ECON 280 Semester Project

Group Members:

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Data Overview:

We used the dataset from this paper. You can access the dataset in the paper from here. It contains detailed information on sleep duration, academic performance, and mental well-being for a sample of 253 students. The data were collected at a Liberal Arts College located in Northeastern America, which may influence the generalizability of the findings.

Measurement of Variables:

Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). Information on **sleep duration** and **substance use** was gathered through a self-report questionnaire. **Academic performance** was measured using the GPA obtained from official transcripts. **Cognitive ability** was evaluated through ZScores derived from a combination of Digital Symbol Coding Task, the Letter Cancellation Task, and a self-assessed memory quality measure.

Research Questions:

- To what extent is cognitive performance and academic achievement (GPA) influenced by sleep hours and other variables?
- In what ways are sleep quality and bedtime influenced by alcohol consumption?
- How does bedtime affect risetime and other variables?
- To what extent is mental well-being influenced by sleep and other variables?
- What are the average GPA and average sleep hours of US college students?
- To what extent does gender affect GPA and sleep duration among students?

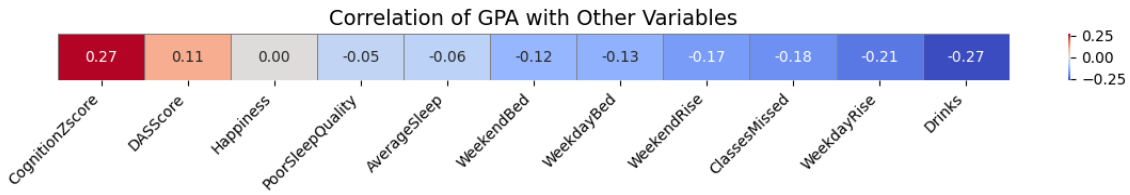
Preliminary Analysis:

Summary statistics have been calculated for each of the variables that we will use in our project to provide an initial overview. You can find the summary statistics below.

Summary Statistics	# Mean	# Standard Deviation	# Minimum	# Maximum	# Median
Average Sleep	7.97	0.96	4.95	10.62	8
GPA	3.24	0.40	2	4	3.3
Classes Missed	2.21	3.24	0	20	1
CognitionZScore	0.00	0.71	-1.62	1.96	-0.01
PoorSleepQuality	6.26	2.92	1	18	6
DASScore	20.04	16.54	0	82	16
Happiness	26.11	5.49	0	35	28
Drinks	5.57	4.10	0	24	5
WeekdayBed	24.85	1.03	21.8	29.1	24.8
WeekendBed	25.58	1.27	21.5	30.25	25.5
WeekdayRise	8.59	0.94	5.5	12.02	8.5
WeekendRise	10.20	1.40	5.25	15	10.25

Now, the research questions will be addressed individually.

“To what extent is cognitive performance and academic achievement (GPA) influenced by sleep hours and other variables?”



Correlations with GPA

GPA × Drinks (-0.27): A moderate negative correlation was observed between GPA and alcohol consumption. Notably, a prior review on the topic reported a similar correlation coefficient of -0.26, which closely aligns with this result. This suggests that heavier alcohol use may be associated with lower academic performance.

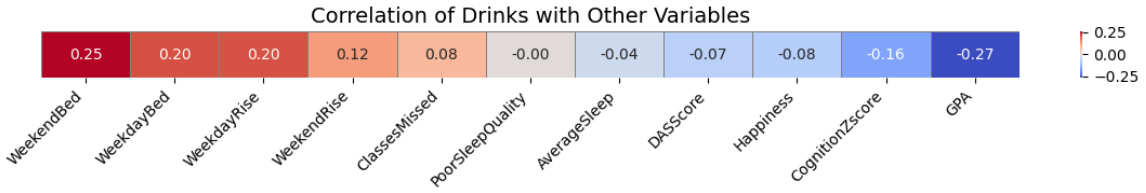
GPA × Cognition Z-score (0.27): A positive correlation was found between GPA and cognitive ability. While cognitive skills alone may not guarantee academic success, their presence appears to contribute positively to academic outcomes.

