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Jessica Danilewitz B.A. Honours
Western University

Graham Reid Ph.D.
1 Department of Psychology, The University of Western Ontario 2 Department of Family Medicine, Schulich School of Medicine and Dentistry, The University of Western Ontario 3 Department of Paediatrics, Schulich School of Medicine and Dentistry, The University of Western Ontario 4 Scientist, Children's Health Research Institute

Kathryn Turnbull Ph.D. Candidate
Western University

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Jessica Danilewitz,* BA Honours
Graham Reid, Ph.D.
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Executive functions are a set of higher level cognitive processes that are necessary for the self-regulation of behavior and emotion, which allow individuals to guide attention engage in planned, goal-oriented behavior. Emotion regulation is the ability to control emotional arousal and adapt to the demands of the daily environment. Sleep has been demonstrated to be important for daily functioning in children, adolescents and adults. However, the impact of emotion regulation on the relationship between sleep and executive functioning in healthy preschool children has not yet been tested. This study investigated the relationship between emotion regulation, executive functions, and negative emotions after sleep restriction in healthy preschool children. It was hypothesized that emotion regulation scores would predict executive functioning scores and negative emotions, and that this relationship would be moderated by the amount of sleep restriction experienced by the participant. Participants were typically developing boys and girls between the ages of three to five years (*N*=55), without sleeping difficulties. A significant relationship between emotion regulation and Delay of Gratification was found. No other significant effects were found. Results are discussed in relation to previous literature and specific characteristics of the sample.

It is important for children to acquire adequate sleep each night in order to deal with the various demands of daily life. Mild sleep loss is common among young children (Molfese et al., 2013). Therefore, it is integral that children are able to adapt to changes in sleep in order to avoid temper tantrums and oppositional behavior. Two commonly used skills for adaptation are executive functions and emotion regulation. These skills are used every day in a variety of situations. First, executive functions are cognitive abilities that allow individuals to allocate attention towards tasks for engaging in purposeful behavior (Bernier et al., 2010). Second, the ability to regulate emotions, especially negative emotions, is important for the development of social relationships and dealing with life challenges. The present study addresses the relationship between executive functions, emotion regulation, and negative emotions, moderated by sleep restriction during early childhood.

Emotion regulation and executive functioning both improve over the course of development, beginning at ages three to four (Rothbart et al., 2013). Emotion regulation has been defined as the ability to manage emotional arousal in order to achieve individual goals and adapt to the social environment (Thompson, 1994). Poor emotion regulation skills have been associated with both internalizing and externalizing problems in children (Calkins, 1994; Hill, Degnan, Calkins & Keane, 2006). For example, a child with poorly developed emotion regulation skills may start crying and throw a temper tantrum when he cannot find his lucky shirt. Instead of verbalizing his feelings of frustration and seeking his mother's help, the

*Initially submitted for Psychology 4850 at Western University. For inquiries regarding the article, please e-mail the author at *jessica.danilewitz@gmail.com*.

child cannot regulate his emotions and may consequently act out his anger.

Executive Functions

Executive functions are defined as a set of higher-level cognitive processes that are necessary for the self-regulation of behavior and emotion, which allow individuals to engage in planned, goal-oriented behavior and to guide attention (Bridgett, Oddi, Laake, Murdock & Bachmann, 2013). Executive functions, controlled by the prefrontal cortex, are important in situations marked by distraction, novelty, or stress (Turnbull, Reid & Morton, 2013). Shifting attention, working memory, inhibitory control (i.e., the ability to inhibit inappropriate or irrelevant information or behavior when performing tasks), and delay of gratification tasks are some of the many available measures of executive functions. These measures of executive functions overlap with the general construct of executive attention (Welch, 2001), defined as the ability to monitor and control behaviour, and engage in planning for actions (Rothbart & Reuda, 2005). Executive functions develop rapidly across the preschool years, continue developing into early adulthood (Turnbull et al., 2013), and are extremely important throughout childhood. Disruptions to executive functioning development, caused by negligent or overly permissive parenting, may result in detrimental consequences for children in the domains of social control, cognitive functioning, behavior and emotional control (Anderson, 2002). With regards to behavior, executive dysfunction may be associated with poor impulse control and inappropriate social behavior. Children who display marked social difficulties as a result of weak emotion regulation may be vulnerable to increased negative emotions. Thus, executive functions are necessary for children to adapt to the demands of daily life.

