The Effect of Pre-Bedtime Habits on Sleep Quality

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Introduction

Older generations love to assign the cause of virtually any ailment to the increased usage of mobile phones and other electronic devices in today's digital age. This extends to the realm of sleep, where it is commonly believed that the use of screens before bed negatively impacts sleep. Past research suggest that blue light exposure from devices decrease sleep quality, sleep duration, and sleep efficacy (Silvani, Werder, and Perret 2022). In contrast, reading a physical book before bed is thought to promote better sleep (Finucane 2021).

While the current experiment found evidence that reading physical books before bed may improve sleep quality compared to using phones, the effect was not statistically significant in our regression models when controlling for covariates. Furthermore, our analysis revealed interesting heterogeneity in treatment effects between participants, with Felice showing notably stronger positive effects from reading books compared to Elyse. This suggests that individual differences may play an important role in how pre-bedtime habits affect sleep outcomes, highlighting the need for larger sample sizes and more personalized sleep recommendations.

Theory

Previous literature suggest that blue light exposure from devices can negatively impact sleep outcomes such as sleep quality, sleep duration, and sleep efficacy (Silvani, Werder, and Perret 2022). Outcomes are believed to be related to how blue light affects melatonin production and circadian rhythms. Melatonin is a hormone that regulates sleep-wake cycles, and its production is inhibited by blue light exposure. In contrast, reading a physical book before bed is thought to promote better sleep by reducing blue light exposure and creating a calming bedtime routine (Finucane 2021).

This experiment tested two hypotheses regarding sleep-related outcomes:

H1: (Sleep Quality) Reading a physical book before bed results in higher sleep quality scores compared to using a phone.

H2: (Sleep Efficacy) Reading a physical book before bed results in better sleep efficacy compared to using a phone.

Experimental Design

Context and Population

Our experiment included two 21-year-old female college students with no known sleep disorders. Each night served as a unit of analysis, with participants collecting data over approximately one month.

Intervention

Each night was randomly assigned to either the treatment condition (reading a physical book for 20 minutes before bed) or the control condition (reading on a phone for 20 minutes before bed). This design allowed us to isolate the effect of the reading medium while keeping the activity (reading) constant.

Random Assignment

We implemented complete random assignment, blocked by participant, to ensure balance between conditions. Each participant was assigned to 15 days of treatment and 15 days of control. The random assignment was conducted using the `sample()` function in R.

Complete randomization was chosen over simple randomization to ensure balanced treatment and control groups, which maximizes statistical power. The treatment condition for each night was determined at the same time each night before bedtime to avoid violations of excludability so that participants would not be able to anticipate the treatment condition and subsequently alter their behavior.

Outcome Measurement

Sleep quality was measured using the Sleep Cycle app on an Apple Watch, which provided a sleep quality score ranging from 0 to 100. This score was calculated based on four measurements: 1) time spent in bed, 2) time spent in deep sleep, 3) frequency and intensity of movements, and 4) number of times the app registered the user as fully awake.

Sleep efficacy was defined as the percentage of time spent asleep while in bed, also measured by the Sleep Cycle app through sound and motion detection.

These measurements were recorded from two different sources:

1. The Sleep Cycle app (app)
2. The Apple Watch itself (aw)

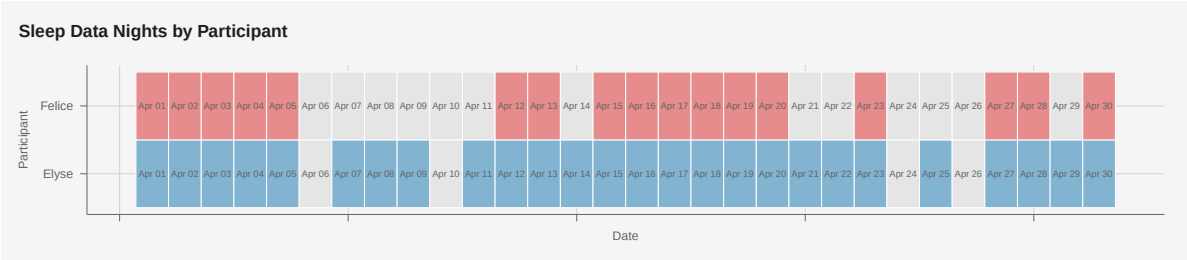
Additionally, participants provided subjective sleep quality ratings each morning on a 0-5 scale.

