Exercise 3

In the previous exercise (2) we calculated the artificial columns {Clarity, Politeness, Satisfaction} for each entry in the data.

In the current exercise we filtered the data, leaving in only subjects with the ages of 18-49. We also filtered out the NA rows from the data.

In order to work with R for statistical analysis, we mapped the Hebrew in the given dataset to English identifiers. The relevant mappings to this exercise are as follows:

Comp_Use_Know:

ID	ORIGINAL VALUE
F1	ידע בינוני (למשל, מסוגל להתקין תוכנות בעצמי)
F2	ידע בסיסי (למשל, יודע לגלוש באינטרנט ובפייסבוק)
F3	ידע רב (משתמש בהרבה תוכנות שונות ויכול לפתור בעצמי הרבה בעיות במחשב)
F4	מומחה (מבין בהרבה תחומים ומסוגל לאבחן ולפתור כמעט כל בעיה)

Sex:

ID	ORIGINAL VALUE
C1	זכר
C2	נקבה

System:

ID	ORIGINAL VALUE
S	מערכת תוכנה רגילה
C	תקשורת מתווכת מחשב

Part 1:

For this section we split the data in two ways: (1) By System {S, C} (2) By Sex {C1, C2} Then we performed two unpaired t-tests for comparing two groups by their Politeness as follows:

We perform variance equality F test between the groups system S, system C and conclude that they have equal variance:

$$F = 1.0485, \quad num\,df = 122, \quad denom\,df = 153, \quad p - value = 0.7779$$

Test 1 for comparing the groups (1):

$$H_0: Poiliteness\big(Data(System = C)\big) = Politeness\big(Data(System = S)\big)$$

$$H_1: Poiliteness\big(Data(System = C)\big) \neq Politeness\big(Data(System = S)\big)$$

We performed unpaired t-test with equal variance and got the following results:

$$t = 3.8093,\ df = 275,\ p\text{-}value = 0.0001719$$

95 $percent\ confidence\ interval$:

0.2463082 0.7731723

As we can see from the results we reject H_0 which means that the factor System has a significant impact on Politeness.

We perform variance equality F test between the groups males, females and conclude that they have equal variance:

$$F = 0.97178, \quad num\,df = 166, \quad denom\,df = 109, \quad p - value = 0.8602$$

Test 2 for comparing the groups (2):

$$H_0: Poiliteness\big(Data(Sex = Male)\big) = Politeness\big(Data(Sex = Female)\big)$$

$$H_1: Poiliteness\big(Data(Sex = Male)\big) \neq Politeness\big(Data(Sex = Female)\big)$$

We performed unpaired t-test with equal variance and got the following results:

$$t = -0.2531,\ df = 275,\ p\text{-}value = 0.8004$$

$$95\ percent\ confidence\ interval:$$

$$4.869261 \quad 4.904545$$

As we can see from the results we cannot reject H_0 which means that the factor Sex has no significant impact on Politeness.

Part 2:

In this section we conducted a two-way ANOVA with the input:

$$Clarity \sim System + Comp\_Use\_Know + System * Comp\_Use\_Know$$

We have $2X4 = 8$ groups according to the possible combinations of the two factors: $System\ and\ Comp\_Use\_Know$.

Descriptive statistics:

	System	Comp_Use_Know	clarity.Mean	clarity.Std_D	clarity.N
1	C	F1	5.471545	0.8440169	41
2	C	F2	5.576923	1.2011094	13
3	C	F3	5.362903	0.8485089	62
4	C	F4	5.355263	0.9626439	38
5	S	F1	4.977011	1.0519484	29
6	S	F2	3.541667	0.5672383	4
7	S	F3	4.697222	1.2886188	60
8	S	F4	5.255556	0.9353973	30

In order to test if the population variances are equal we performed Levene's test and got the following results:

	Df	Sum Squares	Mean Square	F-statistic	p-value
Between Groups	7	6.78302	0.969	2.74904	0.00898
Within Groups	269	94.81927	0.35249		
Total	276	101.60229			

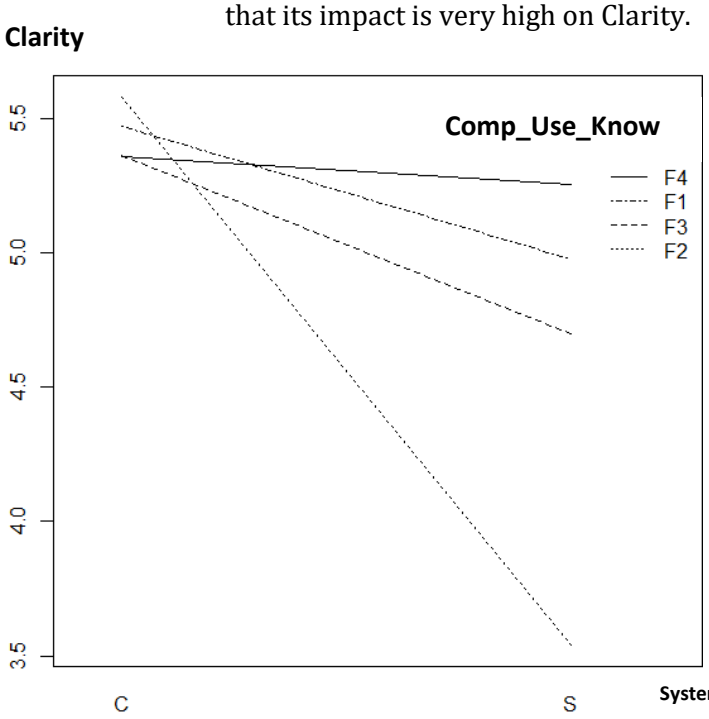
P-value is less than 0.05 therefore we reject the null hypothesis where we have an equal variance and conclude that the variances are not equal.

