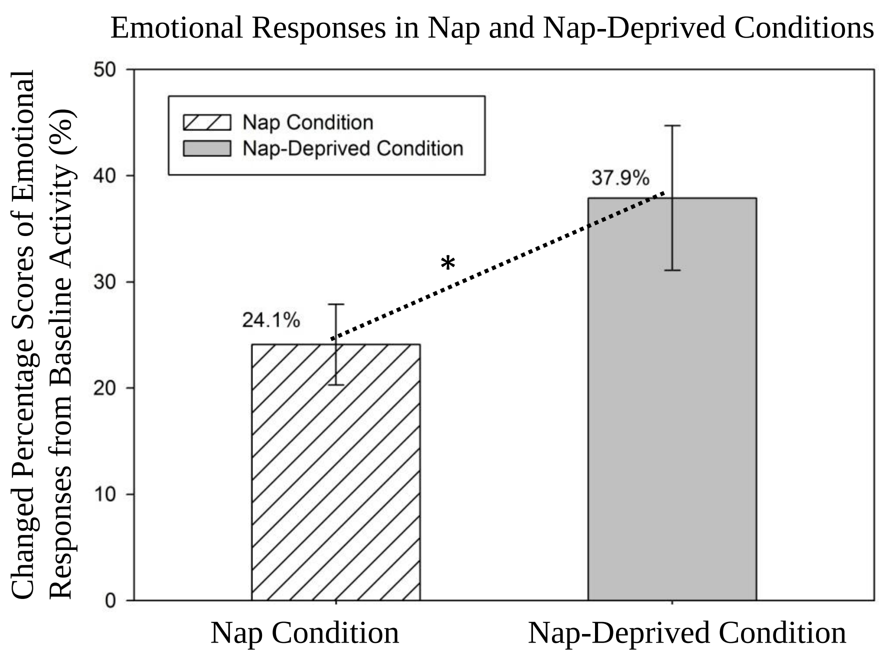

Figure 11. The habitually napping children showed amplified emotional responses after nap-deprivation, compared to nap condition. * $p < .05$.

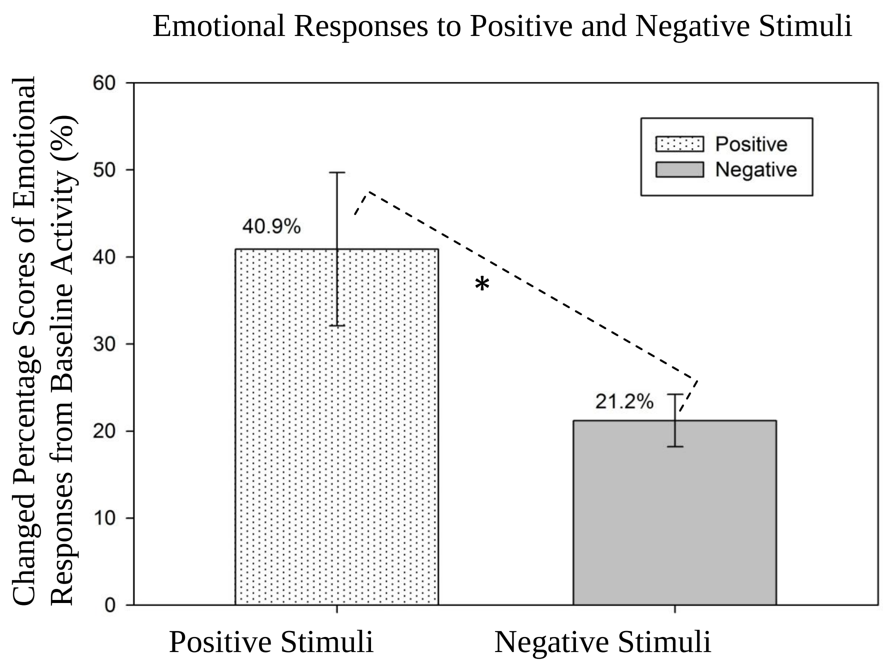

Figure 12. The habitually napping children showed greater emotional responses to positive emotional stimuli, compared to negative emotional stimuli. * $p < .05$.