Executive functions have been further divided into two sub-categories; one that is associated with hot (emotion laden) processing, and the other, which is associated with cold (emotionally independent) cognitive processing (Kim et al., 2013). Hot executive functions include delay of gratification tasks, whereas cold executive functions include measures of inhibitory control, specifically the Go/No-Go task (Kim et al., 2013). Delay of gratification is considered to be a hot executive function because it involves regulating emotions, whereas an inhibitory control task is considered to be a cold executive functioning task because it requires effortful attention and working memory (Bridgett et al., 2013; Kim et al., 2013). All children are faced with both emotional (hot) and cognitive (cold) challenges that require them to utilize executive functioning skills in their daily life. Longitudinal research in preschool-aged children has established a positive relationship between emotion regulation and executive functions (Ursache, Blair, Stifter, Voegtline, 2013). Children who exhibited high emotional reactivity and demonstrated high levels of emotion regulation were also found to have high levels of executive functioning ability (Ursache et al., 2013). Therefore, children require both strong emotion regulation and executive functioning skills to deal with stressors and changes in their environment.

Negative Emotions

Negative emotions are displays of negative affect (e.g., anger and sadness). In the preschool age range, children who experience increased levels of negative emotions may appear somber, tearful, irritable, whiny, cranky, or they may express separation anxiety or withdrawn behaviour. Negative emotions in infants and young children are typically associated with insensitive caregiving (Bradley, 2003) and have been shown to be relatively stable across time (Ursache et al., 2013). Moreover, infants with a disposition to display high levels of negative

emotions in reaction to novelty display these emotions consistently for the first five years of life (Kagan, Snidman, & Arcus, 1998) due to their reduced amounts of attention and inhibitory control (Rothbart, Ellis, Rueda, & Posner, 2003). However, it has been reported that changes in negative emotions can occur during this time period (Ursache et al., 2013). Specifically, 13% of four-month-old infants, labeled as highly reactive, displayed an inhibited temperament at later assessments (Kagan, Snidman, & Arcus, 1998). This change in negative emotion may be partially attributed to the development of emotion regulation behaviors (Ursache et al., 2013). During infancy, the automatic regulation of emotions, when coupled with arousal, is presumed to lead to the development of effortful control of attention, an integral component of executive functions (Ursache et al., 2013).

Sleep in Young Children

Sleep problems, defined here as difficulties initiating sleep and staying asleep, have been reported in 15% to 20% of toddlers and preschoolers within large normative samples (Jenkins et al., 1980; Richman, 1981; Scott & Richards, 1990). Specifically, between 10 and 30% of children between six and 48 months of age exhibit sleep problems (Anders & Dahl, 2007; Lozoff et al, 1996). These sleep problems continue in 30% of children into adulthood (Anders & Dahl, 2007).

Sleep is the main activity of the brain during the child's early development (Dahl, 1996). The relationship between attention, sleep, arousal and emotions is an important area of investigation because they are intimately connected in an active neurobehavioral regulatory system (Dahl, 1996). Children who have disrupted or insufficient sleep tend to have problems managing their emotions and controlling attention (Dahl, 1996). Conversely, children with emotional disturbance often have difficulties with regulating sleep (Dahl, 1996). A meta-analysis by Pilcher and Huffcutt (1996) concluded that sleep deprivation leads to a significant impairment to human performance. Even moderate changes in sleep duration, specifically a one-hour sleep extension, has been shown to create significant improvements on neurobehavioral functioning in children nine to twelve years old (Sadeh, Gruber & Raviv, 2003). Neurobehavioral functioning was evaluated by tasks that measure working memory, a domain under the umbrella of executive functions (Sadeh et al., 2003).

The volume of children's sleep literature demonstrates that sleep is necessary for many cognitive aspects of daily functioning including learning, memory and academic performance. A longitudinal cohort study in three to seven year old children found a correlation between inconsistent bedtimes at age three and lower levels of cognitive performance in girls, but not boys at age seven (Kelly, Kelly, & Sacker, 2013). Self-reported sleep quality and duration of sleep, measured by time in bed, have been correlated with school functioning, achievement motivation and academic performance in elementary school children (Curcio, Ferrara & De Gennaro, 2006; Meijer, Habekothe & Van Den Wittenboer, 2000). Sleep restriction has been correlated with decrements in procedural learning, defined as knowledge of how to complete a task, as well as declarative learning, which refers to factual knowledge about the world (Curcio et al., 2006). It can be concluded that sleep duration is related to memory, learning, and academic performance. It is important that research examines the effects of sleep restriction during early childhood.

Sleep, Negative Emotions and Emotion Regulation

Previous literature has established a relationship between sleep restriction and emotional problems during childhood. Berger et al. (2012) reported that acute sleep restriction

(nap deprivation), in three-year-old children resulted in a reduction in positive emotion responses and an increase in negative emotion responses exhibited by facial expressions. Therefore, children who are sleep restricted display more negative emotions than children who are not sleep restricted (Berger et al., 2012). Children exhibiting increased negative emotions, as a result of sleep restriction, may be more vulnerable to externalizing their emotions by acting aggressively. This would indicate greater emotion dysregulation. Alternatively, a child with high emotion regulation ability may be better able to buffer the negative effects of sleep restriction than a child with low emotion regulation ability. Thus, negative emotions and emotion regulation may be other important areas that are notably disrupted by sleep restriction in young children. Experimental sleep restriction studies (Sadeh et al., 2003) have established that acute sleep deficits cause marked deficits in cognitive functioning and behavior control in school-aged children (i.e., age 6-12). In a recent review article, Turnbull et al., (2013) noted that parent reported sleep difficulties have been correlated with child psychosocial problems, which refer to attention difficulties, anxiety, hyperactivity, mood, and aggressive behavior. The evidence reviewed thus far suggests that adequate sleep is vital to optimize children's emotions, behavior, and cognitive functioning (Turnbull et al., 2013).

