STA305 Homework 4

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1. Description of the Design

I have been recording my sleeping condition since 2013. So when Homework #4 was released on March 22nd, I decided to conduct an experiment on factors that affect my sleeping condition (specifically, the time span of deep sleep). This topic might sound very similar to the one we have talked about in lecture. Therefore, in order to spice it up, besides caffeine and working-out, I want to see if the intake of alcohol also alters one's deep sleeping time. Considering the fact that I am a regular coffee-drinker and jog once every two days, a 2-to-the-power-of-3 factorial design would be suitable. In addition, I want to see some variability in the result, so I double the number of runs, now with consecutive 16 days' record.

To control the experiment, the following rules are also added:

- The intake time of coffee or beer is no more than 3 hours before sleeping time.
- The standard amount of beer is a 500ml tin can with 4.5-5% alcohol (Brands differ)
- The standard amount of coffee is a medium size dark coffee bought from Tim Hortons.
- The workout time is no more than 8 hours before sleeping time.
- The standard amount of workout is 5km jogging with at least 6min/km pace.

- An application called [Sleep Cycle](#) is used to record the sleeping condition of mine. On its website, it claims that it uses the built-in microphone of iPhone to track one's movements in sleep.

- Note:

  - 1h29min nap time on Thursday March 24th. Did not include this in data because the effects I am studying barely have relations with sleep in the afternoon.
  - The deep sleep time is rounded to 2 significant digits in hours, e.g. 3 hour 28 min is rounded to 3.5 hours.
  - The detailed data is attached at the end of report.

2. Analysis of Data

We can represent the data in a cube plot:

Cube Plot for sleeping data

Cube Plot for sleeping data

modeled = TRUE
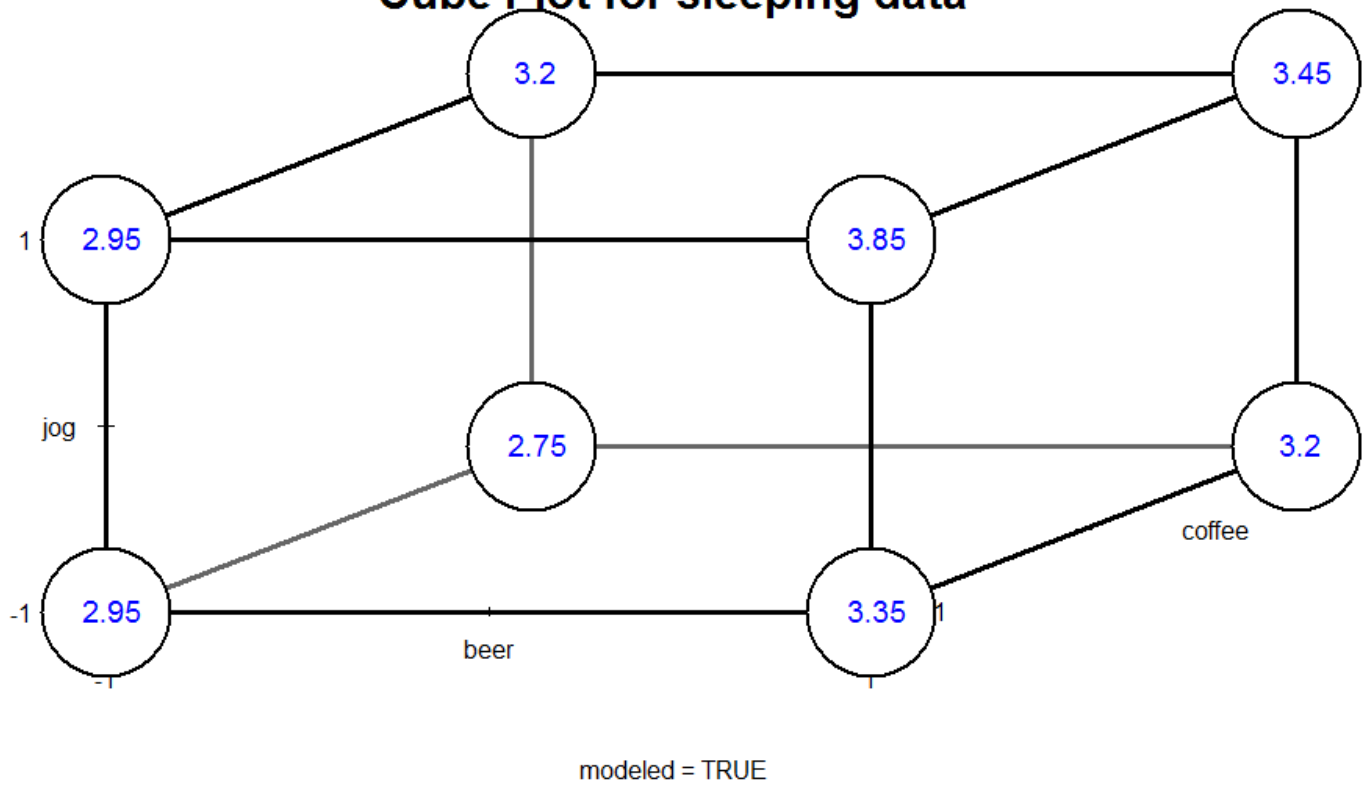
2.1 Main and interaction effects