Results

Descriptive Statistics

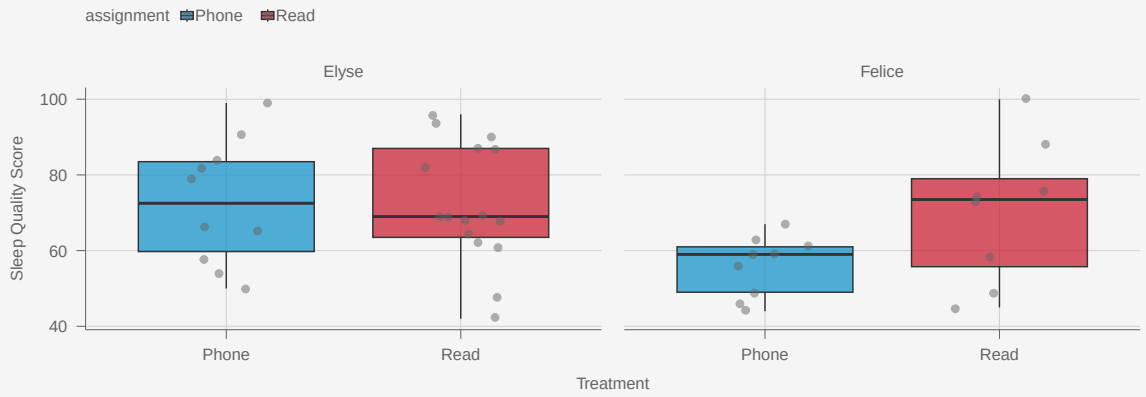
Our dataset includes observations from both participants across the experimental period in April, with some missing data points as shown in the calendar visualization below for reasons such as forgetting to wear the watch or falling asleep before recording data. The dataset contains 43 observations total as a result instead of the expected 60 observations.

The dataset includes information on treatment assignment, sleep quality and efficacy measures, and several covariates including stress levels, caffeine consumption, smoking, alcohol consumption, and exercise.

