305 project

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Description

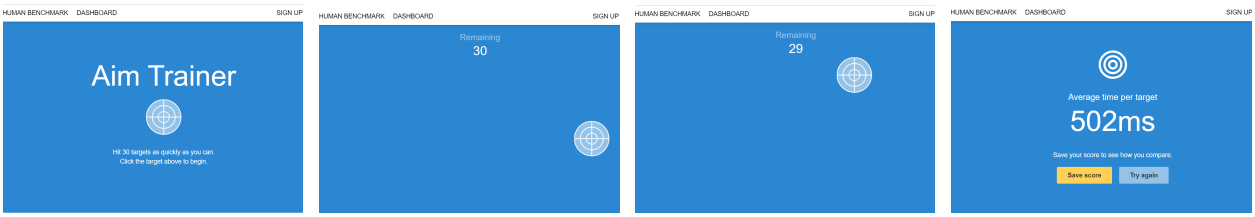
Recently we just experienced course selection on the Quercus, and all of us were required to react and move our mouse as fast as possible to grab our favourite bird course. I failed to select my ideal bird course and started to examine any possibilities to improve the selection speed. Although the internet condition is hard to change at home, we can improve the mouse aiming speed. I researched that first-person shooting game players sometimes switch their mouse pad to soft or hard or change their mouse's dpi (dots per inch, a measurement of mouse sensitivity) setting to improve their aiming accuracy. Note that shooting games are very similar to select a course; we all need to move our mouse to targets quickly and click on it. Further, I found that some mice can swap the right-click button and left-click button, and I wonder whether that will affect the aiming speed.

So, I would like to conduct a replicated 2^3 factorial design to see whether the following three factors will affect the mouse aiming speed. The three factors are:

	Mouse Pad	DPI (dots per inch)	Finger
1	Soft mouse pad (made of cloth and rubber)	1600	Index finger
-1	Hard mouse pad (made of plastic)	800	Middle finger

I am choosing the DPI value to be 1600 and 800, respectively, because they are the most common settings. Here I selected the top five average rated mouse products on Amazon, and four of those mouses can adjust their dpi to either 1600 or 800. Although there are other common settings (most business mouse's dpi is 1000), I choose 800 because I want my mouse to move slower to improve accuracy.

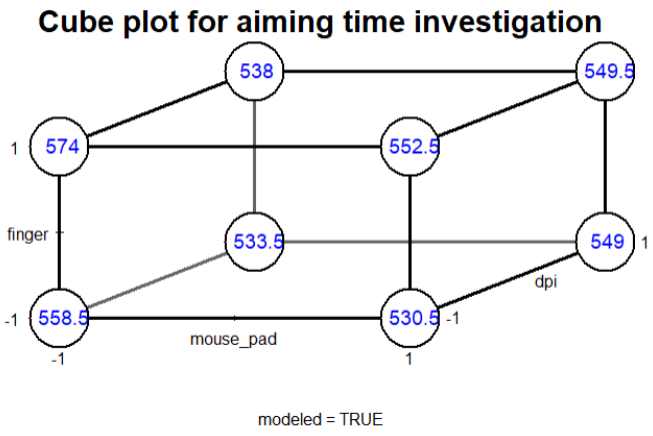
I will use the following program to test my mouse aiming speed: https://humanbenchmark.com/tests/aim. The program will ask you to click on a target that appeared on the screen to begin the test, and then after you click on the target, the target will disappear, and at the same time, another target will randomly appear on the screen. You will need to click on the targets that appeared rapidly until 30 targets were clicked, then the program will then calculate the average reaction time between you click on each target (in ms).The following pictures shows how I did the test.



As the design is a 2^3 factorial design with two replications, there are eight combinations, and I need to collect 16 observations. On Aug 16th morning at noon, (which is similar to the course selection time). I experimented by randomized the run order of the eight combinations and performed the aiming speed test using the assigned mouse pad, dpi, and finger combination. Between each test, I will have five minutes break. On Aug 17th morning noon, I replicated the experiment. Note that I used the same mouse and laptop setting, wore the same cloth and ate the same breakfast as all possible covariants.