The Effects of Sleep on Executive Functions

The effects of sleep restriction on executive functioning of young children, and how emotion regulation ability is involved in this process, is a research area that requires investigation. In terms of the adult literature on this topic, sleep deprivation has been correlated with a lowered performance on executive functioning tasks in adults (e.g., Heuer et al., 2004; Jones & Harrison, 2001; Killgore, Balkin & Wesensten, 2006; Tsai et al., 2005). Similarly, shorter sleep duration in typically developing infants and toddlers is longitudinally associated with decrements in later executive functioning, particularly in tasks that rely on impulse control (Bernier, Carlson, Bordeleau, & Carrier, 2010). Specifically, shorter duration of sleep at 12 months was correlated with both poorer executive functioning and impulse control at 26 months of age, while shorter duration at 18 months was correlated with poorer concurrent working memory and later impulse control (Bernier et al., 2010). Molfese et al., (2013) found that sleep restriction in six to eight year old children negatively impacted children's executive functioning, specifically inhibitory control as measured by the Directional Stroop Task.

Executive functions, due to its long course of development, may be very sensitive to the effects of typical childhood sleep problems (Turnbull et al., 2013). Sleeping problems may lead to decrements in executive functioning skills in childhood and play an important role in self-regulation (Turnbull et al., 2013). Healthy sleep hygiene is needed to promote the optimal development of executive functions during childhood.

Research Rationale and Hypotheses

Cognitive and emotion based self-regulation improve rapidly throughout childhood (Ursache et al., 2013). It is important to conduct research on young children in order to gain a better understanding of these systems because the preschool years are a time of rapid development of both emotion regulation and executive functions. No studies have examined the relationships between emotion regulation, executive functions and negative emotions during the preschool years within the context of sleep. Thus, the preschool age range is particularly relevant for the present study. As a secondary data analysis, the present study aimed to extend research by examining the relationship

between emotion regulation, executive functions and negative emotions in healthy preschool children within the context of sleep. It is important that these mechanisms be investigated at a young age in order to understand the role that they play in development.

The overall goal of the present thesis was to examine the relationship between emotion regulation as a predictor of both executive functioning and negative emotions after sleep restriction in children without sleeping difficulties between the ages of three to five years. The Delay of Gratification Test and the Go/No-Go Task, which measures inhibitory control, were selected as measures of executive functioning based on the volume of literature that supports a relationship between the underlying executive functioning skills measured by these tasks and emotion regulation (Giesbrecht, 2008; Feng et al., 2008).

Two hypotheses were proposed:

(1) Higher emotion regulation was expected to be related to better executive functioning ability (i.e., higher executive functioning scores) and lower levels of negative emotions.

(2) Sleep restriction was expected to moderate the relationship between emotion regulation, executive functioning and negative emotions. Specifically, sleep restriction was expected to affect individuals with lower emotion regulation ability (or poorer emotion regulation skills) more than individuals with high emotion regulation. Under conditions of no/low sleep restriction, individuals with higher emotion regulation scores were expected to have better executive functioning and lower levels of negative emotions than individuals with lower emotion regulation scores. In conditions of higher levels of sleep restriction, individuals with higher emotion regulation scores were expected to be less affected in the domains of executive functioning and negative emotions than individuals with lower emotion regulation scores.

Method

The present study was a secondary data analysis based on the data collected from a study conducted by Kathryn Turnbull under the supervision of Dr. Graham Reid. This was an experimental study with four groups (3 experimental, 1 control), but experimental group assignment was not taken into consideration in the analyses for the present study. The participants, measures and procedure for collecting the data relevant to the current study are outlined below.

Participants

A total of 75 children between the ages of three to five years old (M = 4.3, SD = .88, 37 boys) were recruited to participate in the current study. One child per family was allowed to participate in the study. In order to participate, one parent or guardian agreed to complete the questionnaires and the Sleep and Negative Emotion Diary. Children with sleeping difficulties, non-typically developing children (e.g., Autism Spectrum Disorder), and parents who did not speak English were excluded. The clinical cutoff for emotional disorders, according to the Strengths and Difficulties Questionnaire (SDQ), is a score of 4/5 on the emotionality scale (Goodman, 2001). With respect to the general population 2.2% of children in the normative sample are above the clinical cutoff for emotionality (Goodman, 2001). However, no children scored above 3/5 in the present study. Thus, no children had a clinical level of emotional symptoms as measured by the SDQ. Furthermore, 94.5% of the participants in the present study scored below a 2/5, meaning that the children in the present study displayed a low range of emotional symptoms. Additionally, no children from the present sample scored above the clinical

cutoff for total difficulties as measured by the SDQ.