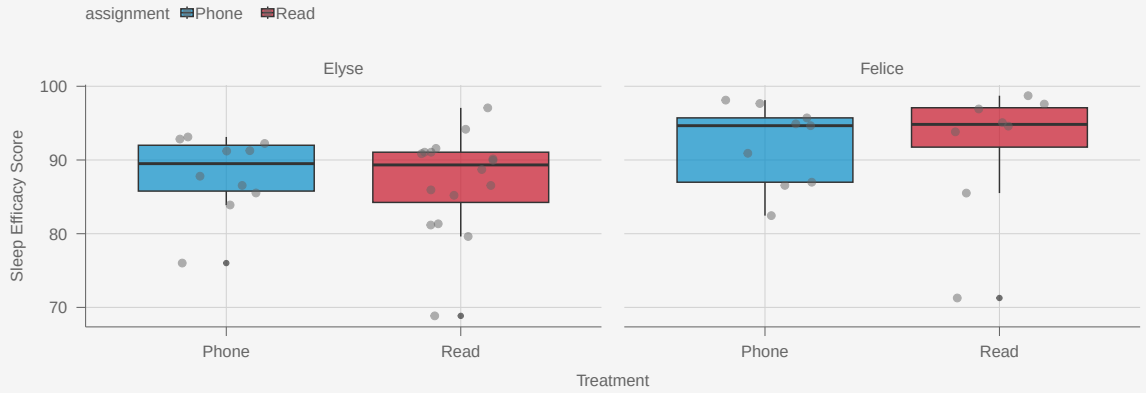


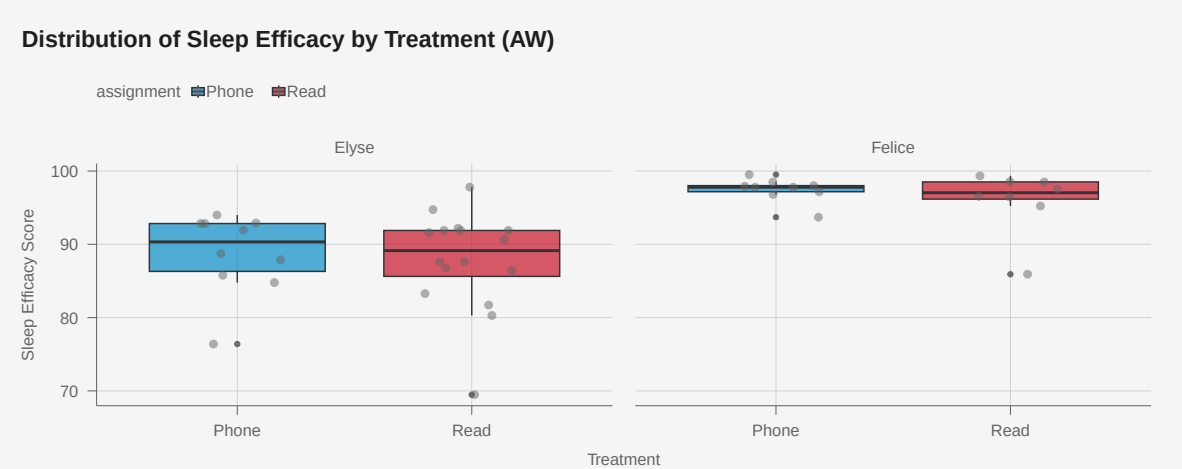
The three figures below show the distribution of sleep quality and efficacy (from both app and watch) by treatment condition for each participant. Visual inspection suggests potential differences between treatment conditions, with some variation between participants. However, in general, it does not appear that the treatment condition had a large effect on sleep quality or efficacy.

Distribution of Sleep Quality by Treatment



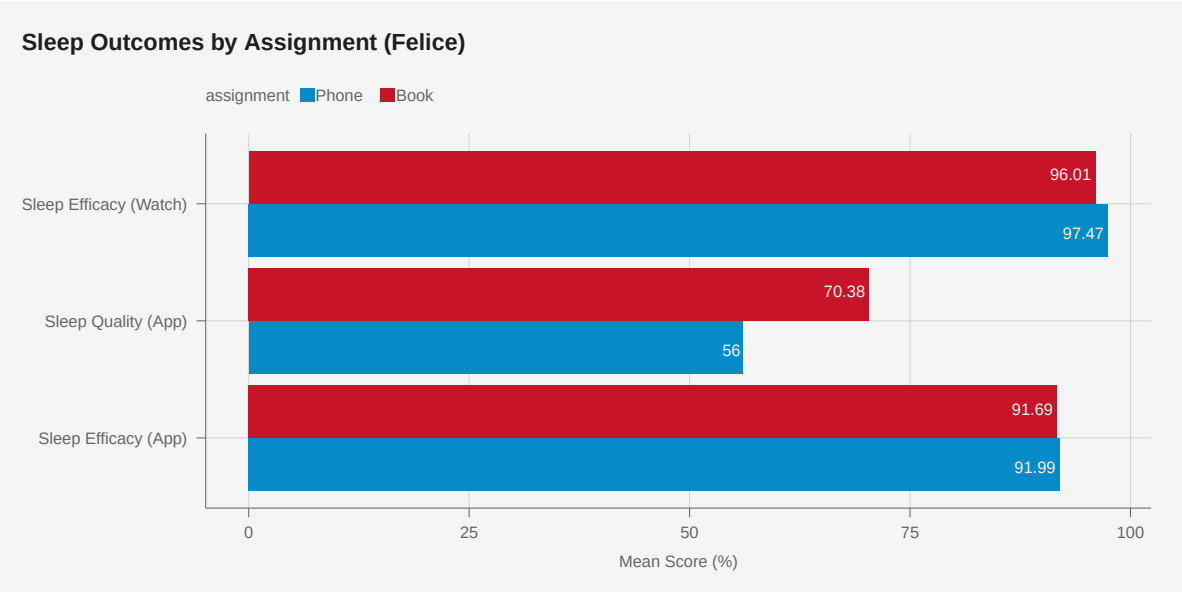
Distribution of Sleep Efficacy by Treatment (App)

