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Kim Bryant graduated in May 2012 from Bridgewater State University with a Bachelor of Science in Psychology. This research began in the spring of 2011 as part of the Adrian Tinsley Program Summer Grant under the direction of Dr. Sandra Neargarder. She presented this research at the 2011 ATP Summer Symposium, at the 2012 National Conference on Undergraduate Research in Ogden, Utah, and at Bridgewater State University's 2012 Undergraduate Symposium. This research was also part of her Honors Thesis in Psychology. Kim continues to work in research as a Clinical Research Assistant in the Neuropsychology Program at Rhode Island Hospital.

Adolescent sleep deprivation has been the focus of recent research; its primary cause is a shift in adolescents' biological rhythms (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998). As a result, many school systems have chosen to restructure their school start times to allow high school students to start school later, resulting in younger students going to school earlier. Despite the research describing the benefits this change in school start times will provide adolescents, there has been virtually no research regarding its effects on younger children. This study examines the effects that a change in school start time between 2^{nd} grade and 3^{rd} grade has on younger children's cognitive performance (CPT II and Digit Symbol) and sleep (actigraph and CSHQ). Participants consisted of two groups: a control group, who started school at 9:00 a.m. in 2^{nd} and 3^{rd} grade, and an experimental group, who changed to an earlier start time from 2^{nd} (9:10) to 3^{rd} (7:45) grade. Results showed no significant within or between group differences in 2^{nd} or 3^{rd} grade on the cognitive measures. Three trends were present from 2^{nd} to 3^{rd} grade, in the experimental group (total number correct, hit reaction time) and the control group (hit reaction time). Correlations existed between some of the sleep and cognitive measures. Results suggest that earlier school start times do not have adverse cognitive effects on school-aged children.

Sleep deprivation has negative effects on adolescents. Specifically, lack of quantity and quality of sleep has been associated with impaired school performance (Lack & Wright, 2007; Drake et al., 2003) and cognitive abilities (Pilcher & Huffcutt, 1996; Sadeh, Gruber, & Raviv, 2003), including impaired sustained attention (Sadeh et al., 2003), response inhibition (Sadeh et al., 2003) speed of processing (Fallone, Owens, & Deane, 2002), and short-term/working memory (Beebe, DiFrancesco, Tlustos, McNally & Holland, 2009). Adolescents on average require 9.25 hours of sleep a night in order to function normally (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998; National Sleep Foundation, 2006). It has been suggested that adolescents should adopt an earlier bedtime to ensure they receive an adequate amount of sleep given their early wake time on school days. Research suggests, however, that this solution is problematic as there are both biological and social/environmental barriers preventing adolescents from doing so (Carskadon et al., 1998; Steinberg, 1996; Wolfson & Carskadon, 1998). Examples of social/environmental barriers include social life (going out/hanging out with friends), after school jobs, extra curricular activities, homework, as well as unlimited access to technology (internet, cell phone, TV, etc.).

This change in sleep in adolescence may be due to a biological barrier called a "sleep phase shift" which refers to the body's natural shift in its circadian rhythm or 24-hour sleep cycle (Carskadon et al., 1998; Lack & Wright, 2007). The National Sleep Foundation (2010) indicated that regardless of level of sleepiness, adolescents have trouble falling asleep before 11 p.m. This makes it extremely difficult for adolescents to get the amount of sleep they need each night, especially on school nights. Drake et al. (2003) conducted a study of 450 eleven to fifteen year olds (sixth, seventh, and eighth grade) and found that 70% of eighth graders, 43% of seventh graders, and only 38% of sixth graders reported going to bed at 11 p.m. or later on weeknights. In addition, a 1998 survey of approximately 3,000 high school students from ninth through twelfth grade indicated they had an average total sleep time on a school night of seven hours and twenty minutes (Wolfson & Carskadon). This is a large discrepancy from the 9.2 hours of sleep a night that adolescents biologically need (Carskadon, Harvey, Duke, Ander, & Dement, 1980) in order to achieve optimal alertness during the day (Carskadon et al., 1980; Carskadon, 1982). In the same survey, results also indicated that students with higher grades reported longer and more regular sleep, and earlier bedtimes on school nights than students with lower grades.