CHAPTER IV

DISCUSSION

The present study indicated that the emotional responses toward strong both positive and negative stimuli by 3- to 5-year-old habitually napping preschoolers were affected by withholding a nap. The present study is one of few studies investigating the effect of altered emotional responses following sleep deprivation on young children of ages 3 to 5 (cf. Berger, Miller, Seifer, Cares, & Lebourgeois, 2012). The results related to four specific hypotheses proposed by this study are discussed in the following paragraphs.

A major purpose of the current study was to investigate the impact of nap-deprivation on children's emotional responses to stimuli. Specifically, the hypotheses predicted that habitually napping children would have greater emotional responses to relatively stronger negative, as well as, stronger positive stimuli. Our data supported these hypotheses by showing greater magnitude of related facial muscle reactivity to emotional stimuli when children were in nap-deprived condition, compared to napping condition. This intensified emotional responses to stronger emotional stimuli after nap-deprivation further supported our working model of hypoactivation in prefrontal cortex. The decreased prefrontal activity following sleep deprivation may be associated with a failure of top-down regulation of activity in amygdala and further related to dysregulation of emotional responses to strong stimuli. Our findings of greater negative emotional responses to strong stimuli were consistent with Yoo et al.'s (2007) fMRI results after sleep deprivation which indicated increased activity in amygdala during the presentation of the 25% most negative emotional pictures. Likewise, our findings of greater positive emotional responses to strong stimuli were in accord with Gujar et al.'s (2011) neural imaging results, which revealed the increased activity in amygdala after sleep-deprived for 35 hours while categorizing the 25% most positive of emotional pictures.

We proposed a moderating effect of sleep loss on the relationship between the intensity of stimuli and the magnitude of emotional responding in an effort to reconcile the inconsistent results of prior investigations (Franzen et al., 2009; Gujar et al., 2011; Yoo et al., 2007; Zohar et al., 2005). Our working model emphasized that the altered emotional responses following sleep deprivation would be affected by the intensity of the emotional stimuli. While our findings with the relatively stronger stimuli were consistent with the model, we did not find support for the hypothesis that habitually napping children would have blunted emotional responses to weaker emotional stimuli when they were deprived of sleep.

In the working model, blunted emotional responses to weak stimuli were expected after no-nap because of the deficit in attention associated with hypoactivation in the prefrontal cortex. A possible explanation of our failure to find blunting is that during the experiment, participating children were asked to attend to the pictures showing on the computer screen. This requirement may have encouraged children to contribute more cognitive effort to processing weak stimuli resulting in compensating the insufficient attention associated with hypoactivation in the prefrontal cortex after nap deprivation. Note that the exploratory ANOVA actually supported the conclusion that nap deprivation was associated with increased responding to both the strong and the weak negative stimuli.

An additional explanation is that while the two sets of stimuli were categorized as “strong” and “weak,” they may not have been perceived as such by the children. This possibility is supported by the failure to find significant differences in the responses to the strong and weak stimulus sets. Although all visual stimuli in the current study were selected from International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1999), the youngest norming sample was children aged 7 to 9. For preschoolers, the understanding of the emotional stimuli may be different from the normative evaluation of older children. Therefore, the classification of magnitude of emotional stimuli may not have been appropriate. The children participating in this study were asked to rate each stimulus by choosing from four different animated faces based on their emotional feelings. This self-report subjective rating was used to verify the manipulation of emotional content of stimuli set in this study. However, most children didn't understand the meaning of the inquiry and provided no analyzable random data.

Another possible explanation of no difference in emotional responses to weak stimuli between nap and nap-deprived condition should be mentioned here. That is, the effect of sleep deprivation on emotional responses may not be moderated by the intensity of emotional stimuli. Specifically, sleep deprivation may consistently make all emotional stimuli more salient and lead to amplified emotional responding to both strong and weak stimuli. Lastly, the statistical results indicated that the variance in emotional responses to weak stimuli was sizable, and this variability may mask the effect of nap deprivation on emotional responses to weak stimuli.