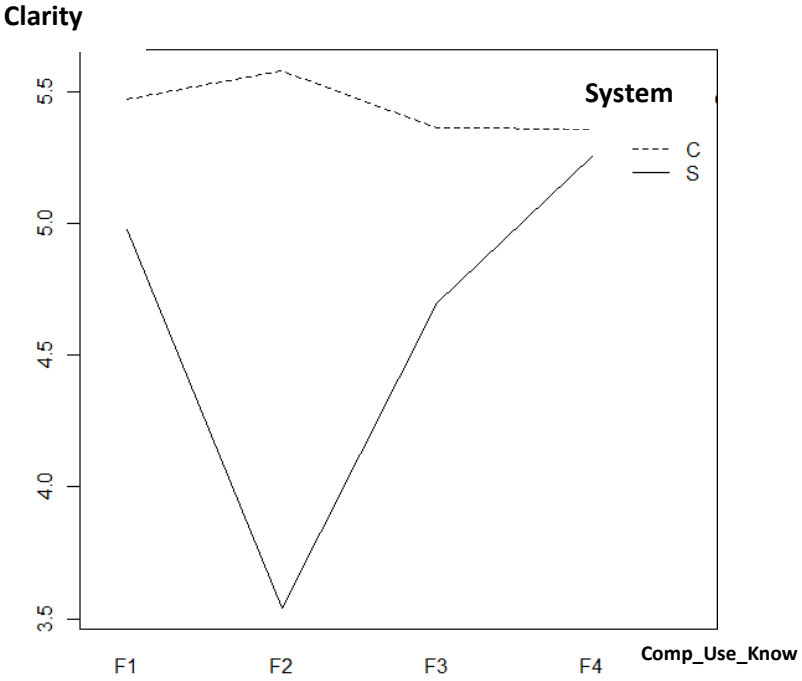
Giving this situation we used a significance level of 0.01 instead of 0.05 in the two-way ANOVA. (Theoretically we should be performing here an a-parametric test like B-F and Welch ANOVA fixes).

We got the following results from the two-way ANOVA:

```
                        Df Sum Sq Mean Sq F value   Pr(>F)
System                   1   20.4  20.402  19.649 1.36e-05 ***
Comp_Use_Know            3    3.8   1.265   1.219   0.3033
System:Comp_Use_Know     3   10.6   3.535   3.404   0.0182 *
Residuals              269  279.3   1.038
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

As it can be seen from the results, the factor System is strongly significant which means that its impact is very high on Clarity.





We cannot conclude that there is an interaction between System and Comp_Use_Know because we use a significant level of 0.01.

According to the interaction plots we see some possible interaction between System and Comp_Use_Know. However, the results from the two-way ANOVA showed that this is not sufficient for the significance level of 0.01.

Because the p-value of the interaction variable is close to 0.01 we decided to do an interaction effects analysis using the following 6 tests:

(1) One-way ANOVA of Clarity~Comp_Use_Know where System = "S".

- Levene's test:

```
                Df  Sum Squares  Mean Square  F-statistic  p-value
Between Groups  3   3.19109      1.0637       2.36255      0.07471
Within Groups   119 53.57765     0.45023
Total           122 56.76874
```

- One-way ANOVA with equal population variances (P-value = 0.05):

```
               Df Sum Sq Mean Sq F value Pr(>F)
Comp_Use_Know   3  13.63   4.544   3.482 0.0181 *
Residuals     119 155.30   1.305
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

(2) One-way ANOVA of Clarity~Comp_Use_Know where System = "C".

- Levene's test:

```
                Df  Sum Squares  Mean Square  F-statistic  p-value
Between Groups  3   1.52606      0.50869      1.85014      0.14055
Within Groups   150 41.24162     0.27494
Total           153 42.76768
```

- One-way ANOVA with equal population variances (P-value = 0.05):

```
               Df Sum Sq Mean Sq F value Pr(>F)
Comp_Use_Know   3   0.77  0.2561    0.31  0.818
Residuals     150 124.01  0.8267
```

(3) T-test of Clarity~System where Comp_Use_Know = "F1".

- Equal Variances F test:

```
F = 0.64374, num df = 40, denom df = 28, p-value = 0.1983
95 percent confidence interval:
 0.3143798 1.2627297
```

- T-test with equal variances:

```
t = 2.1793, df = 68, p-value = 0.03278
95 percent confidence interval:
 0.04170721 0.94735923
```

(4) T-test of Clarity~System where Comp_Use_Know = "F2".