An alternate solution in dealing with this biological barrier is to start school at a later time thereby providing students with extra time to sleep. Lufi, Tzischinsky, & Hadar (2011) conducted a study examining the effects of different school start times on cognition. Results showed that when the school start time was delayed by one hour for five days, the participants in the experimental group slept an average of 55 minutes longer each night compared to the control group, who attended school at the regular time. Also those who slept longer performed better on a continuous performance test known as the Mathematics Continuous Performance Test (MATH-CPT; Lufi, 2006), which is a test that assesses attention. The authors recommend delaying school start time by at least one hour, as it would improve attention and decrease mistakes due to impulsivity. Carskadon, Acebo, Richardson, Tate, & Seifer (1997), made a similar recommendation stating that high school should begin after 8 a.m. This approach is currently being adopted by various high schools throughout the United States (Kirby, Maggi, & D'Angiulli, 2011). Because most schools run on a tiered bus system, however, this new plan often forces the elementary school children to start school much earlier than they had previously by switching the elementary school and high school start times. This is done to eliminate any costs that changing the bus schedule might cause. These findings highlight the inconsistencies that exist between adolescent sleep needs and the schedules that are imposed on them (i.e. school start time). Specifically, the 9.25 hours of sleep adolescents require each night cannot be achieved if they biologically have trouble falling asleep before 11:00 p.m. (in addition to any environmental/social factors) and start school before 8:00 a.m. Adolescents cannot be expected to perform well in school if they are deprived of necessary sleep.

Unlike adolescents, there are currently no known biological or social barriers preventing school-aged children from going to sleep earlier. The only known potential barriers in healthy school-aged children are environmental (Stein, Mendelson, Obermyer, Amromin, & Benca, 2001), for example, having a TV in a child's bedroom that keeps them up later than they would naturally stay up, which the caregiver can easily manipulate. As a result, many school systems have implemented this change in school start time for school-aged children, with the impression that it will have no adverse effects on their school performance or cognitive abilities. The purpose of this study, therefore, was to examine the effects of earlier school start times on school-aged children's sleep and cognitive abilities.

PRESENT PROJECT

It appears that a later school start time may be beneficial for adolescents, but the effects of an earlier start time on school-aged children is unknown. The present study attempts to address this gap in the literature by longitudinally examining sleep and cognition in a control and an experimental group of school-aged children. The school start time for the experimental group was shifted to an earlier time (7:45 a.m. from 9:10 a.m.) as the children entered third grade and remained the same for the control group (9:00 a.m.). Sleep patterns were measured with actigraphy for three nights in second grade and again in third grade. In a within group design, sleep variables and cognitive performance scores were compared from second to third grade. Between groups analyses were used to compare the experimental and control groups from second to third grade to determine if there was a significant change in sleep variables and cognitive performance. This experiment had a two-tailed hypothesis as it was unclear whether or not school start times would adversely affect the experimental group.

METHOD

Participants

There were 10 participants (three males, seven females) ages seven to ten years old, all of which were in the second grade for the first data collection period ($time_1$) and the third grade for the second data collection period ($time_2$) with a one-year inter-test interval. The control group consisted of six participants (three females, three males) from Pembroke, MA and the experimental group consisted of five participants (four females) from Duxbury, MA. Both towns were relatively similar socio-economically and demographically and the schools began at similar times during $time_1$, 9:00 a.m. and 9:10 a.m. respectively and shifted to 7:45 a.m. for the experimental group during $time_2$. Informed parental consent and child assent approved by the Boston University Medical Center Campus Institutional Review Board was obtained. Exclusion criteria consisted of the use of the Child Behavior Checklist (Achenbach & Rescorla, 2001) as a parental report of any neurodevelopmental disorders or psychiatric disorders, and the Children's Sleep Habits Questionnaire (CSHQ; Owens, Nobile, Mcquinn, & Spirito, 2000) which provided reports of sleep disordered breathing and reports of the child taking medications that impacted sleep (psychostimulants). There were no participants excluded from the original group based on these criteria but one participant dropped out after the first data collection period so her data were excluded from the study.

Measures and Procedure

The measures administered to both the control (Pembroke) and experimental (Duxbury) groups included the Conners' Continuous Performance Test II (CPT II; Conners, 2000) and the Digit Symbol Coding B from the Wechsler Intelligence Scale for Children 4th edition (Wechsler, 2003). Sleep variables were measured using actigraphy (AW-64, Respironics, Bend, CO) and the Child Sleep Habits Questionnaire (CSHQ; Owens et al., 2000).

As mentioned previously, the focus of this paper is on the cognitive assessments. Descriptions of the sleep measures are provided, however, as correlations will be performed between the cognitive and sleep measures.

