Case Study 1

Emily, Ruth, Minh

Part 1: Fat Acidity in Flour

Fat acidity is a measure of flour quality that depends on several factors. In one study, researchers investigated the effects of type of flour (Patent or First Clear), flour treatment (extraction) with 11 levels, and length of time the flour has been stored (0, 3, 6, 9, 15, or 21 weeks). For each combination of flour type, extraction, and storage, 2 100g samples of flour are used and the fat acidity is measured for each sample.

Using this information, identify the following:

1. [1pt] Factors and factor levels

Answer: 3 factors: Flour type (2 levels: patent or first clear), flour treatment/extraction (11 levels), length of time stored (6 levels: 0, 3, 6, 9, 15, 21 weeks)

2. [1pt] Number of treatments

Answer: 2 * 11 * 6 = 132 treatments

3. [1pt] Experimental units

Answer: 100 gram sample of flour

4. [1pt] Number of experimental units

Answer: 2 samples per treatment with 132 treatments, so 264 eu's

5. [1pt] Response

Answer: fat acidity of the flour

6. [1pt] Observational units

Answer: 100 gram samples of flour

Part 2: Exercise and Depression

It is well established that physical exercise has mental and physical benefits. Many of these studies have been observational. To establish a potential causal link between exercise and mental health, an experiment with mice was conducted. Mice were randomly assigned to either an enriched environment (EE) with an exercise wheel available or a standard environment (SE) with no exercise options. After 3 weeks in the specified environment, mice were exposed to a "mouse bully"-a mouse that was strong, aggressive, and territorial for 5 minutes per day for 2 weeks. At the end of the two weeks, researchers noted that mice in the SE exhibited maladaptive, depressive-like, and anxiety-like behavior while the mice in the EE group did not. One measure of mouse anxiety used in the study is the amount of time spent hiding in a dark compartment with more time indicating greater anxiety. For each mouse the amount of time spent in the darkness is recorded. Researchers want to examine if mice in the EE group spend less time in darkness after a stress-inducing experience. The data are in the file StressedMice.csv.

```
#read in dataset
StressedMice <- read_csv("./StressedMice.csv")
StressedMice
```

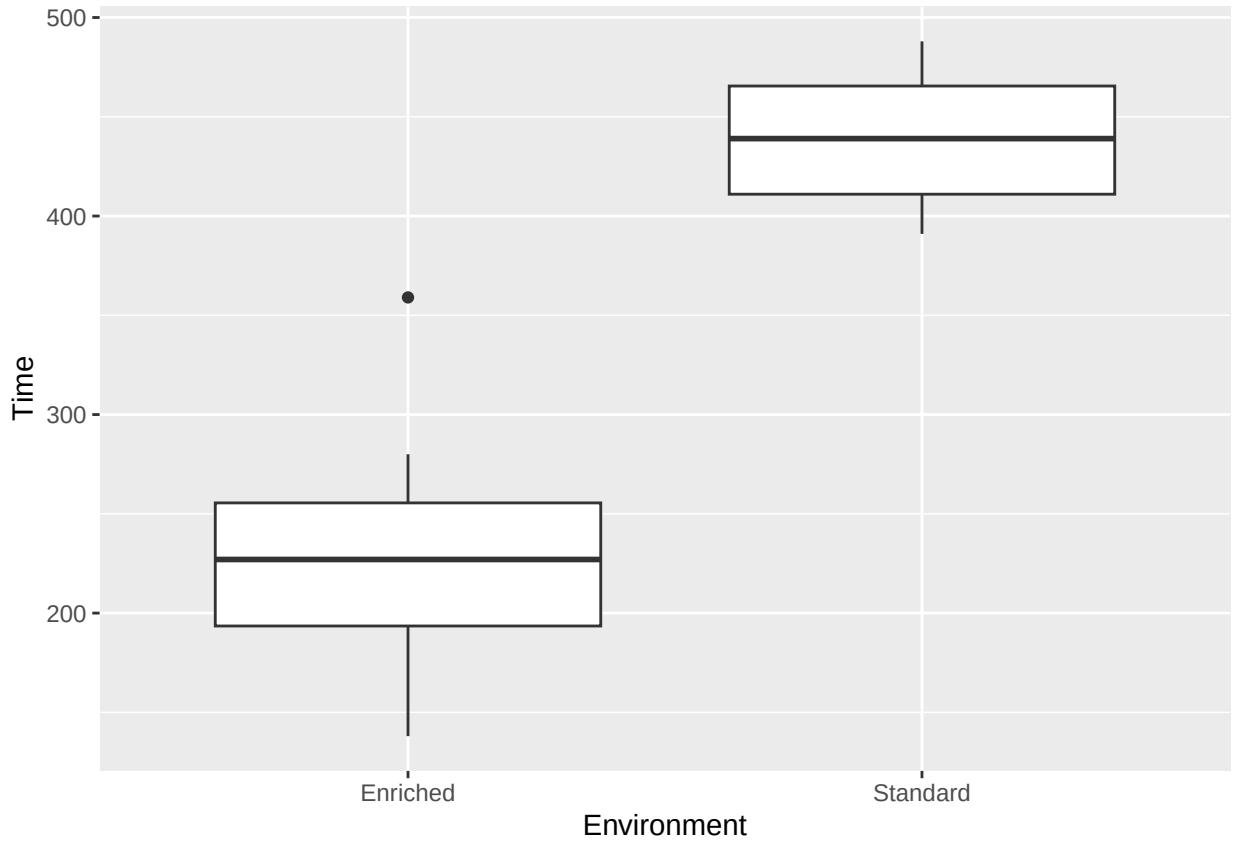
```
## # A tibble: 14 x 2
##     Time Environment
##    <dbl> <chr>
##  1   359 Enriched
##  2   280 Enriched
##  3   138 Enriched
##  4   227 Enriched
##  5   203 Enriched
##  6   184 Enriched
##  7   231 Enriched
##  8   394 Standard
##  9   477 Standard
## 10   439 Standard
## 11   428 Standard
## 12   391 Standard
## 13   488 Standard
## 14   454 Standard
```