The exploratory analysis revealed a greater response to positive emotional stimuli, relative to negative stimuli. This may reflect greater emotional responses in this age group to positive emotional stimuli or to differences in the intensity of the stimulus groups. On the other hand, this result may be attributed to recording from two different facial muscle groups. Instead of reflecting genuine emotional responses, the difference in magnitude of responses to two different emotional stimuli may reflect confounding due to recording from different facial muscle groups. Notably, Epstein (1990)'s facial electromyography study indicated that maximal electromyographic activity was greater in the zygomaticus major muscle during smiling than in the corrugator supercilii muscle during frowning.

Limitations and Future Directions

The major limitation of the present study is the applicability of the EMG measurement of emotional responding on children aged 3 to 5. Facial EMG is a sensitive measure to subtle changes in the electrical activity of corresponding facial muscles as individuals display different specific facial expressions. Likewise, facial EMG is also sensitive to changes in the electrical signals of emotion-unrelated facial muscles when moving tongue or lip. Even body movement (changing head positions or swinging body trunk) may be recorded by the EMG signals. Although the participating children were asked to sit still during the EMG recording while passively listening and watching stimuli, some children frequently moved their tongues and lips, moved the muscles of their cheek, and opened their eyes widely. Visual inspection via video recording was conducted to screen out artifact due to unrelated movement; however, artifact-contaminated EMG signals may still have been recorded. Alternative measurement of emotional responding is an important consideration for future studies.

One limitation is related to potential measurement bias. Since the author was the primary experimenter who recorded, measured, and collected the data, the experimenter may unintentionally influence the results during the process of study. Additionally, the sample size in the current study was limited. Although the number of participants in the present study satisfied the requirement of the statistical power of revealing effects, the small sample size of 14 children may not support the representativeness of population of 3- to 5-year-old children.

One future direction of this study is to further examine the effect of nap deprivation on emotional responses to weak stimuli. However, the classification of strong and weak emotional stimuli needs to be appropriate for diverse populations. Neutral stimuli should be considered to make the gradient of stimulus valence more complete. The pertinent work is to confirm the effect of eliciting corresponding responses by appropriate emotional stimuli selected from the normative database. Additionally, the adopted emotional stimuli should make participating children more engaged into the emotional scenarios. At-home or daycare-settings may be better than laboratory-setting research designed to make children accommodate themselves to the protocol of the study. The future study may consider making the main caregivers involve more with the procedure of the study. The caregivers' assistance may play an important role on soothing the uneasy feeling of participating children in order to reduce the artifact movement during EMG recordings.

APPENDIX A

IRB APPROVAL LETTER

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001 Phone: 601.266.6820 | Fax: 601.266.4377 | www.usm.edu/irb

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

The risks to subjects are minimized.

The risks to subjects are reasonable in relation to the anticipated benefits. The selection of subjects is equitable.

Informed consent is adequate and appropriately documented.

Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.

Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.

Appropriate additional safeguards have been included to protect vulnerable subjects.

Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".

If approved, the maximum period of approval is limited to twelve months.

Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **12050806**
PROJECT TITLE**: How does Nap Restriction Influence the Emotional Responding of Preschool Children?**
PROJECT TYPE**: Dissertation**
RESEARCHER/S**: Hui-Ya (Gail) Han**
COLLEGE/DIVISION**: College of Education & Psychology**
DEPARTMENT: **Psychology**
FUNDING AGENCY: **N/A**
IRB COMMITTEE ACTION**: Expedited Review Approval**
PERIOD OF PROJECT APPROVAL: **05/16/2012 to 05/15/2013**

Lawrence A. Hosman, Ph.D.
Institutional Review Board Chair

APPENDIX B

PRE-SCREENING QUESTIONNAIRE

Caretaker Name:____________________________ **Address:______________________________**

Telephone:_________________________________ ____________________________________

Convenient Time:____________________________

Email:_____________________________________ **Child's Name:_________________________________**