Cognitive Assessments

Conners' continuous performance test II. (CPT II; Conners, 2000) The Conners' Continuous Performance Test II is a computerized test of sustained attention and response inhibition, intended for individuals' ages six years and older. Both sustained attention and response inhibition are affected by sleep deprivation (Sadeh, Gruber & Raviv, 2003; Lufi, Tzischinsky & Hadar, 2011). This particular test was chosen for its complexity and length because if the test isn't complex enough or long enough it might not be sensitive to the attention deficits due to sleep deprivation (Sadeh et al., 2002). Each participant sat at a laptop computer and was instructed to press the space bar each time a letter appeared on the screen except for the letter "X." Each letter that appears on the screen is white and always appears on a black background; each letter is also the same size and same font. There is an inter-stimulus interval of one, two, and four seconds with each letter having a display time of 250 milliseconds. The test is divided into six separate blocks and three sub-blocks with 20 letter presentations each. The different inter-stimulus intervals presented vary between blocks. Each participant was administered a short practice test to ensure they understood the task and then the actual test began and lasted for a total of 14 minutes. Measures include omissions or failure to respond to target letters (non-X's) (test-retest reliability .84), commissions or responses given to non-targets (X's) (test-retest reliability .65), and hit reaction time or the average speed of correct responses (test-retest reliability .55). The CPT is based on a database of 2,686 clinical and non-clinical participants.

Digit symbol coding b. (Wechsler, 2003) This is a test of attention and speed of processing and is intended for participants' ages eight to sixteen years old. The participant was given an 8.5" x 11" sheet of paper and at the top was a key that included a row of numbers 1-9, each had a corresponding symbol underneath. Below were six rows with 21 boxes in each row, containing randomly ordered numbers (1-9) with an empty box below each number. After the key was explained to the participant, they were asked to complete seven empty boxes by filling in the corresponding symbol as a practice exercise. After completing the practice exercise, the participant was instructed that they had two minutes (120 seconds) to write as many correct symbols under their corresponding number as they could. At the end of two minutes, the paper was removed and the participant was then asked to do a free recall. For the free recall, the participant was given a blank sheet of paper and instructed to write down any symbols they could remember from the assessment. At the end a total raw score is calculated of the number of correctly drawn symbols with 119 representing the maximum score. The test is then broken down into 15-second increments and the number correct and incorrect is recorded for each of the eight increments. Measures include total number correct and total number incorrect.

Sleep Behavior

Actigraphy. (AW-64, Respironics, Bend, CO) Actigraphy is a commonly used method of continuously recording gross motor activity in order to determine the sleep pattern for an individual in a naturalistic environment (as opposed to a laboratory setting). This is advantageous for keeping the participant's sleep schedule as routine as possible, which is difficult to do in a laboratory setting. Each participant was fitted with an actigraph, (a watch-like device) on their non-dominant wrist and was worn day and night without being removed for three nights. According to Gruber et al. (2010) a minimum of three consecutive nights of actigraphy recording is required for reliable measures. The actigraph records each movement that is made by the participant and each movement is visually represented as a tic mark. Areas with a lot of movement are

Table 1. Summary of Cognitive Analyses

	Control vs Experimental Time 1	Control vs Experimental Time 2
CPT II		
Omissions	n.s.	n.s
Commissions	n.s.	n.s.
Hit Reaction Time	n.s.	n.s.
Digit Symbol		
Total Number Correct	n.s.	n.s.
Total Number Incorrect	n.s.	n.s.
	Time 1 vs Time 2 Control	**Time 1 vs Time 2 Experimental**
CSHQ		
Omissions	n.s.	n.s
Commissions	n.s.	n.s.
Hit Reaction Time	n.s.	p = .07 (lower at Time 2)
Digit Symbol		
Total Number Correct	n.s.	p = .07 (lower at Time 2)
Total Number Incorrect	n.s.	n.s.

shown as much more dense with tic marks and areas with less or no movement are shown as very few tic marks or as blank space. The actigraph was used in conjunction with a sleep diary. The sleep and wake times recorded in the sleep dairy for each participant were manually entered into the actigraph data and used to calculate the actigraph variables.

The sleep measures pertinent to the current project included total sleep time, sleep fragmentation, and sleep efficiency. Total sleep time refers to the amount of time that an individual actually spends sleeping as opposed to the time spent in bed (Paavonen et al., 2010). Sleep fragmentation refers to how many times an individual wakes during the night (Paavonen, Raikkonen, Pesonen, Lahti, & Komsi, 2010; Sadeh et al., 2003; Sadeh et al., 2002). Sleep efficiency refers to the percentage of time spent in sleep during the reported time in bed (Acebo et al., 1999; Paavonen et al., 2010).

