

Summary

We examined whether night-to-night variability in children's total sleep time in grade 4 could predict their cognitive performance one year later, in grade 5.

Results demonstrated that **children with greater variability in their total sleep time had lower reading abilities and planning abilities one year later** compared to children with more stable sleep.

Greater variability in sleep **also predicted less cognitive improvement in planning abilities** between grades 4 and 5.

Introduction

Sleep and cognition

- Across the lifespan, sleep plays an essential role in cognitive development [1,2].
- In children, numerous studies have demonstrated that shorter sleep time is linked to poorer cognitive performance [3,4].
- The effects of sleep on cognition may be of particular importance in early adolescence as total sleep time (TST) tends to decrease while large night-to-night fluctuations (i.e., intra-individual variability) in sleep increase [5-6].

Gaps in the literature

- Despite the presence of substantial night-to-night fluctuations in sleep schedule, few studies have examined how this intra-individual variability may influence cognition [7].
- To date, most of the research has been cross-sectional. As such, the long-term impacts of inadequate sleep on cognition remain relatively unknown [3].

The current study

- The current study examines the longitudinal relation between intra-individual variability in TST (IIV-TST) and cognitive performance in a sample of school-aged children.
- We hypothesized that greater IIV-TST will be associated with lower cognitive performance after a one-year delay.

Methods

Participants

- Participants were part of an on-going longitudinal study of child development
- Inclusion criteria:
 - Full-term pregnancy
 - Absence of any known disability or developmental delay in the infant
- 83 typically developing children (38 males) were evaluated in two consecutive years
 - T1: Grade 4 (M = 9.91 years, SD = 0.27)
 - T2: Grade 5 (M = 10.93 years, SD = 0.26)

Table 1: Socioeconomic Status of the Participants

	N	Min	Max	Mean	SD
Family income ¹	80	1.00	6.00	4.55	1.40
Parents' years of education	83	11.00	19.00	15.66	1.94

¹ 1 = 20,000\$; 2 = 20,000-39,000\$; 3 = 40,000-59,000\$; 4 = 60,000-79,000\$; 5 = 80,000-99,000\$; 6 = 100,000\$ and up

Procedures

- T1: Sleep assessed objectively for 3 to 7 nights (M = 6.03) using the Mini-Mitter® Actiwatch (threshold of 80 activity counts per epoch)
- T1 & T2: cognition assessed with standardized tasks

Measures

- Sleep: IIV-TST was calculated for each participant by computing the standard deviation of their night-to-night sleep duration.
- Cognitive performance: see table 2.

Table 2: Descriptive Statistics and Correlations for IIV-TST and Cognition

	M	SD	r
IIV-TST	32.08	12.43	–
T1 Planning	13.72	2.15	–.18
T2 Planning	13.38	2.75	–.34**
T1 Reading	115.42	9.84	–.13
T2 Reading	120.67	5.57	–.27*
T1 Cognitive flexibility	986.58	226.94	–.08
T2 Cognitive flexibility	864.87	208.25	–.15
T1 Inhibition	10.86	2.23	.12
T2 Inhibition	10.51	1.77	–.05
T1 Working Memory	6.56	1.60	.14
T2 Working Memory	6.68	1.70	–.04

* p < .05. ** p < 0.01. IIV-TST = Intra-individual variability in total sleep time. T1 = Grade 4. T2 = Grade 5. Scores on planning, reading, and working memory represent accuracy on the NEPSY-II Tower of LondonTM, WIAT-II Word reading, and Backwards Digit Span, respectively. Cognitive flexibility is measured by the Dimensional Change Card Sort task through response time on accurate trials. Inhibition skills reflect the contrasted scaled scores of inhibition on the D-KEFS Stroop as compared to color naming.

Results

Table 3: Hierarchical Regressions of 4th Grade IIV-TST Predicting 5th Grade Planning and Reading Performance

	Planning Performance			Reading Performance		
	B	SE	β	B	SE	β
Model 1						
Participants' sex	0.70	0.67	0.12	-2.12	1.19	-0.21
SES	1.04	0.45	0.27*	0.54	0.80	0.08
Model 2						
Participants' sex	0.86	0.63	0.15	-1.92	1.16	-0.19
SES	0.90	0.43	0.23*	0.37	0.78	0.05
IIV-TST	-0.08	0.03	-0.33**	-0.10	0.05	-0.25*

