

STA305 Project

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December 1, 2019

-Objectives

Sleeping takes up one third of human lives. Sleeping occurs in repeating periods. Our bodies will alternate REM, light sleep and deep sleep. Nowadays, some humans may suffer from the poor sleep quality, such as sleep disorder, insomnia due to the pressure from work, study. Especially, deep sleep is the main factor to decide your sleeping quality. This factorial design is to determine the relationship between the human activities and the percentage of deep sleep. Such as work out(exercise) which is the first factor, gender(gender) which is the second factor and what time we go to bed(time) which is the third factor.

-Methods

Due to there are 2 levels of all three factors. Hence, this is a 2^3 factorial design. There are total 8 combinations in the entire design. I performed 2 repetitions of the design due to the least requirement of 16 groups of data for the cube plot. For samples of this factorial design, I randomly asked a male friend who is also a 4th year student in University of Toronto. I asked him to download the app "Pillow" on his phone and borrowed him my Apple Watch. I asked him to finish these processes twice, first go to bed after 12am without going to the gym that day. Second, go to bed before 12am without going to the gym that day. Third, go to bed after 12am and go to the gym. Last, go to bed before 12am and go to the gym. Finally, he sent me screenshot of his results. I also do all the combinations twice and keep the screenshots. Pillow will detect and analyze our sleeps and I can obtain the data.

Factors	Level 1	Level 2
Gender	Male (1)	Female (-1)
Time	Before 12am (1)	After 12am (-1)
Work out	Yes (1)	No (-1)

The following table is the collected data:

Day	DSpercentage	Gender	Exercise	Time
1	33	1	1	1
2	30	1	1	-1
3	32	1	-1	1
4	26	1	-1	-1
5	35	-1	1	1
6	33	-1	1	-1
7	32	-1	-1	1
8	30	-1	-1	-1
9	35	1	1	1
10	32	1	1	-1
11	29	1	-1	1
12	28	1	-1	-1
13	38	-1	1	1
14	31	-1	1	-1
15	32	-1	-1	1
16	30	-1	-1	-1

-Statistical Analysis

```
##
## Call:
## lm(formula = DSpercentage ~ gender * exercise * time, data = sleep)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
##     -1.5     -1.0      0.0      1.0      1.5
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    3.162e+01  3.644e-01  86.778 3.47e-13 ***
## gender         -1.000e+00  3.644e-01  -2.744  0.02529 *
## exercise        1.750e+00  3.644e-01   4.802  0.00135 **
## time           1.625e+00  3.644e-01   4.459  0.00211 **
## gender:exercise  1.250e-01  3.644e-01   0.343  0.74044
## gender:time     -4.163e-16  3.644e-01   0.000  1.00000
## exercise:time    2.500e-01  3.644e-01   0.686  0.51210
## gender:exercise:time -3.750e-01  3.644e-01  -1.029  0.33359
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.458 on 8 degrees of freedom
## Multiple R-squared:  0.8669, Adjusted R-squared:  0.7505
## F-statistic: 7.445 on 7 and 8 DF,  p-value: 0.005559
```

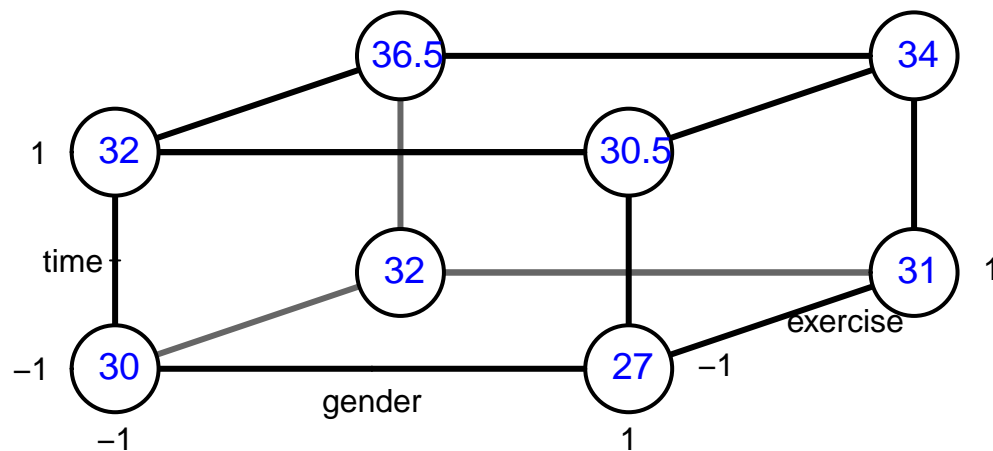
linear regression model:

$$y = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \beta_4 x_{i1}x_{i2} + \beta_5 x_{i1}x_{i3} + \beta_6 x_{i2}x_{i3} + \beta_7 x_{i1}x_{i2}x_{i3} + \epsilon_i$$

We have strong evidences against the null hypothesis($\beta_1 = 0, \beta_2 = 0, \beta_3 = 0$) since the P-values of gender, exercise and time are all less than 0.05. Hence, there is evidence that gender, exercise and time are the factors which will affect sleep quality by affect the percentage of deep sleep.

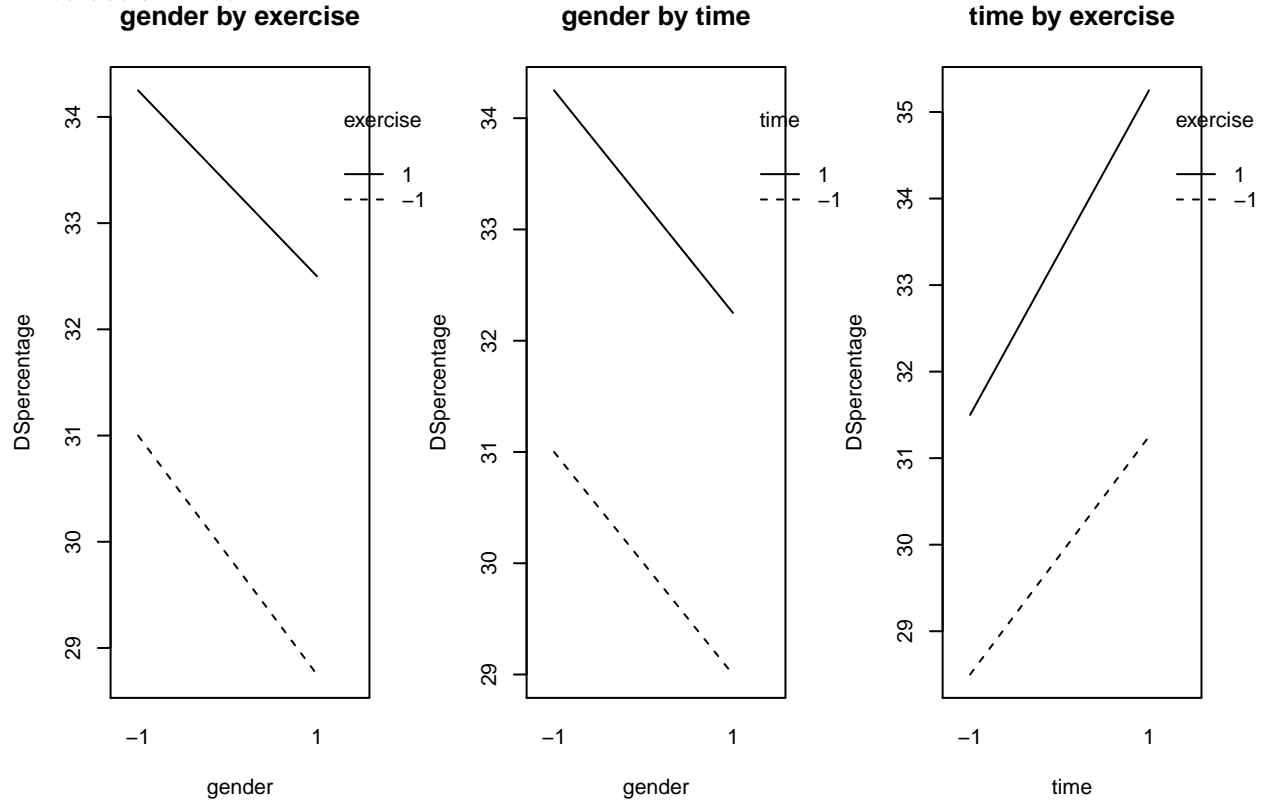
-Cubeplot:

cube plot of deep sleep percentage



modeled = TRUE

-Interaction Plot:



Base on the plots above, the lines are close to parallel in interaction plots of three factors. Hnece there is weak evidence of interaction effects. Also the relevant P-values of the interactions are larger than 0.05 which are non-significant and fail to reject the null hypothesis($(\beta_4 = 0, \beta_5 = 0, \beta_6 = 0, \beta_7 = 0)$) which means there is no two-way and three-way interaction effects between the variables.

-Analysis of Main effects and interaction effects:

We need to multiply the regression coefficients by 2 to obtain the main effects and interaction effects.

factor	effect
gender	-2.0000
exercise	3.5000
time	3.2500
gender:exercise	2.5e-01
gender:time	-8.326e-16
exercise:time	0.500
gender:exercise:time	-7.500e-01

-Comments:

In this factorial design, female is the reference group. The p-value is less than 0.05 then there is strong evidence of gender is one of the factors which affects sleeping quality. -2.00 means the percentage of deep sleep of male is 2% lower that female on average. Hnece, the sleep quality of male is lower than female.

3.5 shows that exercise is a factor which affect the sleeping quality. The relationship between exercise and deep sleep percentage is positive. The p-value is significant and we reject $H_0 : \beta_2 = 0$.

The reference group is go to bed after 12am. The p-value of time to bed is less than 0.05 so we reject

$H_0 : \beta_3 = 0$. There is evidence reflects that going to bed before 12am have positive effect on the percentage of deep sleep.

All the p-value of interactions are more than 0.05 so we fail to reject $H_0.(\beta_4 = 0, \beta_5 = 0, \beta_6 = 0, \beta_7 = 0)$. There is no evidence shows there are interaction effects of gender, exercise and the time to bed. The effects of gender, exercise and time to bed on the sleeping quality are independent of each other.

-Estimated variation of effect:

The standard error of all factorial effects are the same.

$$(standarderror * 2) = 0.3644 * 2 = 0.7288$$

are the standard error.

The estimated variance is:

$$s_i^2 = \sum_{i=1}^2 \frac{(w_i - \bar{w})^2}{2-1}$$

$$s^2 = \frac{\sum_{i=1}^8 s_i^2}{8} = 2.125$$

$$Var(effect) = (\frac{1}{8} + \frac{1}{8})\sigma^2$$

$$= \frac{\sigma^2}{4} = \frac{s^2}{4} = 0.53125$$

-95% CI:

##	2.5 %	97.5 %
## (Intercept)	61.569225	64.9307749
## gender	-3.680775	-0.3192251
## exercise	1.819225	5.1807749
## time	1.569225	4.9307749
## gender:exercise	-1.430775	1.9307749
## gender:time	-1.680775	1.6807749
## exercise:time	-1.180775	2.1807749
## gender:exercise:time	-2.430775	0.9307749

-Comments:

The 95%CI of gender, exercise and the time we go to bed do not contain 0 which is significant. So there are main effects of gender, exercise and the time to bed. There is evidence that female do exercise and go to bed before 12am will improve the percentage of deep sleep. All factors have independent effects on the sleep quality. Also this is consistent with the previous results.

-Conclusion:

This 2^3 factorial design is aimed to find out which factors that influence the percentage of deep sleep which also connected to the sleep quality. Also, determined the main effects and interaction effects of these three factors. From the data analysis, we found out the sleep quality of female is better than male's because female has higher percentage of deep sleep. Both exercise and time to bed before 12 am have positive estimated coefficients and small p-values which is less than 0.05. Hence, there strong evidence to show that exercise daily and go to bed before 12am will improve the quality of the sleeping. In general, the percentage of deep sleep of male is 2% lower than female. Both doing exercise and go to bed before 12am can raise around 3% in the percentage of deep sleep. Because there is no interaction effects within three factors. It means that gender, exercise and time is independent of each other. Through this factorial design, no matter female or male should go to bed before 12am and exercise daily so that can improve sleep quality alought female may have better sleep quality than male does.