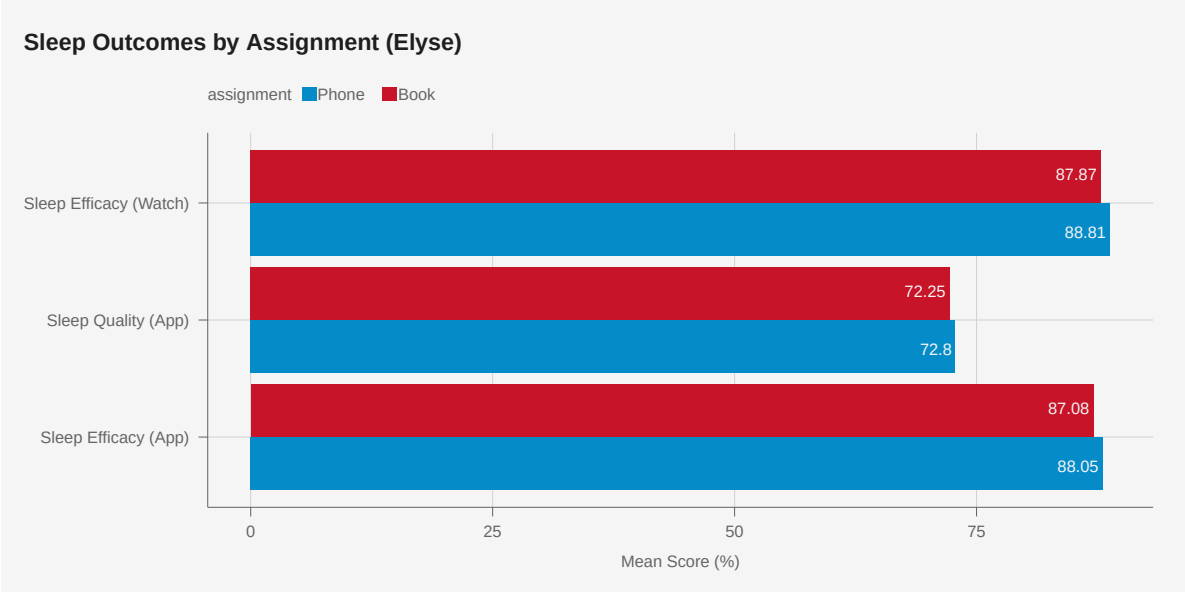


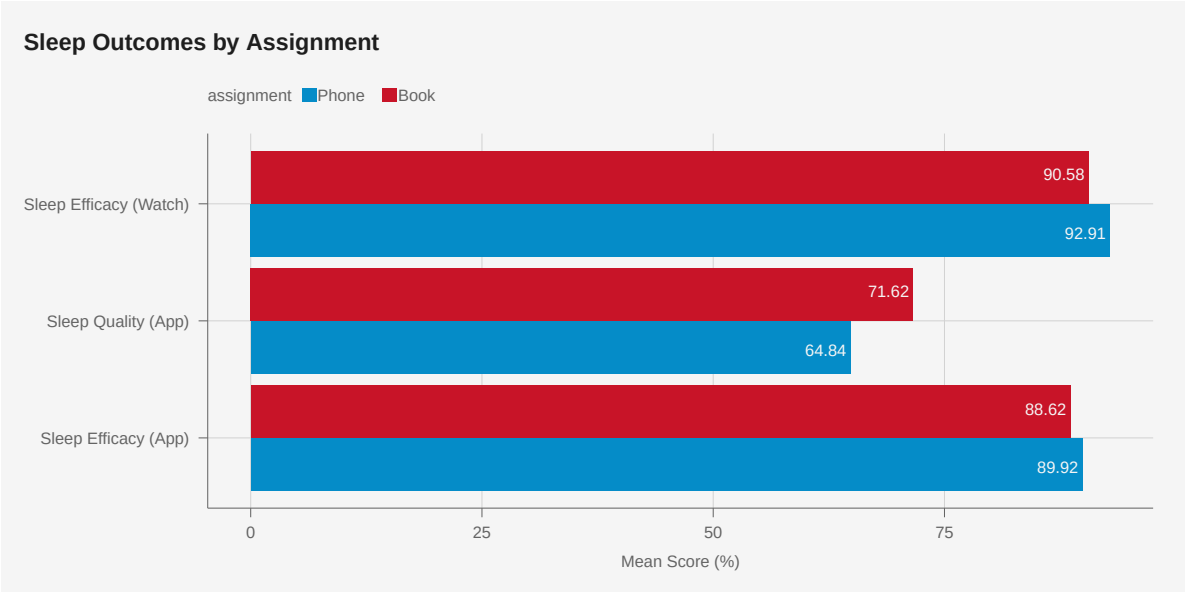


Treatment Effects

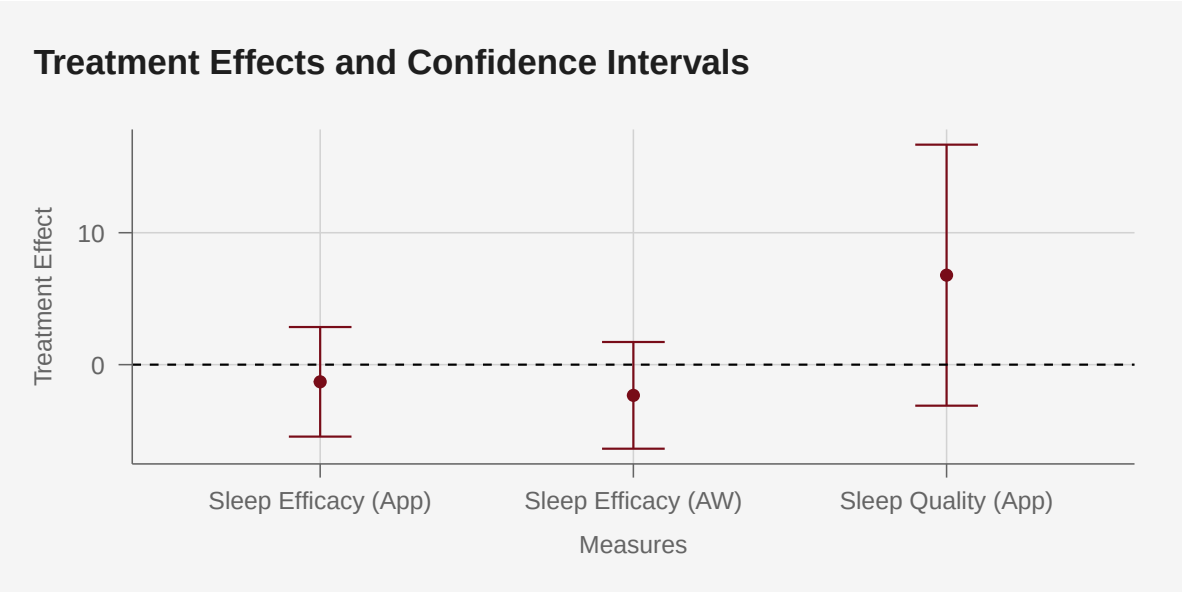
For Felice, sleep quality scores averaged 70.38 for phone nights and 56 for book nights, suggesting an improvement when reading physical books. However, all other measures appeared to be similar across conditions. In fact, outcomes for phone nights were slightly higher than for book nights, contrary to our hypotheses.