1. [2pts] It is noted that most previous studies were observational so an experimental was conducted as a first step in establishing a causal link between exercise and mental health. Clearly explain why these previous (and numerous) observational studies are not able to establish a causal link. Make sure your answer does not rely on statistical jargon and is easily understandable to a wide audience.

Answer: Experimental studies are able to establish causation between variables because experimental studies allow for more control between natural variation between individual measurements and unknown variables that could impacts the results.

2. [3pts] Using the appropriate plots and summary statistics, compare the amount of time spent in the darkness for mice in both environments.

```
#side-by-side boxplots
StressedMice %>%
  ggplot(aes(y = Time, x = Environment)) +
  geom_boxplot()
```




```
#summary stats
favstats(Time~Environment, data = StressedMice)
```

```
##   Environment min    Q1 median    Q3 max     mean       sd n missing
## 1    Enriched 138 193.5    227 255.5 359 231.7143 71.22667 7       0
## 2    Standard 391 411.0    439 465.5 488 438.7143 37.68162 7       0
```

Answer: The distribution of time spent in darkness for both enriched environments and standard environments are symmetric. When comparing centers of the distributions, the standard environment has a higher average time spent in darkness (438.71 minutes) compared to the enriched environment mice (231.71 minutes). The spread of the distribution for enriched environments was larger (71.23 minutes) than the standard environment (37.68 minutes). There is a possible outlier in the enriched environment group with a value of 359 minutes.

3. [5pts] Recall that the researchers are interested in examining if mice in the EE group spend less time in darkness after a stress-inducing experience. Let μ_{EE} be the average time spent in darkness for mice in the EE and μ_{SE} be the average time spent in darkness for mice in the SE.

Set up the hypotheses of interest using correct statistical notation.

Answer: $H_0 : \mu_{SE} = \mu_{EE}$ **vs** $H_a : \mu_{SE} > \mu_{EE}$

Obtain the necessary output and use this to report the test statistic, degrees of freedom, and p-value.

```r
StressedMice_model <- lm(Time~Environment, data = StressedMice)
summary(StressedMice_model)
```

```
##
## Call:
## lm(formula = Time ~ Environment, data = StressedMice)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -93.714 -40.714  -2.714  32.536 127.286
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)           231.71      21.54  10.759 1.61e-07 ***
## EnvironmentStandard   207.00      30.46   6.797 1.91e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 56.98 on 12 degrees of freedom
## Multiple R-squared:  0.7938, Adjusted R-squared:  0.7766
## F-statistic: 46.19 on 1 and 12 DF,  p-value: 1.912e-05
```

Answer: $t = 6.797$, $df = 12$, $p < 0.0001$

Provide your decision for this hypothesis test.

Answer: We reject the null hypothesis that the average time spent in darkness for mice in standard environments and enriched environments is the same.

Provide a conclusion for this hypothesis test. In your conclusion make sure to clearly answer the question of interest to the researchers.

Answer: We reject the null hypothesis and conclude that there is very strong evidence that the average time spent in darkness for mice in standard environments is greater than that of mice in enriched environments ($t = 6.797$, $df = 12$, $p < 0.0001$).

4. [3pts] Researchers would also like to know how much less time mice in the EE spend in darkness compared to mice in the SE, on average. To answer this, obtain and interpret the appropriate 95% confidence interval.