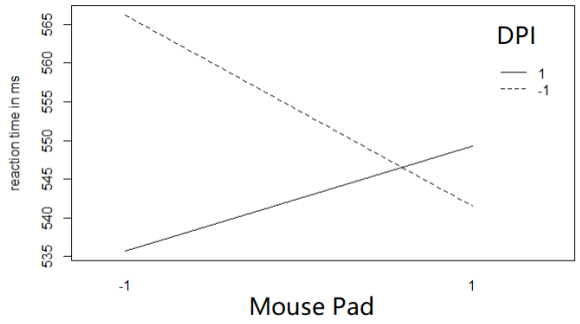
Analysis

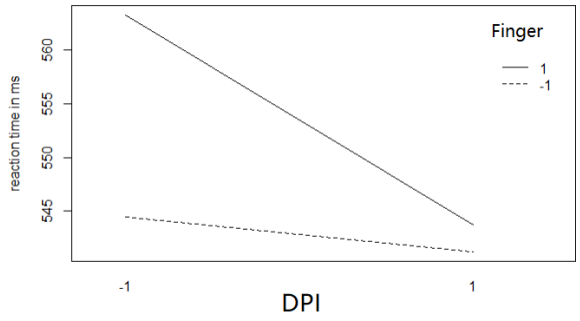
To begin the analysis, we can use a cube plot to show the average reaction time for different combinations.

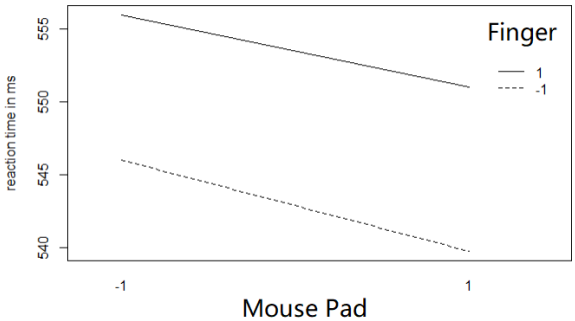


We can observe that the average aiming time does not vary a lot for different combinations. The shortest average reaction time is 530.5 ms, which happens when I use the soft mousepad, 800 dpi and middle finger to perform the test. The longest average reaction time is 574 ms, which occurred when I used hard mousepad, 800 dpi and index finger to complete the test. We can also observe there is always a positive effect between the index finger and mid finger, which is pretty impressive as I thought I would react faster by using the index finger, but the data is in contrast. As we can see, the difference between each value is reasonable, and we will keep using the data for the following analysis.

We can use an interaction plot to see whether there are interactions between any two of the factors. (In case the y-axis is not clear, it is "reaction time in ms")







We observed that there is an interaction that might present between mouse pad type and dpi setting, and

there are no interactions between mouse pad type and finger or dpi and finger. We also noticed that when the sensitivity is 800 dpi, choose which finger to click affect the aiming speed more than in the case of using the 1600 dpi setting. But we don't know whether the interaction is significant from the interaction plot.

Then, we will provide an analysis of whether each coefficient of the fitted linear model is significant. To have an idea of how the data varies, we calculated the pooled estimate variance is $s^2 = \frac{\sum_{i=1}^{8} s_i^2}{8} = \frac{980.5}{8} = 122.5625$. The variance for each effect is $\frac{122.5625}{4} = 30.64062$, the standard deviation for each effect is $sqrt(30.64062) = 5.535341$, and the standard error for each coefficients of the linear model is $\frac{5.535341}{2} = 2.76767$, approximately 2.77. The model summary is shown below. (Here I used the equation from chapter 10)

```
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)            548.188       2.77 198.066 4.73e-16
## mouse_pad               -2.812       2.77  -1.016 3.39e-01
## dpi                     -5.687       2.77  -2.055 7.39e-02
## finger                   5.313       2.77   1.919 9.12e-02
## mouse_pad:dpi            9.563       2.77   3.455 8.63e-03
## mouse_pad:finger         0.313       2.77   0.113 9.13e-01
## dpi:finger              -4.062       2.77  -1.468 1.80e-01
## mouse_pad:dpi:finger    -1.312       2.77  -0.474 6.48e-01
```

We observed that only the p-value for the coefficient of the interaction between mouse_pad and dpi is less than the 0.05 threshold. We reject the null hypothesis H_0, and we can conclude that mouse_pad type and dpi have an interaction effect on the aiming speed. So the interaction that we observed from the interaction plot is significant.