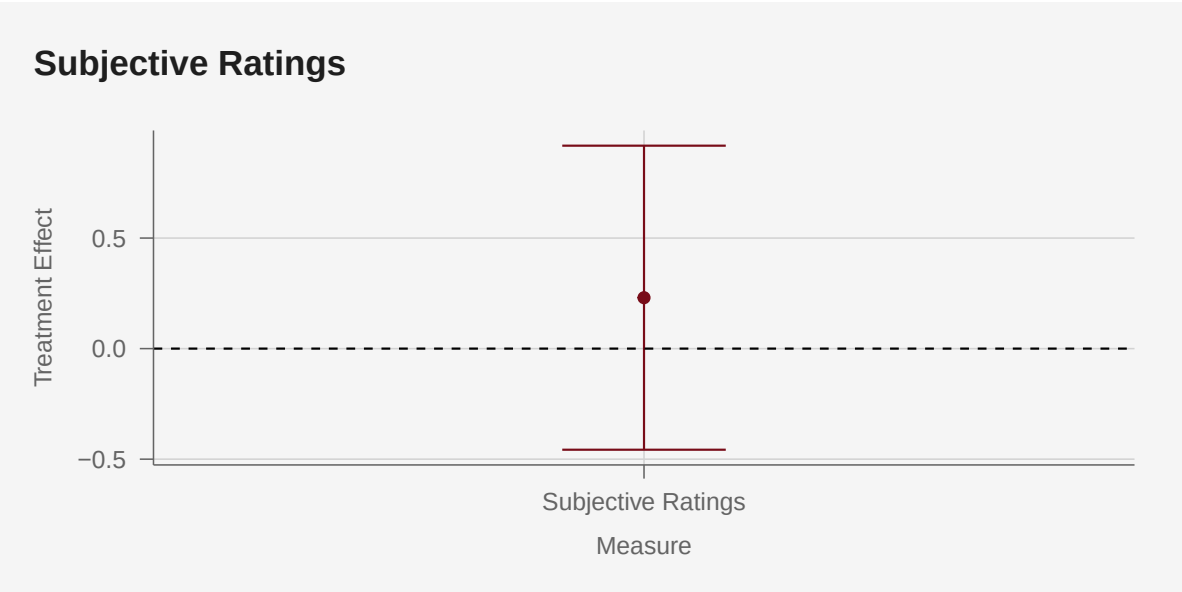






The treatment effects confidence intervals plot below shows that while there appears to be a positive effect on sleep quality, the confidence intervals for all three outcome measures cross zero, indicating that the effects are not statistically significant at the conventional $p<0.05$ level. Similarly, subjective ratings showed no significant differences between conditions.





Regression Analysis

We ran four regression models for each of the three outcome measures:

1. Basic (treatment effect only)
2. With covariates (controlling for the covariates stress, caffeine, smoking, alcohol, exercise)

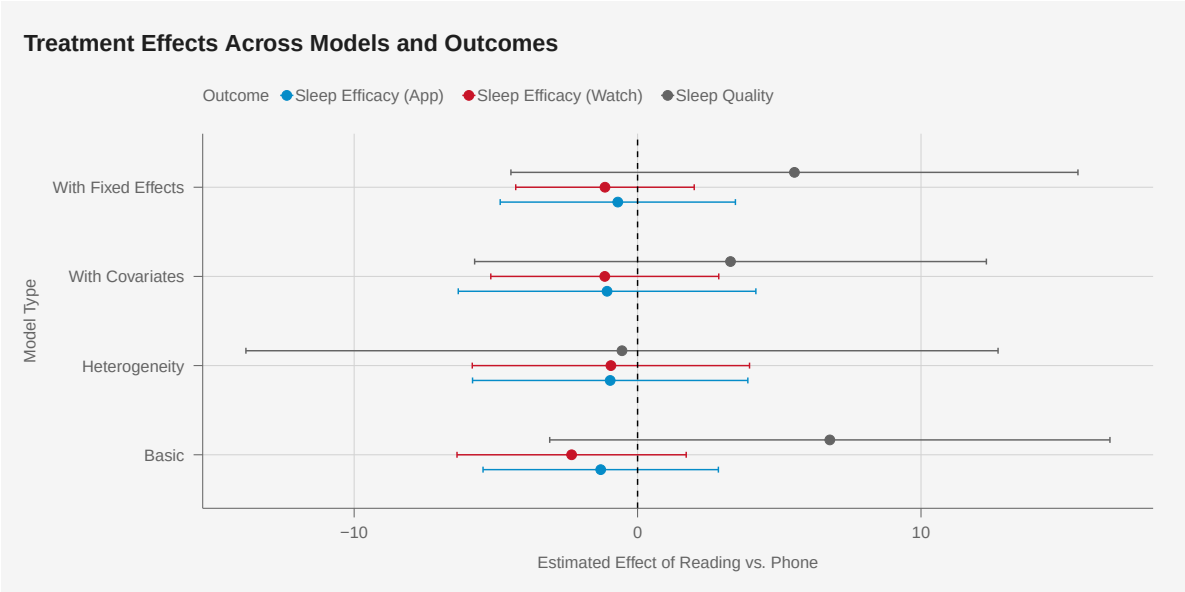
3. With fixed effects (controlling for participant)
4. Heterogeneity in treatment effects (examining treatment by participant interaction)

For sleep quality (Table 1), the basic model shows a positive but non-significant effect of reading books (β = 6.78, p > 0.1). When controlling for covariates, the effect size decreases (β = 3.28, p > 0.1) with significant negative effects of caffeine consumption (β = -12.46, p < 0.001) and smoking (β = -11.51, p < 0.01).