Measures

The Emotion Questionnaire. The Emotion Questionnaire (Rydell, Thorell & Bohlin, 2003) was completed by parents (typically the child's mother). The questionnaire consisted of 40 items that describe the child's emotional reactions of anger, fear, positive emotions, and sadness with regards to 12 statements describing daily situations. Parents rated their child's emotional reactions using a 5-point Likert Scale ranging from 1 (does not apply at all) to 5 (applies very well). A sample item reads as follows: "My child's toy is lost or broken. My child reacts strongly and intensely" (Rydell, Thorell & Bohlin, 2003). The Emotion Regulation subscale of the Emotion Questionnaire was used for the purposes of this study and consisted of 18 items. The scores from all the questions were averaged for a total emotion regulation score; higher scores reflect greater dysregulation of negative emotions.

The Emotion Questionnaire has been established as a reliable measure. The Chronbach's alpha for the overall scale was α = .89 for children five to eight years old (Rydell, Thorell, Bohlin, 2007). Test-retest reliability coefficients for the Emotion Regulation scale ranged from .62 to .79 in eight-year-old children (Rydell, Berlin & Bohlin, 2003). The Emotion Questionnaire has been compared with the Child Behaviour Questionnaire (CBQ) (Rothbart et al., 2001) for the purpose of determining construct validity. As a measure of construct validity, Rydell and colleagues (2003) used the Anger, Fear, Smiling and Laughter subscales of the Children's Behavior Questionnaire (CBQ; Rothbart et al., 2001) to validate the Emotionality subscales of the Emotion Questionnaire. The Soothability, Inhibitory Control, and Attentional Focusing scales were used to validate the Emotion Regulation subscale of the Emotion Questionnaire. The correlation between the Anger subscale in the CBQ, and the Anger subscale within the Regulation scale of the Emotion Questionnaire (r = -.45), demonstrates convergent validity for the Emotion Questionnaire. This correlation demonstrates that children who exhibit a large amount of anger display weak anger regulation skills as measured by the Emotion Questionnaire. The correlation between the Anger subscale on the CBQ, and the Positive Emotions subscale (part of the Regulation scale) of the Emotion Questionnaire (r = -.22), demonstrates adequate discriminant validity.

The Sleep and Negative Emotion Diary. The Sleep and Negative Emotion Diary was developed specifically for the project by Turnbull (2011) based on sleep questions from Buss and Plomin (1984), Corkum et al. (2008), and Izard et al. (2000).

Parents recorded information about the time that their child went to bed and awoke each day, as well as the duration of any naps. Sleep duration was calculated based on the bedtimes, nap time durations, duration of night waking, and morning waking times. Sleep restriction was then calculated as the difference in mean duration of sleep in the experimental period (three days), subtracted from mean sleep duration during the baseline period (seven days) measured in hours. Higher scores reflect greater sleep restriction and consequently less sleep than lower scores.

The emotion measures within the Sleep and Negative Emotion Diary consisted of two subscales. The first was the Emotion Expression Rating Scale (Izard et al., 2000). Parents rated how often his or her child exhibited each of seven emotions (interest, happiness, sadness, anger, fear, shame, guilt) that day using a 6-point Likert scale from 1 (very seldom) to 6 (very often). Only the ratings of negative emotions (sadness, anger, fear, shame, and guilt) were used for the present study. Internal

consistency for negative emotions was reported to be α = .69 in a study of teacher ratings of preschool children (Izard et al., 2000).

A second negative emotion measure was adapted from the Negative Emotionality subscale, part of the EAS Temperament Scale (Buss & Plomin, 1984). Parents were asked to rate how true each of the 5 statements was regarding their child that day using a 5-point Likert scale ranging from 1 (not true) to 5 (very true). A sample item from this subscale reads as follows: "Child cried easily; child tended to be somewhat emotional". The EAS Temperament Scale (Buss & Plomin, 1984) is a widely used, reliable, and valid measure of temperament. However, no studies have as yet assessed the reliability and validity for the Emotionality subscale as a daily report measure in a diary context. This is because the EAS Temperament Scale measures emotionality as a stable temperament construct. However, conceptually it would make sense that emotionality could be reported on a daily basis. The researchers of the current study assessed convergent validity of the EAS Temperament Scale by comparing it with the Emotionality subscale within the SDQ, r = .26 (Goodman, 1997). Scores obtained from the Sleep and Negative Emotion Diary during the seven day baseline period were compared with the scores obtained during the three days of sleep restriction or control condition. Negative emotion was calculated by subtracting the mean negative emotion scores from the experimental period from mean negative emotion scores from the baseline period. Finally, Z-scores of both Negative Emotion and Negative Emotionality were computed in order to combine both subscales into one measure.