Children sleep habits questionnaire. (CSHQ; Owens et al., 2000) This questionnaire is intended for children ages four through twelve to screen for common sleep problems prominent in this age group. This questionnaire was given to the parents to fill out while the child was being fitted with the actigraph and was then collected upon completion of the data collection. Questions included items such as, "Child sleeps the same amount each day," "Child awakens more than once during the night," and "Child takes a long time to become alert." Each of the questions is answered "usually, "sometimes," or "rarely," with "usually" representing five to seven times a week, "sometimes" representing two to four times a week, and "rarely" representing zero to one time a week. In addition, it is asked whether or not each question is a problem sleep habit and answers include "Yes," "No," or "Not applicable N/A." There are 33 individual questions included in the total score and 35 when broken into subscales, as there are two questions that are used in two of the subscales. In both the total score and the subscale ratings, a higher score indicates more sleep problems. The measures that were used in the present project included sleep duration (test-retest reliability 0.40), night wakings (test-retest reliability 0.63), and daytime sleepiness (test-retest reliability 0.65). The reliability and validity data for the Children's Sleep Habits Questionnaire is based on a sample of 469 children ages four to ten years old (community sample) and a clinical sample of 154 patients that have been diagnosed with sleep disorders.

RESULTS

To assess the effects of an earlier school start time on cognitive measures, results were calculated using a series of non-parametric t-tests called the Mann-Whitney U test (Mann & Whitney, 1947) as the between-subject comparison (comparing the experimental [Duxbury] and the control [Pembroke] groups at $time_1$ and $time_2$) and the Wilcoxon sum-rank test (Wilcoxon, 1945) as the within-subject comparison (comparing the experimental group at $time_1$ and $time_2$ and comparing the control group at $time_1$ and $time_2$), which were chosen because of the project's small sample size (control, n = 6; experimental, n = 4). Three different dependent variables were analyzed with regard to the CPT II including omissions, commissions, and hit reaction time. Two different dependent variables were analyzed for the Digit Symbol coding B test including total correct and total incorrect. Both group (Mann-Whitney U test) and time (Wilcoxin sum-rank test) were the independent variables utilized, equaling a total of twenty analyses (see Table 1 for a summary of analyses). In addition, Spearman's Rho was used to correlate the previously mentioned cognitive, dependent variables with several sleep variables including sleep efficiency, total sleep time, and sleep fragmentation, all actigraphy variables, and sleep duration, night wakings, and daytime sleepiness from the CSHQ.

Cognitive Measures

Conners' continuous performance test II. Omissions in the experimental group (*Mdn* = 2.5) did not differ significantly from the control group (*Mdn* = 5) at $time_1$, U = 5.00, z = -1.52, p = .13. At $time_2$, omissions in the experimental group (*Mdn* = 1.5) did not differ significantly from the control group (*Mdn* = 4.5), U = 6.00, z = -1.29, p = .20. Omissions in the experimental group at $time_1$ (*Mdn* = 2.5) did not differ significantly from omission in the experimental group at $time_2$ (*Mdn* = 1.5), z = -.73, p = .47. Moreover, omissions at $time_1$ for the control group (*Mdn* = 5) did not differ significantly from omissions for the control group at $time_2$ (*Mdn* = 4.5), z = -.31, p = .75 (see Figure 1).

Commissions in the experimental group (*Mdn* = 19) did not differ significantly from the control group (*Mdn* = 28) at $time_1$, U = 5.50, z = -1.39, p = .16. At $time_2$, commissions in the experimental group (*Mdn* = 15.5) did not differ significantly from the control group (*Mdn* = 28), U = 5.50, z = -1.39, p = .16. Commissions at $time_1$ for the experimental group (*Mdn* = 19) did not differ significantly from commissions for the experimental group at $time_2$ (*Mdn* = 15.5), z = -1.47, p = .14. Moreover, commissions $time_1$ for the control group (*Mdn* = 28) did not differ significantly from commission for the control group at $time_2$ (*Mdn* = 28), z = 0.00, p = 1.00 (see Figure 2).

The hit reaction time in the experimental group (*Mdn* = 506.18) did not differ significantly from the control group (*Mdn* = 470.61) at $time_1$, U = 6.00, z = -1.28, p = .20. At $time_2$, the hit reaction time in the experimental group (*Mdn* = 475.27) did not differ significantly from the control group (*Mdn* = 466.72), U = 9.00, z = -.64, p = .52. There was a trend present between the hit reaction time at $time_1$ for the experimental group (*Mdn* = 506.18) and the hit reaction time for the experimental group at $time_2$ (*Mdn* = 475.27), z = -1.82, p = .07, r = -.58. Moreover, the hit reaction time at $time_1$ for the control group (*Mdn* = 470.61) did not differ significantly from the hit reaction time for the control group at $time_2$ (*Mdn* = 466.72), z = -1.15, p = .25 (see Figure 3).

