# STAT565_Lab

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## Problem 1 Unbalanced 2-Factor Factorial (Non-significant interaction)

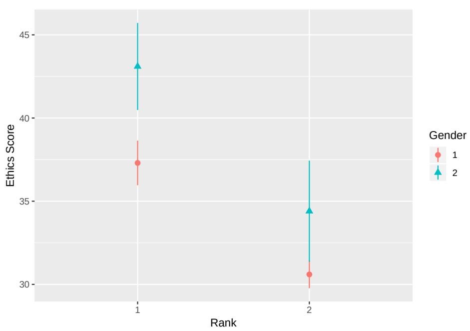
Source: R.D. White, Jr. (1999). "Are Women More Ethical? Recent Findings on the Effects of Gender Under Moral Development," Journal of Public Administration Research and Theory, Vol. 9, 3, pp.459-471. Description: Ethics scores for a sample of members of the U.S. Coast Guard by Gender (1=Male, 2=Female) and Rank (1=Officer, 2=Enlisted). Data simulated to match cell means and SDs.

Variables/Columns:Gender, 8; Rank, 16; Ethics Score,18-24.

(a) Plot the data and report the plot here (A plot with data and means of treatment combinations). Do not report code here. Describe the observed relationship between two factors.

```
## 'data.frame':    299 obs. of  5 variables:
##  $ Gender: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ Rank  : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ Score : num  35 25.1 40.5 51 50.2 ...
##  $ g     : Factor w/ 2 levels "1","2": 1 1 1 1 1 1 1 1 1 1 ...
##  $ r     : Factor w/ 2 levels "1","2": 1 1 1 1 1 1 1 1 1 1 ...
```

```
## No summary function supplied, defaulting to `mean_se()
```




(b) Obtain the numerical summary for each treatment combination and factor levels separately. Report them here in a tabular form

| Gender | min | Q1 | median | Q3 | max | mean | sd | n | missing |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.42 | 25.04 | 31.92 | 40.11 | 63.03 | 32.51 | 11.6 | 252 | 0 |
| 2 | 5.65 | 27.73 | 37.57 | 49.06 | 65.22 | 37.18 | 15.72 | 47 | 0 |

| Rank | min | Q1 | median | Q3 | max | mean | sd | n | missing |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 11.91 | 30.38 | 37.19 | 46.62 | 62.1 | 38.3 | 11.34 | 87 | 0 |
| 2 | 2.42 | 23.44 | 30.25 | 39.37 | 65.22 | 31.17 | 12.29 | 212 | 0 |

| Gender.Rank | min | Q1 | median | Q3 | max | mean | sd | n | missing |
|---|---|---|---|---|---|---|---|---|---|
| 1.1 | 11.91 | 30 | 35.9 | 45.22 | 62.1 | 37.3 | 11.38 | 72 | 0 |
| 2.1 | 27.65 | 36.12 | 44.74 | 51 | 60.11 | 43.1 | 10.14 | 15 | 0 |
| 1.2 | 2.42 | 23.65 | 29.78 | 38.39 | 63.03 | 30.6 | 11.16 | 180 | 0 |
| 2.2 | 5.65 | 21.14 | 30.75 | 44.64 | 65.22 | 34.4 | 17.19 | 32 | 0 |

(c) Fit the two-factor factorial model and report the complete ANOVA table here. Do not report code here. The complete ANOVA table should have a row for each of the following: main effects of each treatment, two-factor interaction effects, error and total.Report the adjusted (Type III) SS for each effect because of unbalanced design. Note that, adjusted SS and SSE do not add up to SSTotal

| | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| **g** | 1 | 860.9 | 860.9 | 6.034 | 0.01461 |
| **r** | 1 | 3048 | 3048 | 21.36 | 5.693e-06 |

|  | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| **g:r** | 1 | 34.1 | 34.1 | 0.239 | 0.6253 |
| **Residuals** | 295 | 42087 | 142.7 | NA | NA |
| **Total** | 298 | 46030.1 | 154.46 | NA | NA |

(d) Based on the ANOVA table write your conclusion appropriately. Perform all the necessary tests and report the conclusion along with the p-value. (no need to do pairwise comparison to save the time)

The line plot shows that not all lines are parallel. Difference in y between methods is not same for different varieties. There could be an interaction effect.

According to ANOVA table, there is a significant interaction effect from methods and varieties on the y at 5% significance level (P-value=0.02409). That means, effect of method and effect of methods and varieties on y is not independent. Therefore, examie the simple effects.