GPA × Weekday Rise / Weekend Rise (-0.21, -0.17): Earlier wake-up times were associated with higher GPAs, particularly on weekdays. This pattern supports the idea that earlier risers may benefit academically, possibly due to better alignment with structured class schedules. The weaker correlation on weekends may reflect the absence of scheduled academic obligations.

GPA × Classes Missed (-0.18): A negative correlation indicates that students who miss more classes tend to have lower GPAs, which is consistent with expectations.

GPA × Average Sleep / Sleep Quality (-0.06, -0.05): Contrary to expectations, weak negative correlations were observed between GPA and both average sleep duration and sleep quality. Previous research has generally reported positive relationships in this area. These unexpected findings may be influenced by confounding variables or the limitations inherent in self-reported sleep data.

"In what ways is sleep quality and bedtime influenced by alcohol consumption?"



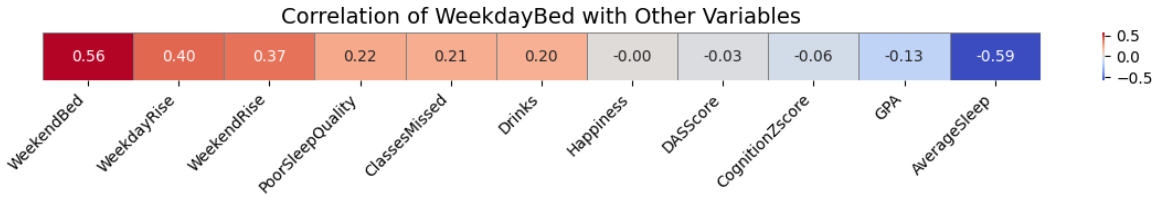
Correlations with Alcohol Consumption

In the dataset, alcohol consumption (measured as *Drinks*) showed a positive correlation with both *Weekend Bedtime*(0.25) and *Weekday Rise Time* (0.20). This aligns with expectations, as students often consume alcohol during nighttime social events, which likely leads to later bedtimes and subsequently later wake times.

However, the absence of a correlation between *Drinks* and *Poor Sleep Quality* is unexpected. A well-established body of research supports a causal link between alcohol use and diminished sleep quality. For instance, previous studies have consistently shown that alcohol disrupts sleep architecture and reduces sleep efficiency. Despite this, the

present dataset does not reflect that relationship, which may be due to sample-specific factors, measurement limitations, or underreporting in self-assessments.

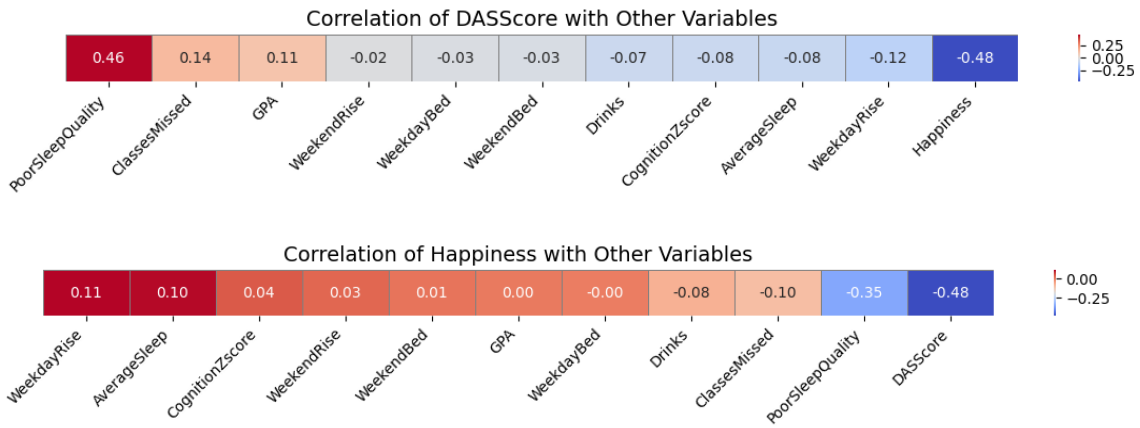
“How does bedtime affect risetime and other variables?”



