

Compulsory Exercise 3 in TMA4267 Statistical Linear Models, Spring 2021

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Design of Experiments (DOE)

The purpose of this exercise is to provide insight and training in planning, performing and analyzing a statistical experiment, as well as to report the results.

High-score in Tetris

A k -factor two-level experiment is performed in order to determine how various factors influence score in the game of *Tetris*. The aim of the game is to attain the highest score possible. This is inherently interesting, because performance is important in life (lol). Our prior knowledge when it comes to factors that influence performance in the game is that concentration is key, as in many other situations in life. Besides this, in-game performance has never been investigated systematically by us, which makes this experiment more interesting, at least for the authors of the study. Hopefully, we can achieve higher high-scores and better performances in Tetris, after uncovering some factors that might boost these positive outcomes.

Selection of Factors and Levels

Some factors that are believed to be relevant to the problem are

```
colnames(ExperimentDesign) <- c("Bright", "Coffee", "Music", "Seating", "Surroundings", "Device")
```

- A - Screen brightness: 10% or 100%.
- B - Coffee break: Is the game played while drinking coffee at least once during the game?
- C - Music: Is the game played with or without listening to Darude Sandstorm?
- D - Seating: Is the game played while laying in bed or while sitting comfortably at a desk?
- E - Surroundings: Is the game played in a quiet room or in front of the TV?
- F - Device: Is the game played on a mobile phone or on a laptop with a larger screen?

We expect an interaction between seating and device, since the mobile phone might be a lot easier to handle while laying in bed compared to the laptop, which might give more confidence when seated at a desk. Moreover, an interaction between low screen brightness and noise could make it even more difficult to concentrate. Also, an interaction between screen brightness and device might be reasonable, since a larger screen might not demand a bright screen compared to the smaller screen. More interactions might be present, but those are the ones I thought of off the top of my head.

The levels that should be used are briefly described in the list above. These are reasonable since they may lead to very different results in the response and they are easy to implement and monitor in practice. These levels can be controlled by simply testing for each of them systematically.

Selection of Response Variable

The response is the score in the game after 30 seconds. Each game is played using the same setup and controls. Several response variables might be interesting, e.g. a mean score over several games with the same levels of the factors. These types of responses are very easy to measure, since Tetris simply outputs the score after each completed round. When it comes to the accuracy of these responses, it is reasonable to assume that the algorithm for calculating the score is the same in each game, which means that they should be reliable. As the pieces received are random each time, we will expect a random element, that is, there will be a lot of variance.

Choice of Design

This experiment will follow 2^{6-2} fractional factorial design. Some of the reasoning behind this is that testing all the combinations of a full 2^6 factorial design would take quite some time to perform. The defining relation is ... **Fornuftig?**

Desired resolution? As large as possible? Blocking? → This should not be necessary IMO, since these experiments should be very quick and easy to perform. Replications? → Perhaps.

Implementation of the Experiment

We create a game mode that lasts for 30 seconds. For each combination of variables, we play one single game, and the game outputs a score.