effects	beer	coffee	jog	beer:coffee	beer:jog	coffee:jog	beer:coffee:jog
main/interaction effect	0.8	-0.4	0.0	0.1	1.0	0.9	-1.4

2.2 Estimated variance of the effects

The variance of deep sleep time is $s^2 = 0.1158333$, then the variance for all factorial effects is the same, which can be calculated as below:

$$\left(\frac{1}{8} + \frac{1}{8} \right) s^2 = \frac{1}{4} \cdot 0.1158333 = 0.02895833$$

The unit is square hour with eight degrees of freedom.

2.3 95% confidence intervals for true values of effects

effects	2.5%	97.5%
beer	0.3685861	1.23141387
coffee	-0.8314139	0.03141387
jog	-0.4314139	0.43141387

beer:coffee	-0.5101113	0.71011135
beer:jog	0.3898887	1.61011135
coffee:jog	0.2898887	1.51011135
beer:coffee:jog	-2.2628277	-0.53717226

2.4 Lenth's plot
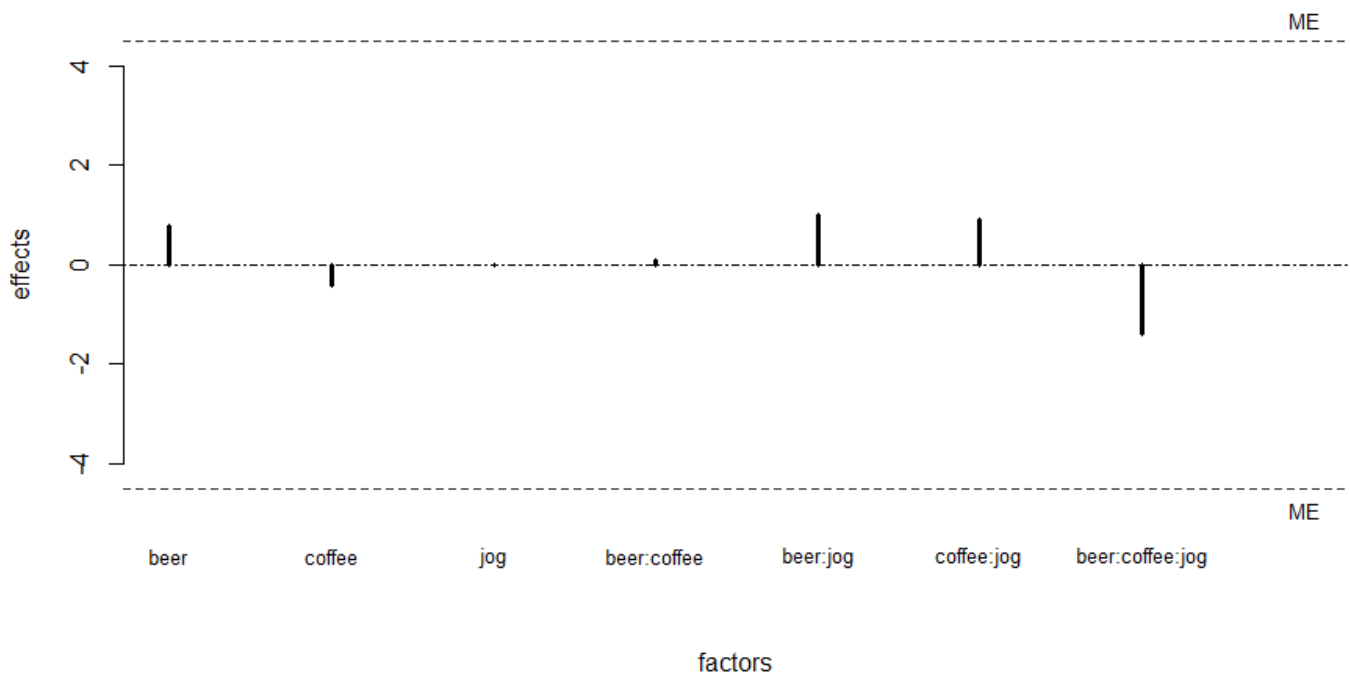
3. Conclusions

- According to 95% CI, main effect `beer`, interaction `beer:jog`, `coffee:jog` and `beer:coffee:jog` do not contain a zero, which indicate significance. And this is also consistent with the hypothesis test (with calcualted p-value).
- However, according to the Lenth's plot, none of the 8 effects is significant. So a contradiction appears against our calculation. This might be explained by noise in data.
- Generally speaking,
    - drinking beer before sleep increases the deep sleep time by 0.8 hour;
    - drinking coffee and working out increases the deep sleep time by 1.0 hour;
    - drinking coffee and working out increases the deep sleep time by similar amount;
    - but drinking both beverage and working out decreases the deep sleep time by 1.4 hour.
- Hence, our experiment seems to draw a strange conclusion. This is probably because the experiment was not run long enough. And in fact, there are many factors which could affect the experiment results. For instance, people's mood could affect his or her sleeping quality, and whehter the mechanism used to

calculate deep sleep time is not systematically verified, etc.