The positive correlations between bedtime and both wake-up time (0.40) and number of classes missed (0.20) are relatively straightforward. Individuals who go to bed later tend to wake up later and are more likely to miss classes, which is consistent with daily scheduling demands and typical sleep-wake patterns.

More revealing, however, is the relationship between bedtime and both sleep quality and average sleep duration. Scientific literature suggests the existence of a “sleep window” -an optimal period for initiating sleep-. Deviating from this window may lead to disruptions in sleep architecture, resulting in poorer sleep quality and shorter overall sleep duration. The observed correlations in the data support this perspective, indicating that late bedtimes may contribute to less restorative sleep.

“To what extent is mental well-being influenced by sleep and other variables?”



A substantial correlation was observed between DASS scores and poor sleep quality. This finding aligns with existing scientific literature; for instance, one study reported that 76% of

individuals diagnosed with some form of mental illness experience sleep disturbances. To illustrate this relationship, scatterplots will be presented.

“What are the average GPA and average sleep hours of U.S. college students?”

Before addressing this question, several assumptions must be outlined:

- **Random Sampling:** The sample was drawn from a liberal arts college. Therefore, generalizations regarding GPA are most appropriately limited to students at similar institutions rather than the entire U.S. college student population. Consequently, the average GPA results will be compared with published data from other liberal arts colleges. In contrast, sleep duration will be compared with data from a broader range of U.S. universities, as sleep patterns may be less affected by institution type.
- **Independence:** It can be assumed that GPA and sleep duration are independent variables within the sample.
- **Normality:** Given the sample size of 253 participants, the assumption of normality is considered reasonable.

To answer the research question, confidence intervals will be calculated. A t-test will be employed instead of a z-test due to the unknown population standard deviations for both GPA and average sleep duration among U.S. college students. The results will then be compared to relevant real-world data.

College	Mean GPA	90% CI (3.20, 3.29)	95% CI (3.20, 3.30)	99% CI (3.18, 3.31)
Vassar College	3.53	❌ Outside	❌ Outside	❌ Outside
Middlebury College	3.53	❌ Outside	❌ Outside	❌ Outside
Kenyon College	3.43	❌ Outside	❌ Outside	❌ Outside
St. Olaf College	3.42	❌ Outside	❌ Outside	❌ Outside
Macalester College	3.40	❌ Outside	❌ Outside	❌ Outside
Wellesley College	3.37	❌ Outside	❌ Outside	❌ Outside
Columbia College Chicago	3.22	✅ Inside	✅ Inside	✅ Inside
Reed College	3.20	✅ Edge (Inside)	✅ Edge (Inside)	✅ Inside

We selected a sample of prominent liberal arts colleges in the United States for comparison. However, our confidence intervals' couldn't catch the GPAs of most of these schools. This situation is largely due to the low margin of error in our data, which limited the range of our confidence intervals. Additionally, increasing the confidence level did not significantly widen the intervals, likely because of the low standard deviation and high sample size in the dataset.

We examined various GPA databases available online to compare their SD with ours. Our initial hypothesis was that if our SD appeared significantly lower than those found in other databases, it might indicate a potential error in data collection. However, we found that many publicly available GPA datasets actually have lower SDs than ours. For instance, one dataset has a SD of 0.29. This suggests that, even if we changed our dataset, it is unlikely that we would capture all schools.

This completes the first part of the research question.

The second part focuses on estimating the average sleep duration of U.S. college students with the current sample we hold. The same assumptions and statistical methods applied in the GPA analysis will be utilized here. The key difference is that, unlike GPA, this estimation aims to find the sleep duration of the entire population of U.S. students. Given the absence of evidence suggesting a systematic relationship between sleep duration and type of institution, it is considered reasonable to infer average sleep hours for U.S. students based on the available sample.

We calculated confidence intervals as follows:

%99 Confidence Interval = (7.81,8.13)

%95 Confidence Interval = (7.85,8.09)

%90 Confidence Interval = (7.97,8.07)

The largest student sleep study to date, comprising 50,000 student data points, reported a mean sleep duration of 7.73 hours. Notably, even at a 99% confidence level, we couldn't catch it in our confidence intervals. Upon reviewing our dataset for potential data quality issues, no anomalies or errors were detected; the data appeared consistent and reliable.