Digit symbol coding b. The total number correct in the experimental group (*Mdn* = 40.5) did not differ significantly from the control group (*Mdn* = 40) at $time_1$, U = 10.50, z = -.32, p = .75. At $time_2$, the total number correct on the Digit Symbol coding B test in the experimental group (*Mdn* = 48.5) did not differ significantly from the control group (*Mdn* = 43), U = 8.50, z = -.75, p = .45. There was a trend present between the total number correct at $time_1$ for the experimental group (*Mdn* = 40.5) the total number correct for the experimental group at $time_2$ (*Mdn* = 48.5), z = -1.84, p = .07, r = -.58. There was also a trend present between, the total number correct at $time_1$ for the control group (*Mdn* = 40) and the total number correct for the control group at $time_2$ (*Mdn* = 43), z = -1.80, p = .07, r = -.58 (see Figure 4).

The total number incorrect in the experimental group (*Mdn* = 1) did not differ significantly from the control group (*Mdn* = 1) at $time_1$, U = 10.00, z = -.46, p = .65. At $time_2$, the total number incorrect in the experimental group (*Mdn* = .05) did not differ significantly from the control group (*Mdn* = 0), U = 10.50, z = -.36, p = .72. The total number incorrect at $time_1$ for the experimental group (*Mdn* = 1) did not differ significantly from the total number incorrect for the experimental group

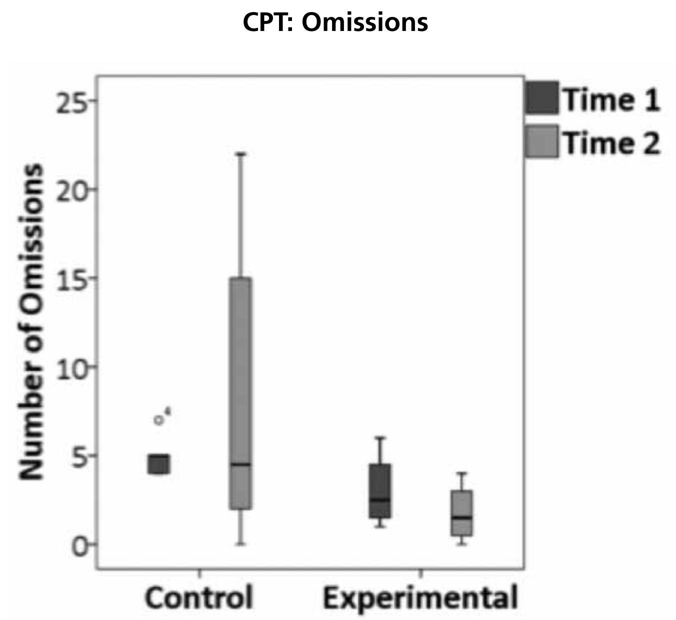

Figure 1. The total number of omissions or the failure to respond to target letters (non-X's) on the Conners' Continuous Performance Test II (CPT II) for both the experimental and control groups from $time_1$ to $time_2$. This is a box-and-whisker plot. The box represents 50% of the data, the line running horizontal through the box represents the median value, and everything above and below the median value to the end of the whisker also represents 50% of the data. The top and bottom whisker represent the maximum and minimum values excluding the outliers, and the circle above the box represents the outliers.

at $time_2$ (*Mdn* = .05), z = -1.13, p = .26. Moreover, the total number incorrect at $time_1$ for the control group (*Mdn* = 1) did not differ significantly from the total number incorrect for the control $time_2$ (*Mdn* = 0), z = -.71, p = .48 (see Figure 5).

Sleep and Cognition

Hit reaction time was significantly correlated to daytime sleepiness $r_s(4)$ = .83, p < .05, in the control group at $time_2$. Hit reaction time was also significantly related to total sleep time

$r_s(4) = -.89$, $p < .05$, in the control group at $time_2$. Correlational trends in the experimental group at $time_1$ were noted between omissions, commissions, hit reaction time and night wakings, $r_s(2) = .95$, $r_s(2) = -.95$, $r_s(2) = .95$, all p's = .051. In the experimental group at $time_2$, a trend was found between hit reaction time and sleep duration $r_s(2) = -.95$, $p = .051$.

CPT: Omissions

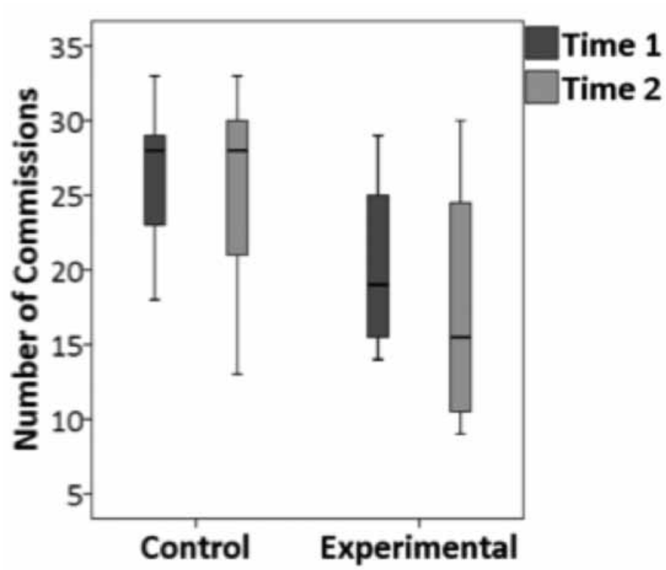

Figure 2. The total number of commissions or responses that are given to non-targets (X's) on the Conners' Continuous Performance Test II (CPT II) for both the experimental and control groups from $time_1$ to $time_2$.