4. Appendix

- script

```
 1 > data <- read.csv("raw.csv")
 2 > var(data$deep)
 3 [1] 0.1158333
 4 > fact.mod <- lm(deep~beer*coffee*jog,data=data)
 5 > round(2*fact.mod$coefficients,2)
 6     (Intercept)              beer           coffee              jog       beer:coffee           beer:j
   og       coffee:jog
 7             5.9               0.8             -0.4              0.0               0.1                1
   .0               0.9
 8 beer:coffee:jog
 9            -1.4
10 > round(summary(fact.mod)$coefficients,2)
11                 Estimate Std. Error t value Pr(>|t|)
12 (Intercept)         2.95       0.07   44.60     0.00
13 beer                0.40       0.09    4.28     0.00
14 coffee             -0.20       0.09   -2.14     0.06
15 jog                 0.00       0.09    0.00     1.00
16 beer:coffee         0.05       0.13    0.38     0.72
17 beer:jog            0.50       0.13    3.78     0.01
18 coffee:jog          0.45       0.13    3.40     0.01
19 beer:coffee:jog    -0.70       0.19   -3.74     0.01
20 > 2*confint.lm(fact.mod)
21                     2.5 %       97.5 %
22 (Intercept)     5.5949443   6.20505567
23 beer            0.3685861   1.23141387
24 coffee         -0.8314139   0.03141387
25 jog            -0.4314139   0.43141387
26 beer:coffee    -0.5101113   0.71011135
27 beer:jog        0.3898887   1.61011135
28 coffee:jog      0.2898887   1.51011135
29 beer:coffee:jog -2.2628277 -0.53717226
30 > library("FrF2")
31 > cubePlot(fact.mod,"beer","coffee","jog",main="Cube Plot for sleeping data")
32 > LenthPlot(fact.mod,cex.fac=0.8)
33     alpha       PSE        ME       SME
34  0.050000  1.200000  4.516948 10.809969
```

- raw data

```
1 run,beer,coffee,jog,deep
2 1,0,1,0,2.7
3 2,0,1,1,3.2
4 3,0,1,0,2.8
5 4,0,0,1,3.0
6 5,0,0,0,3.0
7 6,0,1,1,3.2
8 7,0,0,0,2.9
```

```
 9  8,1,0,1,3.8
10  9,1,1,0,3.2
11  10,1,1,1,3.5
12  11,1,0,0,3.2
13  12,1,1,1,3.4
14  13,1,0,0,3.5
15  14,1,0,1,3.9
16  15,1,1,0,3.2
17  16,0,0,1,2.9
```