Go/No-Go Task. The Go/No-Go Task is a behavioral inhibition computer task (Simpson & Riggs, 2006), which requires a participant to press a button (Go) in response to one type of stimulus that occurs with greater frequency, and not press a button (No-Go) in response to a different type of stimulus. For the current project, a Go/No-Go task was created in Eprime (Psychology Software Tools, 2012) with a picture of a mouse as the Go stimulus and a picture of a cat as the No-Go stimulus. This format was shown to have moderate test-retest reliability (α = .43) and strong convergent validity with the day-night task (α = .58) in previous research with preschool aged children (Simpson & Riggs, 2006). The duration of the task was approximately 5 minutes. The number of errors made (e.g., by clicking the cat No-Go stimulus which indicates a failure to inhibit a dominant response) during the task is computed; higher scores reflect greater difficulties with behavioural inhibition, and therefore poorer executive functioning performance.

Delay of Gratification Task. The Delay of Gratification Task (Mischel & Gilligan, 1964) requires a child to forgo the immediate gratification in order to receive a larger reward at a later point in time. During this task the researcher asked the child to choose two preferred toys from a selection of five options. Once chosen, the researcher placed one of the toys on a square embedded in a board in front of the seated child. The child was told that if he/she waited without touching the toy or playing with it before the researcher returned, then he/she could have both toys to keep. However, the child was told that if he/she wished to play with the toy before the researcher returned, then he/she could only keep one toy. Children were videotaped during this task and a video coder, blind to the degree of sleep restriction experienced by each child, coded the videos to establish when and whether children finished waiting by picking up the toy or moving it before the researcher returned. Children were also judged to have finished waiting if they went to the researcher and/or their parent and verbally indicated that they were finished waiting. The total number of seconds the child waited before picking up the toy, or moving it from within the

square section of the board (up to a maximum of 10 minutes) was computed; higher scores (i.e., longer time the child waited without touching the toy) reflect stronger delay of gratification abilities, and thus better executive functioning performance.

Test-retest reliability data regarding the Delay of Gratification Task has not typically been collected, as performance on this task is often seen as a developmental milestone. Schwartz and Schrager (1983) have validated the use of a Delay of Gratification Task in preschool aged children. Specifically, the finding that choice of the delayed reward was not correlated with age or verbal IQ can be seen as evidence of discriminant validity (Schwartz & Schrager, 1983). This shows that the delay of gratification test effectively measures executive functioning ability, which differs amongst children of the same age, rather than a skill that improves equally among all children, as they grow older.

The Strengths and Difficulties Questionnaire. The SDQ (Goodman, 1997) consists of 25-items. This questionnaire uses a 3-point Likert scale for parent responses, which range from 1 (not true) to 3 (certainly true). The questionnaire is divided into five scales consisting of five items each (emotional symptoms, conduct problems, hyperactivity – inattention, peer relationship problems, and prosocial behavior). One of the sample items reads as follows: "Often loses temper." Normative data have been collected from 2779 children between the ages of four to seven years in the USA. Test-retest reliability after four to six months (r = .62), inter-rater reliability (r = .34) and internal consistency (α = .73) scores demonstrate that the SDQ has strong reliability as a measure for children 5-15 years old (Goodman, 2001). Convergent validity was supported by associations between the SDQ and the occurrence or nonoccurrence of psychiatric disorders with an odds ratio of approximately 15 (Goodman, 2001). This finding explains that the SDQ is correlated with diagnoses of related psychological disorders. For example, the Hyperactivity subscale of the SDQ is correlated with the diagnosis of Attention Deficit Hyperactivity Disorder.

Procedure

The participants were recruited using flyers, which were distributed to various day care and community centers in London, Ontario. Parents were approached by a research assistant who provided them with information about the study. Additionally, advertisements with contact information for the researchers were posted on an on-line classified website (Kijiji) to recruit potential parent participants.

Once parents expressed interest in participating, they were telephoned to be screened for suitability for participating in the study. Parents who agreed to participate and who were eligible were mailed a letter of information and an introductory home visit was scheduled. Written consent was obtained at the home visit. During this visit, the researcher reviewed the study protocol with the parent and showed him/her how to complete the Sleep and Negative Emotion Diary. The parent was asked to complete the diary each day for the duration of the 11-day study. Parents also completed a series of questionnaires including the Emotion Questionnaire.

Following the introductory home visit the child participants completed seven days of normal sleep in order to obtain baseline measures of the child's daily emotions and duration of sleep. Participants were then randomly assigned to one of four sleep conditions. Condition 1 was a control group, with no change in sleep for the participants for the last three consecutive nights of the study. Condition 2 was a sleep delay of 20 minutes for the last three consecutive nights of the study. Condition 3 was a sleep delay of 40 minutes for the last three consecutive nights of the study.