Discussion

This study examined whether a change to an earlier school start time in elementary-aged school children would adversely affect their cognition, similar to that shown in adolescents. As illustrated below, the results indicate no substantial change in the cognitive variables both within and between the control and experimental groups.

Cognition

There were no significant within or between group differences at $time_1$ or $time_2$ for any of the cognitive measures. This illustrates that there was no difference in cognitive performance for the experimental group at $time_2$ both when compared to the experimental group performance at $time_1$ as well as to the performance of the control group at $time_2$. Although results are preliminary, they indicate that cognitive performance was not impaired in the experimental group by their shift from 9:10 a.m. to 7:45 a.m., which could indicate an ability to adapt to earlier school start times. The lack of significant findings, however, could also be the result of the small sample size used in the present project.

CPT: Hit Reaction Time

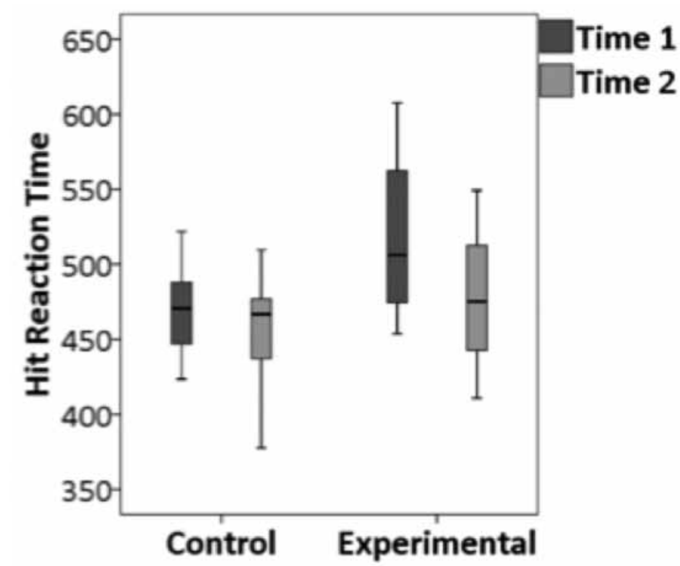

Figure 3. The hit reaction time or the average speed of correct responses on the Conners' Continuous Performance Test II (CPTII) for both the control and experimental groups from $time_1$ to $time_2$.

Digit Symbol: Total Correct

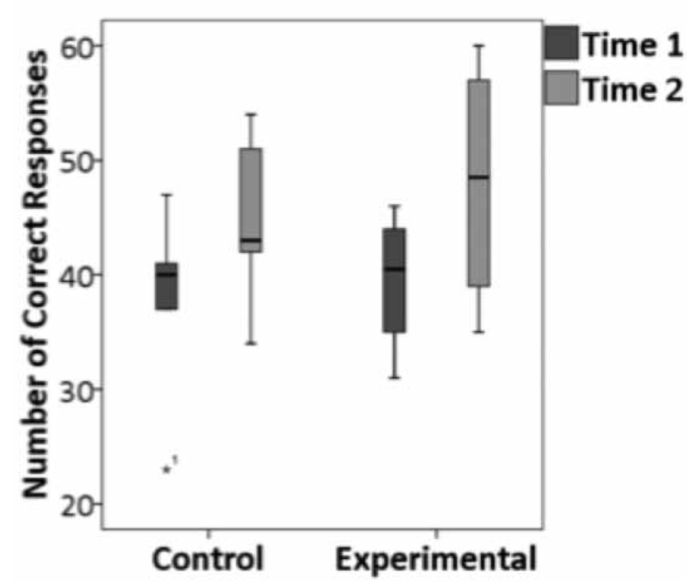

Figure 4. The total number of correct responses on the Digit Symbol Coding B test for both the experimental and control groups from $time_1$ to $time_2$.

There were, however, three trends present in the within group analysis, indicating that the experimental group (hit reaction time and total number correct) and the control group (total number correct) showed improvements with the change in school start times, which is the opposite of what one would expect. Despite these findings, results do not indicate that there were any significant differences between the experimental and control groups from $time_1$ to $time_2$, which supports the main focus of the study that there were no negative effects on cognitive performance.