(e) Report the code here without output.

```
pander(summary(model_ethics))
sum((table_ethics$Score - mean(table_ethics$Score))^2)
Anova(model_ethics, type = "III")
```

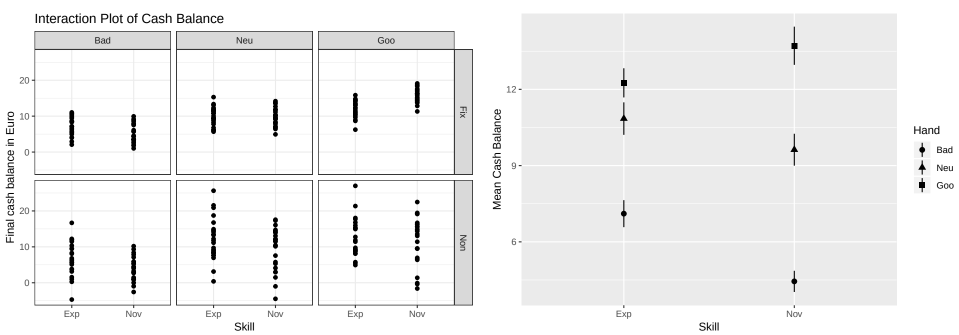
## Problem 2: 3-Factor Factorial (Non-significant interaction)

Results from 3-Factor ANOVA to investigate effects of poker skill (average/expert), poker hand (bad/neutral/good), and bet limit (fixed/none) on winnings. There were 25 individuals in each of 12 combinations (each individual in only one treatment).Use a=0.05

Variables/Columns: Skill: 1=Expert, 2=Average; Hand:1=Bad, 2=Neutral, 3=Good; Limit: 1=Fixed, 2=None; Final Cash Balance (euros)

(a) Plot the data and report the plot here (A plot with data and means of treatment combinations). Do not report code here.

```
## 'data.frame':    300 obs. of  7 variables:
##  $ skill: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ hand : int  1 1 1 1 1 1 1 1 1 1 ...
##  $ limit: int  1 1 1 1 1 1 1 1 1 1 ...
##  $ cash : num  4 5.55 9.45 7.19 5.71 5.32 8.52 4.06 4.97 6.18 ...
##  $ s    : Factor w/ 2 levels "Exp","Nov": 1 1 1 1 1 1 1 1 1 1 ...
##  $ h    : Factor w/ 3 levels "Bad","Neu","Goo": 1 1 1 1 1 1 1 1 1 1 ...
##  $ l    : Factor w/ 2 levels "Fix","Non": 1 1 1 1 1 1 1 1 1 1 ...
```




(b) Obtain the numerical summary for each treatment combination and factor levels separately. Report them here in a tabular form

| s | min | Q1 | median | Q3 | max | mean | sd | n | missing |
|---|---|---|---|---|---|---|---|---|---|
| Exp | -4.68 | 7.145 | 9.59 | 12.35 | 26.99 | 10.07 | 4.64 | 150 | 0 |
| Nov | -4.47 | 4.4 | 9.415 | 14.16 | 22.48 | 9.262 | 5.755 | 150 | 0 |

| h | min | Q1 | median | Q3 | max | mean | sd | n | missing |
|---|---|---|---|---|---|---|---|---|---|
| Bad | -4.68 | 3.4 | 5.7 | 8.41 | 16.68 | 5.777 | 3.618 | 100 | 0 |
| Neu | -4.47 | 7.827 | 10.16 | 12.39 | 25.63 | 10.24 | 4.501 | 100 | 0 |
| Goo | -1.61 | 9.713 | 13.96 | 15.98 | 26.99 | 12.98 | 4.762 | 100 | 0 |

| s.h.l | min | Q1 | median | Q3 | max | mean | sd | n | missing |
|---|---|---|---|---|---|---|---|---|---|
| Exp.Bad.Fix | 2.07 | 5.55 | 7.19 | 9.45 | 11.04 | 7.329 | 2.56 | 25 | 0 |
| Nov.Bad.Fix | 1.02 | 3.43 | 4.39 | 7.53 | 9.94 | 5.05 | 2.55 | 25 | 0 |
| Exp.Neu.Fix | 5.68 | 8.33 | 9.51 | 11.56 | 15.3 | 9.85 | 2.52 | 25 | 0 |
| Nov.Neu.Fix | 4.93 | 8.21 | 9.62 | 11.63 | 14.18 | 9.8 | 2.42 | 25 | 0 |
| Exp.Goo.Fix | 6.24 | 10.56 | 12.37 | 14.12 | 15.84 | 12.12 | 2.32 | 25 | 0 |
| Nov.Goo.Fix | 11.31 | 14.49 | 16.09 | 17.27 | 19.11 | 15.8 | 1.94 | 25 | 0 |
| Exp.Bad.Non | -4.68 | 3.82 | 6.42 | 10.34 | 16.68 | 6.889 | 4.71 | 25 | 0 |
| Nov.Bad.Non | -2.57 | 1.19 | 4.02 | 5.82 | 10.19 | 3.84 | 3.24 | 25 | 0 |
| Exp.Neu.Non | 0.39 | 8.31 | 11.14 | 14.53 | 25.63 | 11.85 | 5.771 | 25 | 0 |
| Nov.Neu.Non | -4.47 | 5.32 | 11.48 | 13.93 | 17.56 | 9.45 | 5.861 | 25 | 0 |
| Exp.Goo.Non | 4.93 | 8.76 | 11.44 | 15.33 | 26.99 | 12.39 | 5.31 | 25 | 0 |
| Nov.Goo.Non | -1.61 | 6.94 | 13.55 | 16.31 | 22.48 | 11.63 | 6.7 | 25 | 0 |