- Equal Variances F test:

```
F = 4.4837, num df = 12, denom df = 3, p-value = 0.2429
95 percent confidence interval:
  0.3127443 20.0607888
```

- T-test with equal variances:

```
t = 3.2247, df = 15, p-value = 0.00567
95 percent confidence interval:
 0.6899923 3.3805206
```

(5) T-test of Clarity~System where Comp_Use_Know = "F3".

- Equal Variances F test:

```
F = 0.43357, num df = 61, denom df = 59, p-value = 0.001441
95 percent confidence interval:
 0.2598205 0.7219369
```

- T-test with unequal variances:

```
t = 3.3584, df = 101.6, p-value = 0.001104
95 percent confidence interval:
 0.2725097 1.0588523
```

(6) T-test of Clarity~System where Comp_Use_Know = "F4".

- Equal Variances F test:

```
F = 1.0591, num df = 37, denom df = 29, p-value = 0.8823
95 percent confidence interval:
 0.518248 2.100629
```

- T-test with equal variances:

```
t = 0.42939, df = 66, p-value = 0.669
95 percent confidence interval:
 -0.3639100  0.5633252
```

The results we got from the 6 tests match the interaction plots.

From the first two One-way ANOVA tests we conclude the following:

When System = "S" the value of Comp_Use_Know effect Clarity significantly with p-value = 0.0181. This result can be seen visually on the left interaction plot where the values of Clarity for each value of Comp_Use_Know are highly distinct. When System = "C" those values are more close to each other which means that Comp_Use_Know has less effect power on Clarity.

From the later four t-tests we conclude the following:

When Comp_Use_Know is F1, F2, F3 the t-test results show that p-value is significant which can be seen on the right interaction plot as the difference between Clarity values of System = "S" and System = "C".

When Comp_Use_Know = F2 the differences of Clarity values are the largest. this makes up for the relatively small size of the data of Comp_Use_Know = F2 according to the descriptive statistics.

When Comp_Use_Know = F4 the t-test results are not significant which can be seen on the plot as the smallest difference on Clarity between the two systems.

Finally, we performed three post-hoc Scheffe tests in order to find out if there are differences between each two values of the factor Comp_Use_Know as follows:

1) $System \in \{S, C\}$

```
    clarity       std   r      Min Max
F1 5.266667 0.9603240  70 2.166667   7
F2 5.098039 1.3907667  17 2.833333   7
F3 5.035519 1.1332745 122 2.000000   7
F4 5.311275 0.9449633  68 2.666667   7

alpha: 0.05 ; Df Error: 269
Critical Value of F: 2.638161

Means with the same letter are not significantly different.

Groups, Treatments and means
a        F4      5.311
a        F1      5.267
a        F2      5.098
a        F3      5.036
```

2) $System = S$

```
    clarity       std  r      Min      Max
F1 4.977011 1.0519484 29 2.166667 6.166667
F2 3.541667 0.5672383  4 2.833333 4.000000
F3 4.697222 1.2886188 60 2.000000 7.000000
F4 5.255556 0.9353973 30 2.666667 7.000000

alpha: 0.05 ; Df Error: 119
Critical Value of F: 2.680811

Means with the same letter are not significantly different.

Groups, Treatments and means
a        F4      5.256
a        F1      4.977
a        F3      4.697
a        F2      3.542
```

3) $System = C$

```
    clarity       std  r      Min Max
F1 5.471545 0.8440169 41 3.333333   7
F2 5.576923 1.2011094 13 3.833333   7
F3 5.362903 0.8485089 62 3.000000   7
F4 5.355263 0.9626439 38 3.333333   7

alpha: 0.05 ; Df Error: 150
Critical Value of F: 2.664907


Groups, Treatments and means
a        F2      5.577
a        F1      5.472
a        F3      5.363
a        F4      5.355
```

As we can see there are no significant differences between the factor values $F1, F2, F3, F4$ according to $\alpha = 0.05$ because each value ended up in the same group a.

Conclusions:

From part 1 we conclude that the factor System has a significant impact on politeness. From part 2 using the interaction plots and the two-way ANOVA results we conclude that C systems are significantly more clear than S systems. We also found that there is some interaction between the factors System and Comp_Use_Know with p-value close to 0.01. Because we used a significance level of 0.01 we could not conclude statistically that there is an interaction. However, because the p-value was close to 0.01 we decided to perform the interaction analysis and got the following conclusions:

When the system is C there are no differences among the different knowledge levels of computer use. When the system is S there is a large variance between the knowledge levels where the order from the highest to the lowest on the level of clarity is F4 (Expert), F1 (Medium), F3 (High), F2 (Basic) which is a bit surprising because we expect this order to be F1, F3, F1, F2. The level of clarity is not changed over the different systems for F4(Expert) which is reasonable. The post-hoc test we performed at the end didn't reveal any interaction between the factors values.