"To what extent can gender affect GPA and sleep hours?"

We'll use hypothesis testing to find out. Here are the assumptions we're making:

- **Independence:** Each student's GPA and sleep hours are independent from one another.
- **Normality:** Since we have 253 students, it's safe to assume the data is roughly normally distributed.
- **Random Sampling:** Our sample comes from a liberal arts college, but at the same time most of the liberal arts colleges has STEM programs so this probably wouldn't be an issue.
- **Different Variances:** The variability in GPA and sleep hours is different between men and women. Because of this, we used Welch's t-test, which takes this variance difference into account.

- **Null Hypothesis (H0):** There is no significant difference in the mean GPAs of male and female students. ($\mu_{male} = \mu_{female}$)
- **Alternative Hypothesis (H1):** There is a significant difference in the mean GPAs of male and female students. ($\mu_{male} \neq \mu_{female}$)

We did our calculations, you can see them in the appendix the p value is 0.0001243. Since this value is much lower than the significance level(0.05), the null hypothesis was rejected. This indicates that there are significant differences in GPA between males and females.

The same procedure will now be applied to analyze sleep hours.

- **Null Hypothesis (H0):** There is no significant difference in the average sleep hours of male and female students. ($\mu_{male} = \mu_{female}$)
- **Alternative Hypothesis (H1):** There is a significant difference in the average sleep hours of male and female students. ($\mu_{male} \neq \mu_{female}$)

The p-value for sleep hours was calculated as 0.56, which is well above the 0.05 significance threshold. Therefore, the null hypothesis cannot be rejected in this case.

ECON 280 Semester Project Appendix

Variable Descriptions:

Average Sleep: Average hours of sleep for all days

GPA: Grade point average (0-4 scale)

Classes Missed: Number of classes missed in a semester

CognitionZScore: Z-score on a test of cognitive skills

PoorSleepQuality: Measure of sleep quality (higher values are poorer sleep)

DASScore: Combined score for depression, anxiety and stress

Happiness: Measure of degree of happiness

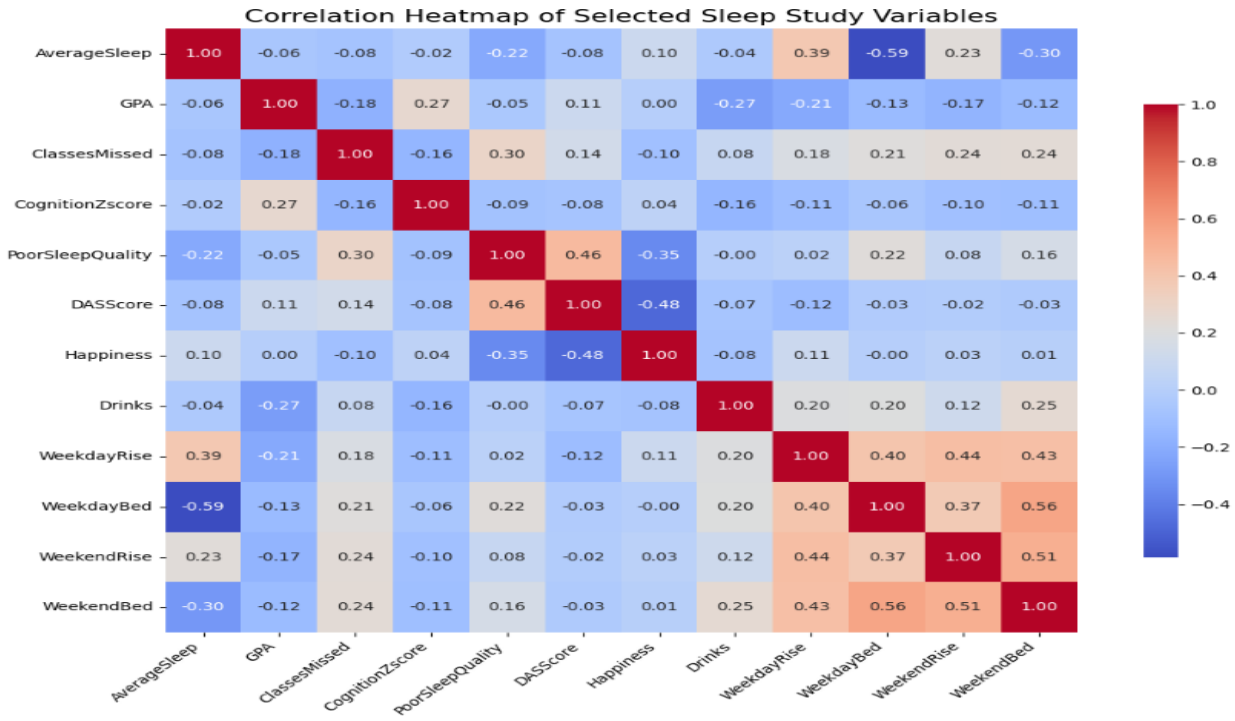
Drinks: Number of alcoholic drinks per week