Analysis of Data

```
# importing packages
# require(FrF2)
```

```
results = c(7863,6977,6597,8982,5056,4352,7814,5472,6450,4031,4915,5365,3213,4540,7917,4842,6968,6717,7192,6767,5821,6387,64,4742,5246,3150,5463,7588,6430,3573,5867,4608,1564,728,1574,362,1673,3063,2816,1500,2845,496,2184,911,1241,3107,1657,1803,2552,2358,2218,2527,1460,403,1714,3391,2006,1789,4118,577,2018,658,4528,662)
```

```
results
```

```
#> [1] 7863 6977 6597 8982 5056 4352 7814 5472 6450 4031 4915 5365 3213 4540 7917
#> [16] 4842 6968 6717 7192 6767 5821 6387 64 4742 5246 3150 5463 7588 6430 3573
#> [31] 5867 4608 1564 728 1574 362 1673 3063 2816 1500 2845 496 2184 911 1241
#> [46] 3107 1657 1803 2552 2358 2218 2527 1460 403 1714 3391 2006 1789 4118 577
#> [61] 2018 658 4528 662
```

```
length(results)
```

```
#> [1] 64
```

```
?gl
```

```
ExperimentDesign <- expand.grid(A = gl(2, 1, labels = c("+", "-")),
                                B = gl(2, 1, labels = c("+", "-")),
```

```

C = gl(2, 1, labels = c("+", "-")),
D = gl(2, 1, labels = c("+", "-")),
E = gl(2, 1, labels = c("+", "-")),
FF = gl(2, 1, labels = c("+", "-")) # FALSE IS RESERVED

# colnames(ExperimentDesign) <- c("Bright", "Coffee", "Music", "Seating", "Surroundings", "Device")

#View(ExperimentDesign)
ExperimentDesign

```

```

#>      A B C D E FF
#> 1  + + + + + +
#> 2  - + + + + +
#> 3  + - + + + +
#> 4  - - + + + +
#> 5  + + - + + +
#> 6  - + - + + +
#> 7  + - - + + +
#> 8  - - - + + +
#> 9  + + + - + +
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```

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#> 64 - - - - - -
```

```
#print(FrF2(nruns=2^4,nfactors=4, randomize=FALSE))
# må sette default.levels = c(1, -1)

#plan = FrF2(nruns = 2^6, nfactors=6, randomize=FALSE)
#plan <- add.response(plan, results)

attach(ExperimentDesign)
summary(lm(results~(A+B+C+D+E+FF)^2), data=ExperimentDesign)
```

```
#>
#> Call:
#> lm(formula = results ~ (A + B + C + D + E + FF)^2)
#>
#> Residuals:
#>      Min       1Q   Median       3Q      Max
#> -4315.7  -623.8  -107.6   792.6  2161.9
#>
#> Coefficients:
#>              Estimate Std. Error t value Pr(>|t|)
#> (Intercept)   7030.25    840.05   8.369 1.72e-10 ***
#> A-              54.75    877.40   0.062  0.9505
#> B-             34.44    877.40   0.039  0.9689
#> C-            -1462.75    877.40  -1.667  0.1029
#> D-            -1406.62    877.40  -1.603  0.1164
#> E-             -262.75    877.40  -0.299  0.7661
#> FF-            -5048.81    877.40  -5.754 8.96e-07 ***
#> A-B-             221.12    716.40   0.309  0.7591
#> A-C-             265.25    716.40   0.370  0.7131
#> A-D-            -1261.25    716.40  -1.761  0.0856 .
```

```

#> A-:E-          67.50      716.40    0.094    0.9254
#> A-:FF-        -440.63      716.40   -0.615    0.5418
#> B-:C-          50.13      716.40    0.070    0.9446
#> B-:D-         776.38      716.40    1.084    0.2847
#> B-:E-        -188.87      716.40   -0.264    0.7933
#> B-:FF-        -177.50      716.40   -0.248    0.8055
#> C-:D-         984.25      716.40    1.374    0.1768
#> C-:E-        -820.75      716.40   -1.146    0.2584
#> C-:FF-        1403.63      716.40    1.959    0.0567 .
#> D-:E-         492.25      716.40    0.687    0.4958
#> D-:FF-         954.38      716.40    1.332    0.1900
#> E-:FF-         828.63      716.40    1.157    0.2540
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
#>
#> Residual standard error: 1433 on 42 degrees of freedom
#> Multiple R-squared:  0.7599, Adjusted R-squared:  0.6399
#> F-statistic:  6.33 on 21 and 42 DF,  p-value: 2.101e-07

```

Conclusion and Recommendations

In the full factorial model, the only two significant factors are the intercept, and the device. When playing on mobile, the expected score decreases with about 5000 points, with a p-value of $9e - 7$, which is not insignificant.