Condition 4 was sleep fragmentation, where the participants went to bed at their usual bedtime and were awoken after 1.5 hours of sleep, and kept awake for 20 minutes for the last three nights of the study.

After three nights in the experimental or control sleep conditions, a researcher or trained research assistant visited the home of the child participant to test his/her executive functioning. Executive functioning tasks included: Go/No-Go Task, Delay of Gratification Task, Visual-Spatial Memory Test, Digit Span Test. Of the four executive functioning tasks administered in the original study (Go/No-Go Task, Delay of Gratification Task, Visual-Spatial Memory Test, Digit Span Test) the Go/No-Go Task and the Delay of Gratification Task were included as outcome measures in the present study. The tasks were administered in the same order for each participant. Parents were provided with a total of $80 in gift cards for completing the entire 11-day study.

Results

Preliminary Analyses

From the original 75 participants, 16 were excluded from the present analyses. Nine participants were excluded because they did not complete the emotion regulation questionnaire. Five participants were excluded because they withdrew before completing all 11 days of the study. Finally, two participants were excluded for medical reasons (one child contracted an illness that required a visit to the hospital during the study, and 1 child was excluded because of a history of a head injury in which there was a loss of consciousness).

Four participants with scores that were outliers were excluded from the present analyses. Two participants had extreme negative emotion scores, and two participants had sleep restriction scores that were more than three standard deviations below the mean. The final data analysis consisted of a sample of 55 participants (28 males; $M_{age} = 4.27$, $SD = .817$).

The distribution of negative emotion scores was significantly skewed. A square root transformation normalized the distribution. Furthermore, Delay of Gratification Test scores were significantly skewed. Consequently, a logarithm transformation was performed.

Emotion regulation and sleep restriction variables were each split into terciles based on the shape of the normal distribution of scores. Emotion regulation tercile cutoff scores ranged from: Low Ability ≥ 3.33, Medium Ability $\leq 3.32 - \geq 2.99$, to High Ability ≤ 2.98. Larger scores in emotion regulation indicate greater emotion regulation dysregulation. Sleep restriction tercile cutoff scores, measured in hours, ranged from: Low ≤ -0.12, Medium $> -0.11 - < 0.46$, to High ≥ 0.47. A negative score indicates that the participant obtained more sleep on average during the experimental sleep period than the baseline period. A positive score indicates that the participant obtained less sleep in the experimental sleep period than during the baseline period. A median split was used to group Delay of Gratification Test scores. Delay of Gratification Test cutoff scores, measured in seconds, ranged from: Low ≤ 399, to High > 399. The Go/No-Go Task was divided into two groups, those who made no errors, and those who made one or more errors.

A 3 (emotion regulation) x 3 (sleep restriction) Between Subjects ANOVA was conducted for the outcome variable negative emotions. Levene's Test of Equality of Error Variances was found to be significant, $F(8, 46) = 2.699$, $p = .016$. Thus, the differences found in sample variances are unlikely to have been found from a randomly sampled population with equal variances. Consequently, findings with regards to negative emotion should be interpreted with caution.

Analyses

Research question A) Do emotion regulation scores predict executive functioning (Delay of Gratification) after sleep restriction? A Multiway Frequency Analysis (Hierarchical Loglinear Analysis) was conducted to determine if there was a significant interaction effect between emotion regulation, sleep restriction and executive functioning (Delay of Gratification Test). This analysis was not statistically significant: χ^2 (4, N = 55) = 1.902, p = .745, G^2 (4, N = 55) = 1.928, p = .749. Thus, there was no significant interaction between emotion regulation, and sleep restriction on executive functioning (Delay of Gratification).

Two Chi-Square Analyses were conducted to examine main effects of emotion regulation and sleep restriction on executive functioning (Delay of Gratification). Contrary to the original hypothesis, a significant main effect was not found for sleep restriction on the Delay of Gratification Test, $\chi^2(2, N = 55) = 2.786$, p = .248 (see Table 1). However, results did support the original hypothesis with a significant main effect for emotion regulation on the Delay of Gratification Test, $\chi^2(2, N = 55) = 6.728$, p = .035 (see Table 2).

Research question B) Do emotion regulation scores predict executive functioning (Inhibitory Control: Go/No-Go Task) after sleep restriction? A Multiway Frequency Analysis (Hierarchical Loglinear Analysis) was conducted to determine if there was a significant interaction effect between emotion regulation, sleep restriction and executive functioning (Go/No-Go Task). This analysis was not statistically significant: $\chi^2(4, N = 55) = 1.574$, p = .813, G^2 (4, N = 55) = 1.559, p .816. Thus, there was no significant interaction between emotion regulation and sleep restriction on executive functioning (Inhibitory Control: Go/No-Go Task).