Notably, the heterogeneity model reveals a substantial interaction between treatment and participant. While Elyse showed a non-significant negative effect of reading books (β = -0.55, p > 0.1), Felice showed a strong positive effect (β = -0.55 + 14.93 = 14.38), though the interaction term itself was not statistically significant (p > 0.1).

For sleep efficacy (Tables 2 and 3), all models showed non-significant effects of reading books, with small negative point estimates for both app and watch measurements. These models, however, revealed significant differences between participants, with Felice showing consistently higher sleep efficacy than Elyse (App: β = 4.30, p < 0.1; Watch: β = 8.39, p < 0.001). This likely just means that Felice is a better sleeper than Elyse, regardless of the treatment condition. In other words, Felice falls asleep faster and sleeps more soundly than Elyse.

The figure below visually summarizes the treatment effects across all models and outcomes, showing the consistent pattern of non-significant effects with confidence intervals crossing zero.



The next figure highlights the heterogeneity in treatment effects between participants. While Felice showed a substantial positive effect of reading books on sleep quality (approximately

Table 1: Effect of Reading vs. Phone on Sleep Quality

	(1)	(2)	(3)	(4)
Book (vs. Phone)	6.783	3.279	5.534	−0.550
	(4.894)	(4.451)	(4.949)	(6.560)
Felice (vs. Elyse)			−8.895+	−16.800**
			(5.043)	(5.867)
Stress Level		−3.467+		
		(2.005)		
Caffeine Consumption		−12.460***		
		(2.907)		
Smoking		−11.505**		
		(4.012)		
Alcohol Consumption		−4.713		
		(6.845)		
Exercise		7.130		
		(4.800)		
Book × Felice				14.925
				(9.726)
Num.Obs.	43	43	43	43
R2	0.044	0.360	0.116	0.167
R2 Adj.	0.021	0.253	0.072	0.103

+ p <0.1, * p <0.05, ** p <0.01, *** p <0.001

Table 2: Effect of Reading vs. Phone on Sleep Efficacy (App)

	(1)	(2)	(3)	(4)
Book (vs. Phone)	−1.301	−1.077	−0.697	−0.966
	(2.056)	(2.589)	(2.053)	(2.401)
Felice (vs. Elyse)			4.298+	3.949
			(2.234)	(2.505)
Stress Level		0.159		
		(0.969)		
Caffeine Consumption		1.292		
		(2.786)		
Smoking		1.168		
		(1.916)		
Alcohol Consumption		−0.859		
		(2.736)		
Exercise		−1.712		
		(2.521)		
Book × Felice				0.660
				(4.442)
Num.Obs.	43	43	43	43
R2	0.009	0.033	0.102	0.103
R2 Adj.	−0.015	−0.129	0.057	0.034