And all the p-values for the other factors or interaction between each element are greater than the 0.05 threshold, which we fail to reject the null hypothesis H_0 and conclude that they do not have any effect on the aiming speed.

Here we can calculate the 95% confidence intervals for the effect of each term.

```
##                         2.5 %  97.5 %  effects
## (Intercept)          1083.61 1109.14 1096.375
## mouse_pad             -18.39    7.14   -5.625
## dpi                   -24.14    1.39  -11.375
## finger                 -2.14   23.39   10.625
## mouse_pad:dpi           6.36   31.89   19.125
## mouse_pad:finger      -12.14   13.39    0.625
## dpi:finger            -20.89    4.64   -8.125
## mouse_pad:dpi:finger  -15.39   10.14   -2.625
```

We can see only the 95% confidence interval for the mouse_pad:dpi does not include zero, which is (6.36, 31.89). This result conforms with what we conclude from the p-value analysis, but we can see how the interaction effect ranges by observing the confidence interval. Hence we can conclude that there is an interaction effect between mouse_pad and dpi on the aiming speed. We can conclude that using soft mousepad (value is 1) with 800 dpi (value is -1) setting or using hard mousepad (value is 1) with 1600 dpi (value is -1) setting will decrease the estimated reaction time comparing to using soft mousepad (value is 1) with 1600 dpi (value is 1) setting or using hard mousepad (value is -1) with 800 dpi (value is -1) setting. Hence only the interaction between mouse pad and dpi setting will affect your aiming speed.

Conclusions and Discussions

In conclusion, my aim for this experiment is to find out if we can improve our aim speed, in other words, I want to find out if we can improve the speed we use the mouse to click on a target and then switch to another target. I choose to use a soft and hard mouse pad as one factor's two levels and choose to use 1600 dpi, 900 dpi, as two levels of another factor, at last, I choose to use either index finger, middle finger to perform the test as the two levels of the third factor. In the analysis, we observed that there is an interaction that might present between mouse pad type and dpi setting. And from the linear model's output, we found the interaction between mouse pad type and dpi setting affects the reaction speed. And the 95 percent interval further showed that the interaction between mouse pad type and dpi setting has an effect on the aiming speed is not due to chance. Hence we are confident that when their interaction parameter becomes -1 (using soft mousepad (value is 1) with 800 dpi (value is -1) setting or using hard mousepad (value is 1) with 1600 dpi (value is -1)), the aiming speed will increase.

Although we figured out that modifying our mouse pad type and dpi setting is likely to change our aiming speed, the confidence interval shows the effect will be reasonably small. Note that the highest point in the confidence interval is approximately 32 milliseconds, which is 0.032 seconds. Compared to the lowest mean aiming time on the cube plot, which is 530.5 milliseconds, the difference is less than 1/10 of it. So it might not have any effects in real life, which means even if you are 0.032 times quicker, it is unlikely to make you select the course you want. During the experiment, I have an exciting discovery. By observing the cube plot, we can see the test result done by the middle finger is slightly quicker, and the positive estimated effect derived by the model can show this point as well, but it is not statistically significant. Hence, although it is significant that you can change your dpi settings and mouse pad together to achieve a faster-aiming speed, the effect is too small. It might not affect the final result you want to accomplish by aiming faster. Also, by only changing your mouse pad, dpi setting or which finger to click does not significantly affect the aiming speed, so people can confidently use any configuration they want in the situation of course selection or when playing first-person shooting games. To conclude this experiment, one downside is the online test has not been proven its accuracy. Still, according to many of YouTuber's videos about this test, I am confident that the test can reflect the difference if I made any improvements on my real aiming speed. So I choose the online test as the "y" value in my factorial experiment.