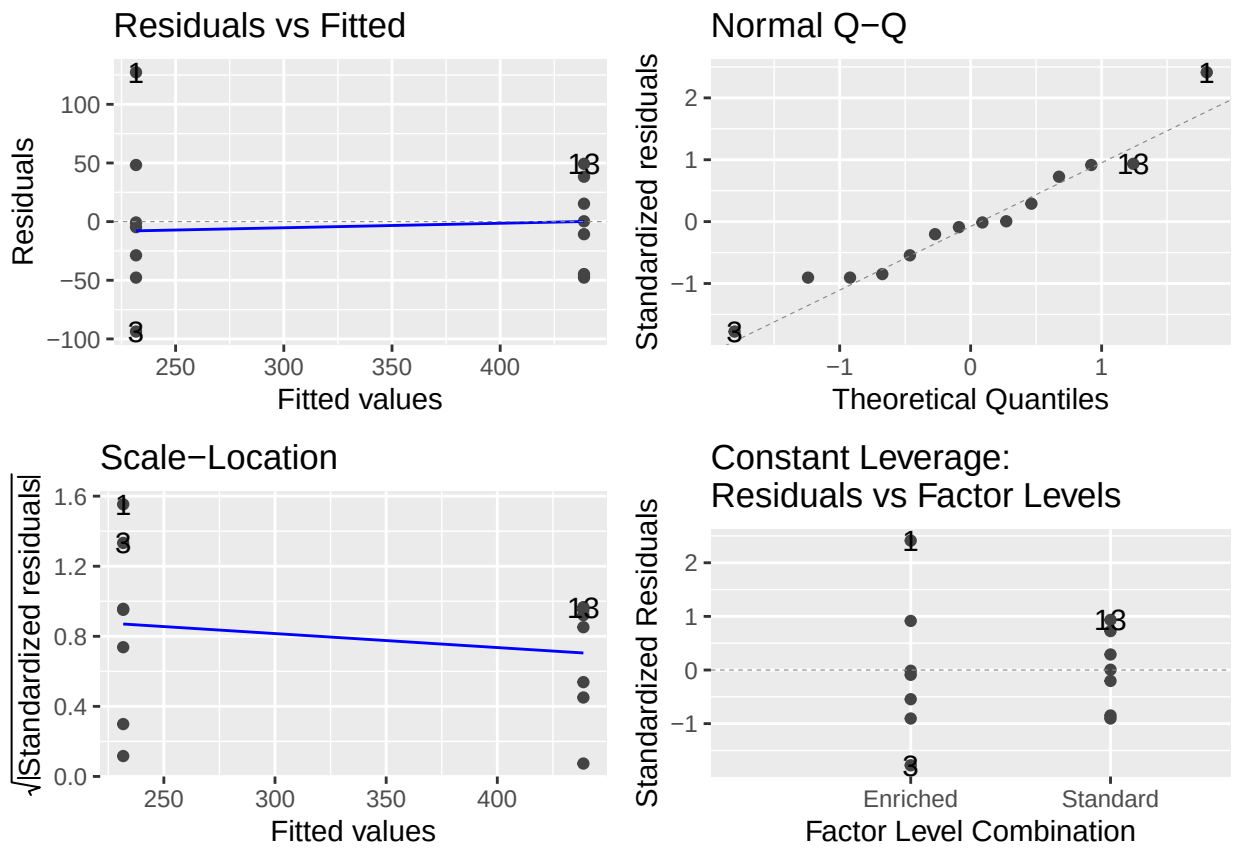
```r
confint(StressedMice_model)
```

```
##                         2.5 %   97.5 %
## (Intercept)         184.7915 278.6370
## EnvironmentStandard 140.6412 273.3588
```

Answer: With 95% confidence, the population average amount of time spent in darkness for mice in standard environments is between 140.64 minutes and 273.36 minutes higher than the average amount of time spent in darkness for mice in enriched environments.

5. [3pts] For the results of your analysis to be valid there are 3 assumptions that must be reasonably satisfied. For each assumption, clearly explain if it is reasonably satisfied referencing appropriate statistics and plots as necessary.

```
autoplot(StressedMice_model)
```




```
71.23/37.68
```

```
## [1] 1.890393
```

Answer: Independence: The independence assumption is reasonably satisfied in this study because there is no indication that mice were measured more than once or that there were any cluster effects, and the experimental unit was the same as the observational unit.

Answer: Equal Variance: The equal variances assumption is reasonably satisfied because the ratio between the higher standard deviation (enriched) and the lower standard deviation (standard) was less than 2 (1.89).

Answer: Normality: The normality assumption is reasonably satisfied because the points lie along the dashed line of the QQ plot relatively well without a U or S shape to the points.

6. [3pts] You may have noticed that though the difference in means is rather large, the sample sizes are rather small. When reporting results from studies like this, it is common to report the observed or retrospective power of the test for a given effect size. Suppose that the researchers were interested in detecting a difference of at least 100 minutes at the 5% significance level. Calculate the observed power.

```r
power.t.test(n = 7, delta = 100, sd = 56.97869, sig.level = 0.05, power = NULL, type = "two.sample")
```

```
##
##      Two-sample t test power calculation
##
##               n = 7
##           delta = 100
##              sd = 56.97869
##       sig.level = 0.05
##           power = 0.8535725
##     alternative = two.sided
##
## NOTE: n is number in *each* group
```

Answer: The observed power for this study would be 85.36%. That means that 85.36% of the time we would conclude that the average time spent in darkness is greater for the SE group than the EE group and that hypothesis is really true.