(c) Fit the two-factor factorial model and report the complete ANOVA table here. Do not report code here. The complete ANOVA table should have a row for each of the following: main effects of each treatment, two-factor interaction effects, error and total.

| | Df | Sum Sq | Mean Sq | F value | Pr(>F) |
|---|---|---|---|---|---|
| **s** | 1 | 49.17 | 49.17 | 2.839 | 0.09308 |
| **h** | 2 | 2647 | 1323 | 76.41 | 2.389e-27 |
| **l** | 1 | 31.68 | 31.68 | 1.829 | 0.1773 |
| **s:h** | 2 | 219 | 109.5 | 6.324 | 0.002052 |
| **s:l** | 1 | 119.1 | 119.1 | 6.878 | 0.009191 |
| **h:l** | 2 | 97.29 | 48.64 | 2.809 | 0.06192 |
| **s:h:l** | 2 | 42.38 | 21.19 | 1.224 | 0.2957 |
| **Residuals** | 288 | 4987 | 17.32 | NA | NA |
| **Total** | 299 | 8192.67 | 27.40 | NA | NA |

(d) Based on the ANOVA table write your conclusion appropriately. Perform all the necessary tests and report the conclusion along with the p-value.

The line plot shows that not all lines are parallel. Difference in y between methods is not same for different varieties. There could be an interaction effect.

According to ANOVA table, there is a significant interaction effect from methods and varieties on the y at 5% significance level (P-value=0.02409). That means, effect of method and effect of methods and varieties on y is not independent. Therefore, examie the simple effects.

(e) Suppose that we want to compare the average final cash balance between two types of Skill (Expert versus Average) when the type of Hand is 3 (Good) and Limit is 1 (Fixed). This is the simple effect contrast we learned in class. Test this contrast and report conclusion with p value.

(f) Report the code here without output.

```
# If the 3-factor interaction is significant, then test 2-factor interaction
# for each level of 3rd factor# To do all pairwise comparisons at each level
# of skill(s) factor # Load lsmeans or emmeans package #
contrast(lsmeans(model_poker, ~h * l | s), interaction = "pairwise")  # You may use and adjustment method as shown
```

```
## s = Exp:
##  h_pairwise l_pairwise estimate   SE  df t.ratio p.value
##  Bad - Neu  Fix - Non     2.439 1.66 288  1.465  0.1440
##  Bad - Goo  Fix - Non     0.712 1.66 288  0.428  0.6692
##  Neu - Goo  Fix - Non    -1.727 1.66 288 -1.037  0.3004
##
## s = Nov:
##  h_pairwise l_pairwise estimate   SE  df t.ratio p.value
##  Bad - Neu  Fix - Non     0.861 1.66 288  0.517  0.6055
##  Bad - Goo  Fix - Non    -2.959 1.66 288 -1.778  0.0765
##  Neu - Goo  Fix - Non    -3.820 1.66 288 -2.295  0.0225
```

```
# To do all pairwise comparisons at each level of hand (h) factor # Load
# lsmeans or emmeans package #
contrast(lsmeans(model_poker, ~s * l | h), interaction = "pairwise", adjust = "bonferroni")
```

```
## h = Bad:
```

```
##  s_pairwise l_pairwise estimate   SE  df t.ratio p.value
##  Exp - Nov  Fix - Non    -0.771 1.66 288 -0.463  0.6437
##
## h = Neu:
##  s_pairwise l_pairwise estimate   SE  df t.ratio p.value
##  Exp - Nov  Fix - Non    -2.349 1.66 288 -1.411  0.1593
##
## h = Goo:
##  s_pairwise l_pairwise estimate   SE  df t.ratio p.value
##  Exp - Nov  Fix - Non    -4.442 1.66 288 -2.668  0.0081
```

```r
# To write contrasts in terms of cell means # First, create a 3-factor
# interaction term of factors s, h and l # Then fit the model with that
# factor #
table_poker$shl <- interaction(table_poker$s, table_poker$h, table_poker$l)
# Load lsmeans or emmeans package # Save the LSmeans for interaction terms
# of factors s, h and l #

# Before writing a contrast, check the order of terms in previous lsmf
# output # Then create a vector of contrast in terms of LSmeans of treatment
# combinations # Below is the contrast to test mean for two levels of skill
# factor (Expert versus Average) # when the type of Hand is 3 (Good) and
# Limit is 1 (Fixed) #
summary(contrast(lsmeans(lm(cash ~ shl, table_poker), "shl"), list(c1 = c(rep(0,
    4), 1, -1, rep(0, 6)))))  # rep(0,11) creates a vector of 11 zeros #
```

```
##  contrast estimate   SE  df t.ratio p.value
##  c1          -3.68 1.18 288 -3.127  0.0019
```