WeekdayRise: Average weekday rise time (8.0 = 8am)

WeekdayBed: Average weekday bedtime (24.0 = midnight)

WeekendRise: Average weekend rise time (8.0 = 8am)

WeekendBed: Average weekend bedtime (24.0 = midnight)



GPA and Sleep Duration Confidence Interval Calculation:

GPA Confidence Interval Calculation:

$$point\ estimate \pm t^{\star}\ x\ SE$$

$$\text{point estimate} \pm t^{\star}_{df} \times SE \quad \rightarrow \quad \bar{x} \pm t^{\star}_{df} \times \frac{s}{\sqrt{n}}$$

x̄ = 3.24(from the summary statistics)

sd = 0.4(from the summary statistics)

df = n -1 = 253 -1 = 252

SE = s/(n^½) = 0.4/(253^½) = 0.0251

```python
from scipy.stats import t

def get_t_value(confidence_level, df):

    alpha = 1 - confidence_level
    t_value = t.ppf(1 - alpha/2, df)
    return t_value

# Example usage:
confidence_level = 0.90
degrees_of_freedom = 252
t_val = get_t_value(confidence_level, degrees_of_freedom)
print(f"t-value for confidence level {confidence_level*100}% and df={degrees_of_freedom}: {t_val}")
```

```
t-value for confidence level 90.0% and df=252: 1.6509227554442152
```

```python
from scipy.stats import t

def get_t_value(confidence_level, df):

    alpha = 1 - confidence_level
    t_value = t.ppf(1 - alpha/2, df)
    return t_value

# Example usage:
confidence_level = 0.95
degrees_of_freedom = 252
t_val = get_t_value(confidence_level, degrees_of_freedom)
print(f"t-value for confidence level {confidence_level*100}% and df={degrees_of_freedom}: {t_val}")
```

```
t-value for confidence level 99.0% and df=252: 2.595479296280097
```

```python
[ ] from scipy.stats import t

    def get_t_value(confidence_level, df):

        alpha = 1 - confidence_level
        t_value = t.ppf(1 - alpha/2, df)
        return t_value

    # Example usage:
    confidence_level = 0.99
    degrees_of_freedom = 252
    t_val = get_t_value(confidence_level, degrees_of_freedom)
    print(f"t-value for confidence level {confidence_level*100}% and df={degrees_of_freedom}: {t_val}")
```

```
t-value for confidence level 99.0% and df=252: 2.595479296280097
```

We calculated three different T values for three different confidence intervals. Let’s gather them here. And found our confidence intervals.

t value for % 90 confidence interval = 1.65

t value for % 95 confidence interval = 1.97

t value for % 99 confidence interval = 2.60

1.65x 0.0251 = 0.041415 ME for %90

1.97x 0.0251 = 0.049447 ME for %95

2.60x 0.0251 = 0.06526 ME for %99

(3.20,3.28) Confidence Interval for %90

(3.19,3.29) Confidence Interval for %95

(3.17,3.31) Confidence Interval for %99

Sleep Duration Confidence Interval Calculation:

SD: 0.96

Mean = 7.97

SE = s/(n^½) = 0.96/(253^½) = 0.06

df = 253 -1 = 252

%99 Confidence Interval = (7.81,8.13)

%95 Confidence Interval = (7.85,8.09)

%90 Confidence Interval = (7.97,8.07)

GPA - Gender Relationship Hypothesis Testing Calculation:

$$SE = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$

Where:

- s_1^2 is the sample variance of the first group.
- n_1 is the sample size of the first group.
- s_2^2 is the sample variance of the second group.
- n_2 is the sample size of the second group.