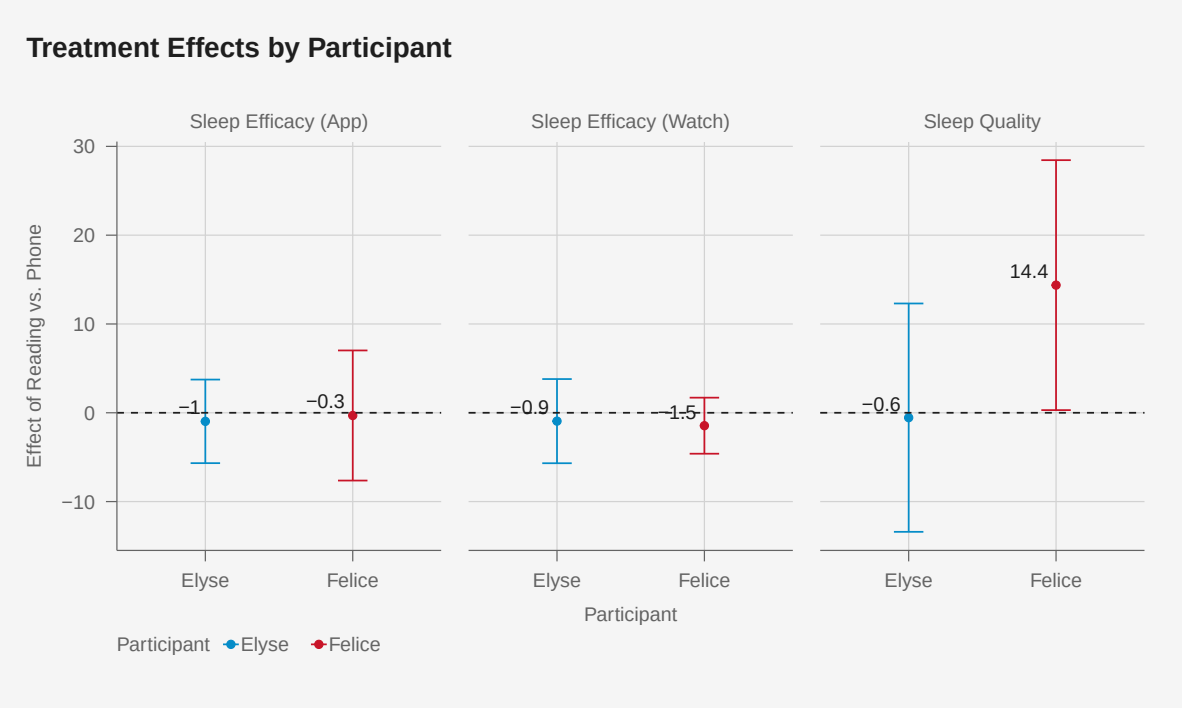
+ p <0.1, * p <0.05, ** p <0.01, *** p <0.001

Table 3: Effect of Reading vs. Phone on Sleep Efficacy (Watch)

	(1)	(2)	(3)	(4)
Book (vs. Phone)	−2.327	−1.157	−1.150	−0.941
	(2.002)	(1.983)	(1.558)	(2.418)
Felice (vs. Elyse)			8.388***	8.660***
			(1.456)	(1.802)
Stress Level		0.371		
		(0.862)		
Caffeine Consumption		4.997***		
		(1.357)		
Smoking		2.071		
		(1.843)		
Alcohol Consumption		0.510		
		(2.168)		
Exercise		−2.332		
		(2.327)		
Book × Felice				−0.513
				(2.905)
Num.Obs.	43	43	43	43
R2	0.031	0.234	0.408	0.409
R2 Adj.	0.007	0.107	0.379	0.363

+ p <0.1, * p <0.05, ** p <0.01, *** p <0.001

+14.4 points), Elyse showed small negative effects across all outcome measures. This 14.4-point difference is larger than what would be expected by random variation, suggesting genuine heterogeneity in how individuals respond to pre-bedtime reading habits.



Discussion

Our experiment examined how pre-bedtime habits affect sleep quality and efficacy, specifically comparing reading physical books versus using phones. The results revealed several important insights:

Mixed Evidence for Overall Effects: While descriptive statistics suggested potential benefits of reading books before bed, particularly for sleep quality, regression analysis controlling for covariates and individual differences showed non-significant effects.

Substantial Individual Heterogeneity: The most striking finding was the difference in treatment effects between participants. Felice showed substantial improvements in sleep quality when reading books, while Elyse showed minimal or even negative effects. This heterogeneity suggests that the relationship between pre-bedtime habits and sleep outcomes may be individualized. However, it should be noted that this conclusion is still tentative due to the small sample size and limited number of observations.

Importance of Confounding Factors: Our regression analysis revealed significant effects of variables like caffeine consumption and smoking on sleep quality, underscoring the complexity of factors affecting sleep and the need to control for these in experimental designs.

Measurement Considerations: The differences between subjective ratings, app measurements, and watch measurements highlight the challenges of reliably quantifying sleep quality and efficacy. Future studies should consider multiple measurement approaches and their potential limitations.

This experiment provides preliminary evidence that reading physical books before bed may improve sleep quality for some individuals compared to using phones, but the effects appear individualized. The substantial heterogeneity in treatment effects suggests that personalized approaches to sleep improvement may be more effective than one-size-fits-all recommendations. While our findings do not conclusively support or refute existing theories about blue light and sleep, they highlight the complexity of sleep processes and the importance of considering individual differences in sleep research and recommendations. In conclusion, older generations may or may not be right about the negative effects of mobile phones on sleep, but our findings suggest that reading physical books before bed may be a beneficial habit for some individuals.