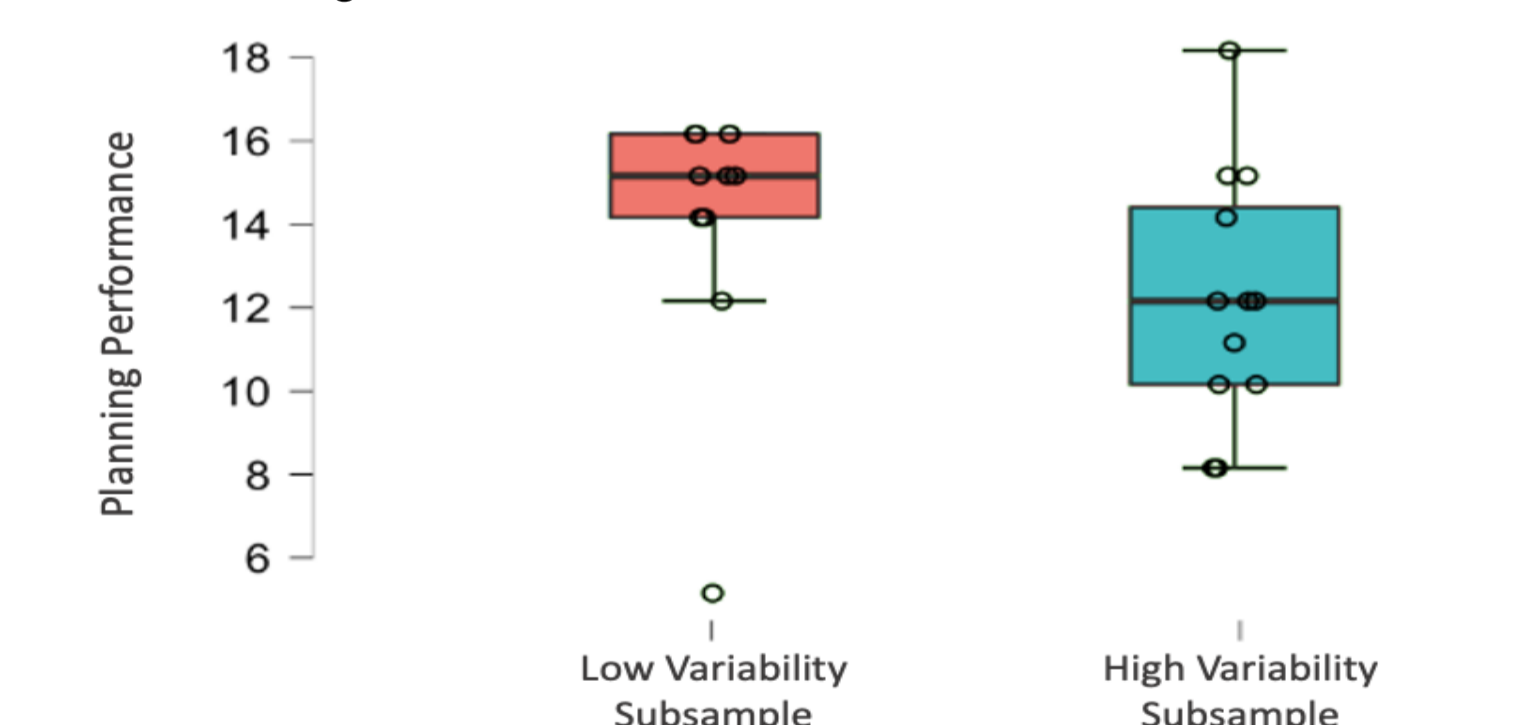
* p < .05. ** p < 0.01. IIV-TST = Intra-individual variability in total sleep time.

Table 4: Hierarchical Regressions of 4th Grade IIV-TST Predicting Improvements in 5th Grade Planning and Reading Performance

	Planning Performance			Reading Performance		
	B	SE	β	B	SE	β
Model 1						
Participants' sex	0.72	0.69	0.12	-2.10	1.16	-0.21
SES	1.08	0.46	0.28*	0.81	0.77	0.12
Model 2						
Participants' sex	0.42	0.64	0.07	-1.80	1.06	-0.18
SES	1.00	0.42	0.25*	0.55	0.71	0.08
4 th Grade Performance	0.57	0.16	0.40**	0.21	0.06	0.42***
Model 3						
Participants' sex	0.55	0.62	0.09	-1.71	1.05	-0.17
SES	0.88	0.41	0.23*	0.43	0.70	0.07
4 th Grade Performance	0.50	0.16	0.35**	0.21	0.06	0.40***
IIV-TST	-0.06	0.03	-0.24**	-0.07	0.04	-0.17

* p < .05. ** p < 0.01. *** p < 0.001. IIV-TST = Intra-individual variability in total sleep time. Either fourth grade planning abilities or reading abilities were entered into each respective model to account for the previous year's cognitive performance.

Figure 1: Contrasting Planning Performance for Participants with Low and High IIV-TST



Note. Boxplot depicting planning performance for a subsample of participants with the least variable sleep (bottom 15% of the total sample, n = 11) and the most variable sleep (top 15% of the total sample, n = 12). $t(21) = 1.48, p = .07, d = 0.62$.

Discussion

Scientific Contribution

- This study examined school-aged children's night-to-night variability in their total sleep time (IIV-TST).
- Greater IIV-TST was significantly associated with poorer planning performance and reading ability one year later.
- Greater IIV-TST was significantly associated with less improvement in planning (though not in reading) after a year delay.
- These results are consistent with a small but growing body of research suggesting that sleep variability is a meaningful factor associated with cognitive performance [7-10].

Suggestions for Future Studies

- These results accentuate the importance of stability in sleep schedules and highlight the need to study diverse aspects of sleep, not only its average duration.
- As reading abilities and planning skills are both valuable skills for academic success [11-13], future research examining IIV-TST and academic performance is warranted.
- Experimental studies are necessary to determine whether these relations indicate causal processes.

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