Telephone Screen

1. Child's DOB: ___________ and Age _________
2. What is your child's gender? [ ] M [ ] F
3. What is your child's race? [ ] B [ ] W
4. How many days per week does your child nap? ____
5. Does your child have regular napping days? [ ] Y [ ] N What days______________________
6. What time does usually your child take a nap? ____
7. What time does usually your child wake up from nap? ____
8. The duration of napping time:____
9. Is your child in daycare? [ ] Y [ ] N Where? ___________________________
10. Do you "know" when your child wakes up? ____
11. Does your child have any medical conditions? [ ] Y [ ] N [ ] DK
12. Does your child take any medications?
    a. Allergy meds
    b. Asthma meds
    c. Anti-inflammatories
13. Does your child have any indication they may have a sleep disorder? [ ] Y [ ] N [ ] DK
14. Caretaker Daily Schedule: ____

APPENDIX C

CHILD DEMOGRAPHICS/SLEEP QUESTIONNAIRE

Child Demographics/Sleep Questionnaire

Directions: These questions ask basic information about your child and your family. Some questions will ask you to write in the answers. For the other questions, put an "X" in the circle next to your answer.

Today's Date (mm/dd/yyyy): _____ / _____ / _____

1) Select one of the following for household contributor(s):
   - ☐ One spouse, male or female, gainfully employed
   - ☐ Both spouses gainfully employed
   - ☐ Head of house has never been married
   - ☐ Divorced person, employed full-time
   - ☐ Widow or widower who is not gainfully employed
   - ☐ Separated or divorced person who receives support payments

2) Total household income before taxes:
   - ☐ Less than $15,000
   - ☐ $15,000 to $24,999
   - ☐ $25,000 to $49,999
   - ☐ $50,000 to $99,999
   - ☐ $100,000 to $149,999
   - ☐ $150,000 or more

3) Contributor 1: Relationship to child:
   - ☐ Mother
   - ☐ Father
   - ☐ Other

4) Contributor 1: Highest level of education:
   - ☐ Jr. High
   - ☐ High School
   - ☐ Vocational
   - ☐ Some College
   - ☐ College Graduate
   - ☐ Graduate/Professional school

5) Contributor 1: Job title ____

6) Contributor 1: Age __________

7) Contributor 2: Relationship to child:
   - ☐ Mother
   - ☐ Father
   - ☐ Other

8) Contributor 2: Highest level of education:
   - ☐ Jr. High
   - ☐ High School
   - ☐ Vocational
   - ☐ Some College
   - ☐ College Graduate
   - ☐ Graduate/Professional school

9) Contributor 2: Job title ____

10) Contributor 2: Age __________

11) What is your child's usual bedtime on weekdays? ____:____ ☐ am ☐ pm

12) What is your child's usual wake time on weekdays? ____:____ ☐ am ☐ pm

13) What is your child's usual bedtime on weekends? ____:____ ☐ am ☐ pm

14) What is your child's usual bedtime on weekends? ____:____ ☐ am ☐ pm

15) If you child naps during the week, write in the usual time that this nap begins:

____:____ ☐ am ☐ pm

16) If you child naps during the week, write in the usual time that this nap ends:

____:____ ☐ am ☐ pm

17) How many days does your child naps during the weekend (Saturday - Sunday): ______

18) If you child naps during the weekend, write in the usual time that this nap begins:

____:____ ☐ am ☐ pm

19) If you child naps during the weekend, write in the usual time that this nap ends:

____:____ ☐ am ☐ pm

APPENDIX D

GENERAL SLEEP INFORMATION

General Sleep Information

The University of Southern Mississippi • Sleep Research Laboratory
parent-report form for 2- to 8-year-old children

Directions:
Please answer each of these questions by writing in or choosing the best answer.