Sleep and Cognition

The two significant correlations that were present were both found in the control group at $time_2$, the first was a positive

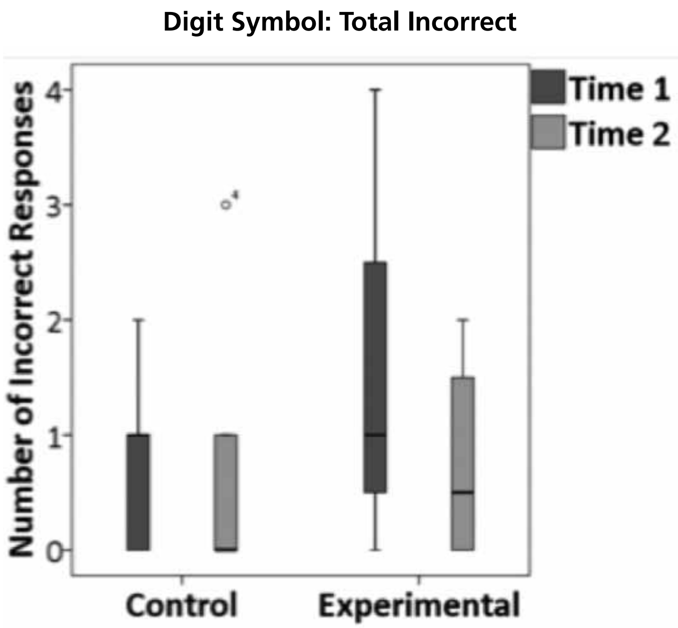

Figure 5. The total number of incorrect responses on the Digit Symbol Coding B test for both the experimental and control groups from $time_1$ to $time_2$.

relationship between daytime sleepiness and hit reaction time, indicating that as daytime sleepiness increased, hit reaction time also increased (got slower). The second significant correlation was a negative relationship between total sleep time and hit reaction time, with this inverse relationship indicating that as total sleep time increased, hit reaction time decreased (got faster). Overall, the correlations do show relations between measures of sleep and cognition in the predicted directions.

Additional Factors and Limitations

When making decisions regarding changes in school start times, many factors must be taken into consideration. One factor is school schedules of all the individuals involved, from teachers to local business owners that employ students (CAREI, 1998; Wahlstrom, 2001). Additional factors include scheduling after school activities as well as the issue of the cost of changing the buses. This information simply illustrates the various factors involved, besides sleep, in trying to establish school start times for various groups of school-aged children and adolescents.

The biggest limitation of this study was the small sample size for both the experimental and control groups. A second limitation of this study was the dropout rate from the first year to the second year because with such a small sample size to begin with it's important to have a high retention rate. The retention rate would have been better if we had a larger time frame for data collection and were able to better accommodate schedules. A third limitation was that the sample used was a convenience sample rather than a random sample as a result of the controversial nature of the topic in the recruitment area. A final limitation was the fact that although the two groups were similar to each other socioeconomically, they both had relatively high SES's which is not generalizable to other populations.

Conclusion

Overall, the findings of this study suggest that the change in school start time had no effect on the cognitive performance in school-age children. This may indicate that going to school earlier does not have negative effects on younger children because, unlike adolescents, they may be better able to naturally adjust their sleep schedule to accommodate an earlier school start time. If so this might be a solution that works for many school systems. Further research on whether there is an impact of sleep on cognitive performance in this age group is warranted.

References

Achenbach, T. M., & Rescorla, L. A. (2001). Manual for the ASEBA School-Age Forms & Profiles. *Burlington: University of Vermont, Research Center for Children, Youth, and Families*.

Beebe, D.W., Difrancesco, M.W., Tlustos, S.J., McNally, K.A., & Holland, S.K. (2009). Preliminary fMRI findings in experimentally sleep-restricted adolescents engaged in a working memory task. *Behavior and Brain Function*, 5, 9.

Carskadon, M. A., Harvey, K., Duke, P., Anders, T. F., Litt I. F. & Dement, W. C. (1980). Pubertal changes in daytime sleepiness. *Sleep*, 2, 453-460.

Carskadon, M. A. (1982). The second decade. In C. Cuilleminault (Ed.), *Sleeping and waking disorders: Indications and techniques*. Menlo Park: Addison-Wesley.

Carskadon, M. A, Acebo, C., Richardson, G. S., Tate, B. A., & Seifer, R. (1997). Long nights protocol: Access to circadian parameters in adolescents. *Journal of Biological Rhythms*, 12, 278-289.

Carskadon, M.A., Wolfson, A.R., Acebo, C., Tzischinsky, O., & Seifer, R. (1998). Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. *Sleep*, 8, 871-881.