Two Chi Square Analyses were conducted to examine main effects of emotion regulation and sleep restriction on executive functioning (Inhibitory Control: Go/No-Go Task). A significant main effect was not found for sleep restriction on the Go/No-Go Task, $\chi^2(2, N = 55) = .236$, p = .889 (see Table 3), which does not support the original hypothesis. Additionally, a significant main effect was not found for emotion regulation on the Go/No-Go Task, $\chi^2(2, N = 55) = 3.307$, p = .191 (see Table 4), which does not support the original hypothesis.

Research question C) Do emotion regulation scores predict negative emotions after sleep restriction? A 3(emotion regulation) x 3(sleep restriction) Between Subjects ANOVA was conducted. Contrary to the initial hypothesis, a significant main effect for sleep restriction was not found, $F(2, 55) = 1.213$, p = .307, η^2 = .050. Furthermore, a significant main effect for emotion regulation was not found, $F(2, 55) = .392$, p = .678, η^2 = .017. This finding does not support the original hypothesis. There was also no significant interaction effect between sleep restriction and emotion regulation $F(4, 55) = 1.049$, p = .392, η^2 = .084 (see Table 5).

Discussion

In support of the original hypothesis, emotion regulation significantly predicted Delay of Gratification Test scores. Children with higher emotion regulation ability waited longer in the Delay of Gratification Task in order to obtain a toy, compared to children who had lower emotion regulation ability. Emotion regulation did not predict executive functioning and negative emotions after sleep restriction. Specifically, emotion regulation did not predict inhibitory control, as measured by the Go/No-Go Task. The lack of a statistically significant main effect found for emotion regulation on the Go/No-Go task, but not the Delay of Gratification Test, may suggest that emotion regulation is more related to the delay of gratification component of executive functions,

Table 1

Percentage of Children in Each Sleep Restriction and Delay of Gratification Test Group tested by Chi Square Analysis

	Delay of Gratification Group	
Sleep Restriction Group	Low	High
Low	20.0%	12.0%
Medium	16.4%	18.2%
High	10.9%	21.8%

Table 2

Percentage of Children in each Emotion Regulation and Delay of Gratification Test Group tested by Chi Square Analysis

	Delay of Gratification Group	
Emotion Regulation Group	Low	High
Low	12.0%	21.0%
Moderate	23.6%	9.0%
High	10.0%	21.8%

Table 3

Percentage of Children in Each Sleep Restriction and Go/No-Go Task Group tested by Chi Square Analysis

	Go/No-Go Group	
Sleep Restriction Group	0 Errors	1+ Errors
Low	12.7%	20.0%
Medium	12.7%	21.8%
High	14.5%	18.2%

Table 4

Percentage of Children in each Emotion Regulation and Go/No-Go Task Group tested by Chi Square Analysis

	Go/No-Go Group	
Emotion Regulation Group	0 Errors	1+ Errors
Low	9.1%	25.5%
Moderate	12.7%	20.0%
High	18.2%	14.5%

Table 5

Means and Standard Errors of Emotion Regulation and Sleep Restriction Groups Tested as Independent Variables in the ANOVA of Negative Emotions

	Mean	Standard Error
Emotion Regulation Group		
High	.051	.201
Low	- .078	.206
Medium	.182	.211
Sleep Restriction Group		
Low	- .280	.206
Medium	.168	.201
High	.043	.211

than inhibitory control. This explanation supports research by Kim et al. (2013) who suggested that delay of gratification requires emotion regulation ability as it is a hot executive functioning task, whereas inhibitory control (Go/No-Go task) does not require as much emotion regulation ability, because it is a cold executive functioning task that uses sustained attention.

The participant sample of typically developing children without sleeping problems allowed the present study to control for prior sleeping problems, developmental delays, and psychological disorders. However, this homogenous sample of participants may have limited the range of emotion regulation in the sample by eliminating children that were more likely to display extremely weak emotion regulation abilities. This speculation is supported by a relatively small standard deviation regarding the distribution of emotion regulation scores in the present study, which indicates a more narrow distribution (M = 3.13, SD = .39). This can be compared to the normative sample reported in the Regulation of Negative Emotions subscale of the Emotion Questionnaire at age five, which had a greater mean and standard deviation (M = 3.53, SD = .75) (Rydell, Thorell & Bohlin, 2004). In general, because there is less variation in emotion regulation in the current study it is likely that the results are underestimating the impact of emotion regulation and the strength of the relationship between emotion regulation and other variables. This homogenous sample may explain why there was no significant finding with regards to emotion regulation and inhibitory control (Go/No-Go task) and negative emotions.