1. Does your child have a regular bedtime routine? ☐ yes ☐ no
   If yes, how long does this evening routine last? _____minutes
2. Does your child have a regular bedtime? ☐ yes ☐ no
   If yes, write in the bedtime: ____ : _____
3. Does your child have his/her own bedroom? ☐ yes ☐ no
4. Does your child have his/her own bed? ☐ yes ☐ no
   If no, does your child share a bed with… ☐ an adult **OR** ☐ another child

---

5. When is your child most alert (choose one)? ☐ Morning ☐ Afternoon ☐ Evening
6. If allowed, how many nights each week would your child stay up past his/her regular bedtime? _____nights
7. If allowed, how many mornings each week would your child "sleep in" past his/her regular wake time? ______mornings

---

8. Where does your child usually fall asleep in the evening (choose one)?
   ☐ Own bedroom ☐ Play room
   ☐ Parental bedroom ☐ Family room
   ☐ Sibling's bedroom ☐ Other _________________________
9. Write in the amount of time your child spends in this room before he/she falls asleep: ______ hours ______ minutes

---

10. Mark the number of days each week your child takes a nap: ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7
    If child naps, write in usual nap time(s): ____ : ____ ☐ a.m. ☐ p.m. to ____ : ____ ☐ a.m. ☐ p.m.
    ____ : ____ ☐ a.m. ☐ p.m. to ____ : ____ ☐ a.m. ☐ p.m.
    ____ : ____ ☐ a.m. ☐ p.m. to ____ : ____ ☐ a.m. ☐ p.m.

---

11. Write in the earliest time your child goes to bed during a typical week. ____ : ____
12. Write in the latest time your child goes to bed during a typical week. ____ : ____

---

13. Write in the earliest time your child awakens during a typical week. ____ : ____
14. Write in the latest time your child awakens during a typical week. ____ : ____

15. Does your child resist or delay going to bed?

☐ yes ☐ no

If yes, do you think this resistance is…

☐ no problem
☐ a mild problem
☐ a moderate problem
☐ a severe problem

16. Does your child have difficulty falling asleep?

☐ yes ☐ no

If yes, do you think this difficulty is…

☐ no problem
☐ a mild problem
☐ a moderate problem
☐ a severe problem

17. Does your child arouse or awaken during the night?

☐ yes ☐ no

If yes, do you think these are…

☐ no problem
☐ a mild problem
☐ a moderate problem
☐ a severe problem

18. After arousing or awakening during the night, does your child have difficulty going back to sleep?

☐ yes ☐ no

If yes, do you think this difficulty is…

☐ no problem
☐ a mild problem
☐ a moderate problem
☐ a severe problem

19. Is your child difficult to awaken in the morning?

☐ yes ☐ no

If yes, do you think this is…

☐ no problem
☐ a mild problem
☐ a moderate problem
☐ a severe problem

20. Is your child a poor sleeper?

☐ yes ☐ no

If yes, do you think this situation is…

☐ no problem
☐ a mild problem
☐ a moderate problem
☐ a severe problem

21. Rate your child's **success** from **very poor** to **very good** for the following areas of sleep :

Going to bed at bedtime

very poor | | | | | | | | | | very good

Going to sleep after "lights-out"

very poor | | | | | | | | | | very good

Staying asleep during the night

very poor | | | | | | | | | | very good

Returning to sleep after waking during the night

very poor | | | | | | | | | | very good

Waking up in the morning

very poor | | | | | | | | | | very good

Overall sleep

very poor | | | | | | | | | | very good

22. Mark the OVERALL physical activity level of your child during the 30 minutes before he/she falls asleep:

|__|__|__|__|__|__|__|__|__|__|

very active very inactive

Weekday Sleep Schedule

23. The child's usual bedtime on weekday nights: ______:______

24. The child's usual wake time on weekday mornings: ______:______

Weekend Sleep Schedule

25. The child's usual bedtime on weekend nights: ______:______

26. The child's usual wake time on weekend mornings: ______:______

APPENDIX E

CHILDRENS' SLEEP WAKE SCALE

Children's Sleep Wake Scale

The University of Southern Mississippi • Sleep Research Laboratory
parent-report form for 2- to 8-year-old children

Directions

Please think about **the past week** when answering the following questions. If the past week has been unusual for some reason, choose the **most recent typical week.** You should answer how often the behaviors happen each week using these choices:

Never
Once in Awhile
Sometimes
Quite Often
Frequently, if not always
Always

Also, tell us the number of days or nights per week each behavior happens by circling a number between 0 and 7.