Conners, C. K. (2000). Conners' Continuous Performance Test (CPT II) Computer Program for Windows Technical Guide and

Software Manual. *North Tonawanda, NY: Multi-Health Systems, Inc*.

Drake, C., Nickel, C., Burduvali, E. et al. (2003). The pediatric daytime sleepiness scale (PDSS): Sleep habits and school outcomes in middle-school children. *Sleep*, 26(4), 455-458.

Epstein, R., Chillag, N., & Lavie, P. (1998). Starting times of school: Effects on daytime functioning of fifth-grade children in Israel. *Sleep*, 21, 250–256.

Fallone, G., Acebo, C., Arnedt, J.T., Seifer, R., & Carskadon, M.A. (2001). Effects of acute sleep restriction on behavior, sustained attention, and response inhibition in children. *Perception and Motor Skills*, 93, 213-29.

Fallone, G., Owens, J.A., & Deane, J. (2002). Sleepiness in children and adolescents: Clinical implications. *Sleep Medicine Reviews*, 6, 287-306.

Fallone, G., Seifer, R., Acebo, C., & Carskadon, M.A. (2002). How well do school-aged children comply with imposed sleep schedules at home?. *Sleep*, *25*(7), 739-745.

Gruber, R., Laviolette, R., Deluca, P., Monson, E., Cornish, K., & Carrier, J. (2010). Short sleep duration is associated with poor performance on IQ measures in healthy school-age children. *Sleep Medicine*, 11(3), 289-294

Kirby, M., Maggi, S., & D'Angiulli, A. (2011). School start times and the sleep-wake cycle of adolescents: a review and critical evaluation of available evidence. *Educational Researcher*, 56-61.

Lack, L. C., Wright, H. R. (2007). Clinical management of delayed sleep phase. *Behavioral Sleep Medicine*, 5(1), 57–76.

Lufi, D. (2006). The development of a computerized test to assess attention (MATH-CPT). Paper presented at *The 26th International Congress of Applied Psychology*, Athens, Greece.

Lufi, D., Tzischinsky, O., & Hadar, S. (2011). Delaying school starting time by one hour: Some effects on attention levels in adolescents. *Journal of Clinical Sleep Medicine*, 7, 137-43.

Mann, H. B., & Whitney, D. R. (1947). On a test whether one of two ransom variables is stochastically larger than the other, *Annals of Mathematical Statistics*, 18, 50-60.

National Sleep Foundation. Sleep in America poll. (2006). Teens and sleep. *National Sleep Foundation Web site*. Available at http://www.sleepfoundation.org/article/sleep-america-polls/2006-teens-and-sleep. Accessed February 1, 2012

National Sleep Foundation. Later school start times improved adolescent alertness. (2010). Adolescents. *National Sleep Foundation Web site*. Available at http://www.sleepfoundation.org/alert/later-school-start-times-improved-adolescent-alertness.Accessed January 10, 2012

Owens, J. A., Spirito, A., McGuinn M., & Nobile, C. (2000). Sleep habits and sleep disturbance in elementary school-aged children. *Journal of Developmental and Behavioral Pediatrics*, 21, 27-36.

Paavonen, E.J., Raikkonen, K., Pesonen, A., Lahti, J., & Komsi, N. (2010). Sleep quality and cognitive performance in 8-year-old children. *Sleep Medicine*, *11*, 386-392

Pilcher, J. J., & Huffcutt, A. I. (1996). Effects of sleep deprivation on performance: A meta-analysis. *Sleep*, 19, 318–326.

Sadeh, A., Gruber, R., & Raviv, A. (2002). Sleep, neurobehavioral functioning, and behavior problems in school-age children. *Child Development*, *73*(2), 405-417.

Sadeh, A., Gruber, R., & Raviv, A. (2003). The effects of sleep restriction and extension on school aged children: What a difference an hour makes. *Child Development*, *74*(2), 444-455.

Steinberg, L. (1996). Beyond the classroom: why school reform has failed and what parents need to do. New York: Simon and Shuster.

Stein, M.A, Mendelson, J., Obermyer, W.H., Amromin, J., & Benca, R. (2001). Sleep and behavior problems in school-aged children. *Pediatrics*, *107*(4), 1-9

Wahlstrom, K.L. (2001). School start time study. technical report volume II: analysis of student survey data. *Center for Appiled Research and Educational Improvement* (CARE1)- University of Minnesota, http://education.umn.edu/carei/Reports/default.html.

Wechsler, D. (2003). Wechsler Intelligence Scale for Children—Fourth Edition. *San Antonio, TX: Psychological Corporation*.

Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics*, 1, 80-83.

Wolfson, A. R. & Carskadon, M. A. (1998). Sleep schedules and daytime functioning in adolescents. *Child Development*, 69, 875–887