Variance (Female): 0.14

Sample Size (Female):151

Mean GPA(Female): 3.25

Variance (Male): 0.174

Sample Size (Male):102

Mean GPA (Male): 3.12

$$\sqrt{\frac{0.1407171567}{151} + \frac{0.1744255873}{102}} = 0.05139996573$$

Next, the degrees of freedom were determined using the appropriate formula.

The degrees of freedom (ν) in Welch's t-test are calculated using the **Welch-Satterthwaite equation**:

$$\nu \approx \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}}$$

Where:

- s_1^2 is the sample variance of the first group.
- n_1 is the sample size of the first group.
- s_2^2 is the sample variance of the second group.
- n_2 is the sample size of the second group.

$$\frac{\left(\frac{0.1407171567}{151} + \frac{0.1744255873}{102}\right)^2}{\frac{\left(\frac{0.1407171567}{151}\right)^2}{150} + \frac{\left(\frac{0.1744255873}{102}\right)^2}{101}} = 200.9021972$$

The t-value was then calculated by subtracting the difference between female and male means from zero, reflecting the null hypothesis that there is no difference between the groups.

$$\frac{(3.324900662 - 3.12372549 - 0)}{0.05139996573} = 3.913916462$$

```python
from scipy import stats

t = 3.913916462
df = 200.9021971

# Two-tailed p-value
p_value = 2 * (1 - stats.t.cdf(abs(t), df))
print("Two-tailed p-value:", p_value)
```

```
Two-tailed p-value: 0.00012429800112756517
```

Sleep Duration-Gender Relationship Hypothesis Testing Calculation:

We chose a significance level (α) of 0.05.

Variance (Female): 0.98

Sample Size (Female):151

Mean Sleep Hours (Female): 7.99

Variance (Male): 0.85

Sample Size (Male):102

Mean Sleep Hours (Male): 7.92

SE calculation

$$\sqrt{\frac{0.9869237792}{151} + \frac{0.8538676471}{102}} = 0.1220949242$$

Degrees of Freedom calculation

$$\frac{\left(\frac{0.9869237792151}{151} + \frac{0.8538676471}{102}\right)^2}{\frac{\left(\frac{0.9869237792151}{151}\right)^2}{150} + \frac{\left(\frac{0.8538676471}{102}\right)^2}{101}} = 227.0767349$$

T value calculation

$$\frac{(7.994768212 - 7.923235294 - 0)}{0.122} = 0.5863353934$$

P value calculation

```
from scipy import stats

t = 0.5863353934
df = 227

# Two-tailed p-value
p_value = 2 * (1 - stats.t.cdf(abs(t), df))
print("Two-tailed p-value:", p_value)
```

```
Two-tailed p-value: 0.5582327311126538
```

AI Usage (ChatGPT, Gemini):

- **Literature Scanning:** We referred to a lot of scientific studies in our work, and AI really helped us find and understand them quickly.
- **"Text Academizer":** AI helped us to make our text more elegant and academically fashionable.
- **Python Helper:** We used Python to calculate our p-values and t-values, and the code we used was generated with help from AI.
- **Welch Test:** We hadn't learned how to find degrees of freedom when comparing the means with different variances, ChatGPT showed us how we can do that.

Project Timeline:

Stage 1:

- We chose the dataset
- We chose which variables we will use, and which questions we can answer

Stage 2:

- We gave the overview of data
- We did preliminary analysis

- We visualized data
- We assigned roles
- We set the timeline

Stage 3:

- We conducted a more in-depth investigation into the answers to our research questions.
- We made hypothesis test and confidence interval calculations
- We concluded our results

Roles:

Safa ÖKSÜZ: Report writing, dataset selection, question and variable selection, hypothesis testing

Jana HOFMANN: Dataset selection, question and variable selection and data visualization, confidence interval calculations