Another explanation for the insignificant findings regarding emotion regulation and inhibitory control may be related to the measure chosen for inhibitory control. Overall, 40% of participants made no errors on the Go/No-Go task. This ceiling effect may have contributed to the lack of significance found between emotion regulation and the Go/No-Go task by limiting the range of inhibitory control scores obtained from the sample. Some children failed to hit the target Go stimuli, but also failed to hit the No-Go stimuli, which would not truly reflect a good inhibitory control score. Children who are extremely poor and children who are extremely successful at the Go/No-Go task may have obtained the same score, zero errors while actually holding different executive functioning abilities. Analyzing scores would not yield significant differences between the two groups (zero errors, and one or more errors). Future

research would benefit from using a more sensitive measure of inhibitory control, for example the Stroop task (Stroop, 1935), or using a more challenging version of the Go/No-Go task.

Sleep restriction was not found to predict executive functioning performance (both Delay of Gratification and Go/No-Go Task scores), nor negative emotions. Sleep restriction was not found to moderate the relationship between emotion regulation, executive functioning and negative emotions, which does not support the original hypothesis. Children with high emotion regulation ability were not able to buffer the negative effects of sleep restriction better than children with low emotion regulation ability, as measured by executive functioning performance and the display of negative emotions. The narrow range in emotion regulation scores and the lack of significance found for sleep restriction may lead one to conclude that for children without any sleeping problems or psychological disorders, acute sleep restriction may not impair executive functioning or influence the display of negative emotions. Therefore, changes in sleep schedules may not hinder executive functioning performance, nor increase displays of negative emotions in children with adequate emotion regulation ability, as they may be able to adapt to new situations without difficulty.

A lack of significance found for sleep restriction as a predictor for both negative emotions and executive functioning, and the lack of interaction effect between sleep restriction with emotion regulation, may also be attributed to the degree of sleep restriction. The minimum duration of sleep restriction in the high sleep restriction group, which was 28.2 minutes per night over three nights, may not have been long enough to create a significant effect on executive functioning and negative emotions. The limited period of sleep restriction of only three days may not have been a long enough period of time to see a significant effect on executive functioning and negative emotions. The findings regarding sleep restriction may indicate that children without pre-existing sleep problems are resistant to small changes in sleep of up to three consecutive days. Future research may benefit from using a longer period of experimental sleep restriction and longer increments of sleep restriction per night.

Emotion regulation and sleep restriction were not found to significantly predict increased negative emotions during the experimental period of the study. Children with high emotion regulation ability, and children who obtained more sleep were not more likely to exhibit fewer negative emotions than children who had weak emotion regulation ability or children who had obtained less sleep. The results of previous literature may have differed from the present study due to the use of direct observation and facial coding of negative emotions, rather than use of parent report measures (Berger et al., 2012). Trained researchers may more easily and objectively observe negative emotions and consequently report wider ranges of emotion regulation ability in preschool children. Social desirability bias may have impacted the current findings because parents may have evaluated their child more favorably by reporting better emotion regulation ability and fewer negative emotions exhibited by their child compared to more objective measures. The range in emotion regulation scores reported by the parents could be narrowed substantially, which would reduce the possibility of finding significant effects regarding emotion regulation. Parent report measures were chosen because observational methods were not feasible for an 11-day study. The time commitment required for observational methods would be too taxing for busy parents of young children. Future researchers may want to consider using alternative methods of data collection. This might involve tasks that

challenge the child to use emotion regulation skills that are scored by a researcher.

Previous literature also differed from the present study with regards to the age of participants, and the dependent measures used. For example, Sadeh et al. (2003) may have found significant effects of sleep restriction because of their older sample of participants, and measures of neurobehavioral functioning as their dependent measure. The significant effects of sleep restriction may be observed more easily in older children, compared to preschool children, because emotion regulation abilities strengthen and become more noticeable with age. The significant relationship between emotion regulation and executive functioning found by Ursache et al. (2013) may have been a result of the longitudinal study design. Considering that childhood emotion regulation and executive functioning skills are continuously developing throughout childhood, a longitudinal design might have better captured individual differences with respect to these skills.

Due to natural constraints, the researchers had to rely on a sample of individuals that volunteered to participate. Self-selection may have influenced the results by attracting participants who did not care about the integrity of the study and who were interested in the financial incentive rather than for the purpose of contributing to scientific research.

The present study examined the relationship between emotion regulation, executive functions, and negative emotions after sleep restriction. The hypothesis that emotion regulation would predict executive functioning performance in preschool children, as measured by the Delay of Gratification Test, was supported. This finding supports the need for programs that foster emotion regulation skill development in young children. However, all other components of the original hypothesis (based on current literature) were not supported. The current research extends previous literature by examining the direct relationships between emotion regulations, sleep restriction, executive functions, and negative emotions, in preschool aged children. The present study has implications for understanding children's behavioral and emotional problems, as well as the treatment of sleep problems in early childhood. Further research in this field is needed to explore these relationships and to replicate the present findings.

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