Questions 1 – 12 **only concern** your child **Taking a Nap .**

	When its time to go to nap (name of child)…..	Never	Once in Awhile	Sometimes	Quite Often	Frequently, if not always	Always	# of nights per week the behavior occurs
1.	…seems wide awake	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
2.	…goes straight to his/her cot/mat	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
3.	…does not listen to directions	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
4.	…argues with caretaker	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
5.	…makes repeated requests (for example: asks for another drink, hug, story)	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
6.	…wants to stay up and do other things (for example: read, play, or watch TV)	N	O	S	Q	F	A	0 1 2 3 4 5 6 7

		Never	Once in Awhile	Sometimes	Quite Often	Frequently, if not always	Always	# of nights per week the behavior occurs
(child's name)								
7.	…enjoys naptime	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
8.	…asks for his/her nap	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
9.	…is ready to to take a nap	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
10.	…complains about taking a nap	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
11.	…"puts off" or delays getting on his/her cot	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
12.	IF SO, write in how long the child usually "puts off" or delays naptime: ____minutes							

Questions 13 – 20 **only concern** your child **Falling Asleep.**

								# of nights per week the behavior occurs
When it's time to go to sleep (lights-out), (name of child)								
13.	…is quiet and calm	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
14.	…has trouble settling down	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
15.	… gets off his cot/mat	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
(name of child								
16.	…has trouble going to sleep	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
17.	…needs help getting to sleep	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
18.	…falls asleep quickly after "lights-out"	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
19.	…has difficulty falling asleep without someone near him	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
20.	Write in how long it usually takes your child to fall asleep: ____ minutes							

Questions 21 – 27 **only concern** your child **<u>Arousing and Awakening</u> during Nap time.**							
		Never	**Once in Awhile**	**Sometimes**	**Quite Often**	**Frequently, if not always**	**Always**
<u>During naptime,</u> (name of child)							
21.	…tosses and turns on the cot	N	O	S	Q	F	A
22.	…is very restless	N	O	S	Q	F	A
23.	…moans, groans, or talks in sleep	N	O	S	Q	F	A
24.	…kicks off the covers	N	O	S	Q	F	A
25.	…arouses, but does not fully awaken	N	O	S	Q	F	A
26.	…awakens more than once	N	O	S	Q	F	A
(Name of child)							
27.	…sleeps soundly through naptime	N	O	S	Q	F	A

of nights per week the behavior occurs
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7

Questions 28 – 37 **only concern** your child **<u>Returning to Sleep</u> after waking during the Naptime**							
<u>After arousing or awakening</u>, (name of child)…							
28.	…has trouble going back to sleep	N	O	S	Q	F	A
29.	…cries or is upset	N	O	S	Q	F	A
30.	… gets off his cot	N	O	S	Q	F	A
31.	…awakens other children	N	O	S	Q	F	A
32.	…needs help to go back to sleep	N	O	S	Q	F	A
33.	…calls out for the caretaker	N	O	S	Q	F	A
34.	…goes into someone else's cot.	N	O	S	Q	F	A
35.	…rolls over and goes back to sleep	N	O	S	Q	F	A

of nights per week the behavior occurs
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7

36.	…goes back to sleep by himself or herself	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
37.	Write in how long it takes your child to go back to sleep after arousing or awakening: ____ minutes							

Questions 38 – 43 **only concern** your child **Waking in the Morning**.								
		Never	**Once in Awhile**	**Sometimes**	**Quite Often**	**Frequently, if not always**	**Always**	
After nap, (name of child) wakes up...								**# of days per week the behavior occurs**
38.	…without any help	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
39.	…and is ready to get up for snack	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
40.	…rested and alert	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
(name of child)								
41.	…is slow-to-start after nap	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
42.	…is difficult to get off the cot.	N	O	S	Q	F	A	0 1 2 3 4 5 6 7
43.	Write in how long it takes your child to become alert after nap: ____ minutes							

APPENDIX F

SLEEP DIARY

ID #:___________________

Start Date: ___________________

Preschool Napping Program

Weekly Sleep Diary

Instructions: Please answer the top part of each page after your child wakes up in the morning. Answer the bottom part of each night after your child goes to bed at night.

BUTTON PRESSES:

- LIGHTS OUT
    - Time child expected to start falling asleep
- WAKE TIME
- NAP START/END
- WATCH OFF/ON

Day of Week (circle): Mon Tues Wed Thurs Fri Sat Sun ID: ___________________
Date:__________________

ANSWER 1 – 6 JUST AFTER YOUR CHILD WAKES UP

1. Number of times child awakened during the night: ___ 0 ___ 1 ___ 2 ___ 3 ___ 4+
2. If they woke up during the night, what time (s) did they wake up? _________________
3. Did child awaken before you today? ___ Yes ___ No ___ Not Sure
4. Time child finally woke up today: ________________
5. Child was awakened by: ___ Just woke up ___ Parent/other person ___ Alarm ___ Other________________
6. Time child finally got out of bed today: _______________

STOP! … Finish The Rest Of The Questions Later!!!

ANSWER 7-15 AFTER CHILD FALLS ASLEEP AT NIGHT

7. Did any of these happen today? ___ Child sick ___ School/day care cancelled ___ Holiday/Vacation
   ___ Missed School
8. Any naps/sleep during the day? ___ No nap opportunity ___ Nap opportunity, but child did not sleep ___ Child accidentally fell asleep today
   ___ Scheduled Nap: Start time? _______________ End Time? _______________
   ___ Accidental Nap: Start time? _______________ End Time? _______________
9. Any caffeine today?
   ___ Yes / No (Circle one) How much? _______________
10. Any different medication today?
    ___ Yes / No (Circle one) Type? _______________
11. Took watch off today because: ___ Did not take the watch off today
    Time Off? _______________Time Back On? ____________ Reason: ____________________
    Time Off? _______________Time Back On? ____________ Reason: ____________________
    Time Off? _______________Time Back On? ____________ Reason: ____________________
12. Tonight, child got into bed at (time): _________________________
13. Lights out/child tried to fall asleep at (time): ________________________
14. Length of time (minutes) for child to fall asleep after turning the lights out: ____ minutes
15. Please tell me one exciting thing that happened today (Ex: child played with his new friend Eric).
    ____
    ____

STOP!!! End Of Diary For Today!!!

APPENDIX G

SUMMARY TABLE OF REPEATED-MEASURE ANOVA

Three Way (Nap × Valence × Intensity) Repeated-Measure ANOVA Summary Table

Source	DF	SS	MS	F	P
Nap condition (Napping/ Nap-deprived)	1	5376.57	5376.57	7.602	.016*
Error	13	9194.43	707.26		
Intensity (Strong/Weak)	1	814.32	814.32	2.794	.119
Error	13	3789.18	291.48		
Valence (Negative/Positive)	1	10842.90	10842.90	5.245	.039*
Error	13	26874.61	2067.28		
Nap × Intensity	1	8.036	8.04	.010	.922
Error	13	10419.96	801.54		
Nap × Valence	1	270.32	270.32	.296	.596
Error	13	11868.68	912.98		
Intensity × Valence	1	165.143	165.14	.329	.576
Error	13	6524.36	501.87		
Nap × Intensity × Valence	1	41.29	41.29	.057	.815
Error	13	9375.71	721.21		

* $p < .05$

APPENDIX H

MEANS & STANDARD DEVIATIONS BY CONDITION

Means and Standard Deviations by Condition

	Nap Condition (M=24.14, SD=14.40)		Nap-Deprived Condition (M=37.90, SD=25.52)	
	Strong Stimuli	Weak Stimuli	Strong Stimuli	Weak Stimuli
Negative Valence (M=21.23, SD=11.118)	13.50, 10.04	18.21, 17.59	26.00, 20.12	27.21, 22.29
Positive Valence (M=40.91, SD=32.784)	28.86, 23.98	36.00, 24.77	45.14, 27.97	53.64, 73.79

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