

Experimental Design and Data Analysis: Assignment 4

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Group 19

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Exercise 1

1

```
sample_slices = sample(1:18, 18)
```

2

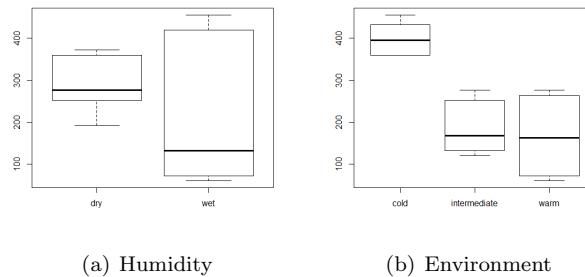


Figure 1: Boxplots of Hours with Humidity and Environment

3

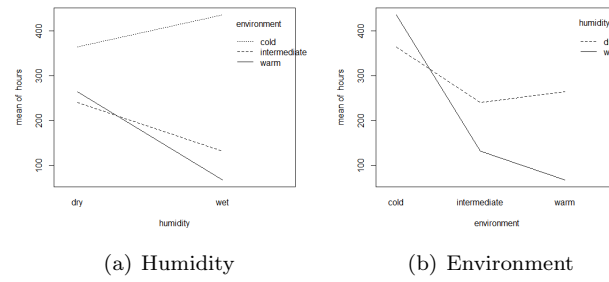


Figure 2: Interactionplots of Hours with Humidity and Environment

4

Analysis of variance on both factors:

Analysis of Variance Table

Response: hours

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
environment	2	201904	100952	23.1057	3.674e-05 ***
humidity	1	26912	26912	6.1596	0.02637 *
Residuals	14	61168	4369		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1

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Exercise 2

1

2

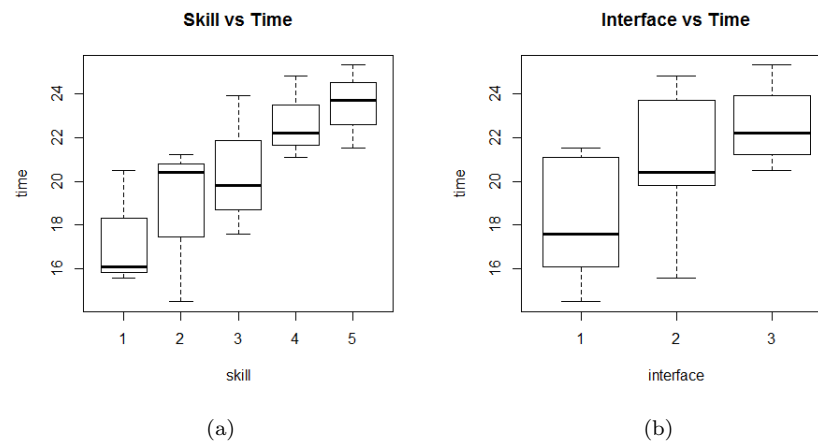


Figure 3: Box Plots of Skill and Interface vs Time

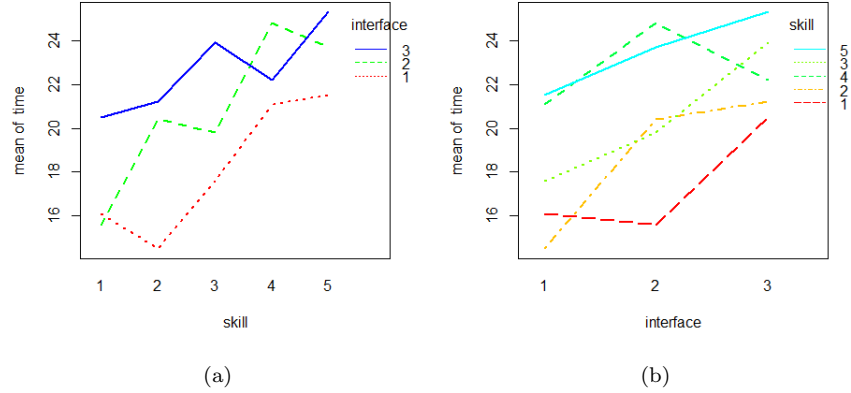


Figure 4: Interaction plots of Skill and Interface vs Time

It is difficult to conclude that there is an interaction between skill and interface as they are clearly not parallel, but they follow the same general trajectory, so this interaction may be due to noise.

3

Using the Kruskal-Wallis rank sum test, we test if the distributions of our populations in regards to the time measured for different interfaces are the same, and we obtain the following results:

Kruskal-Wallis **rank sum** test

data: **time** and **interface**

Kruskal-Wallis $\chi^2 = 4.22$, **df** = 2, **p-value** = 0.1212

Thus with a p-value of 0.1212 we reject the null hypothesis that our populations are the same, therefore the search time for all interfaces is not equal.

4

5

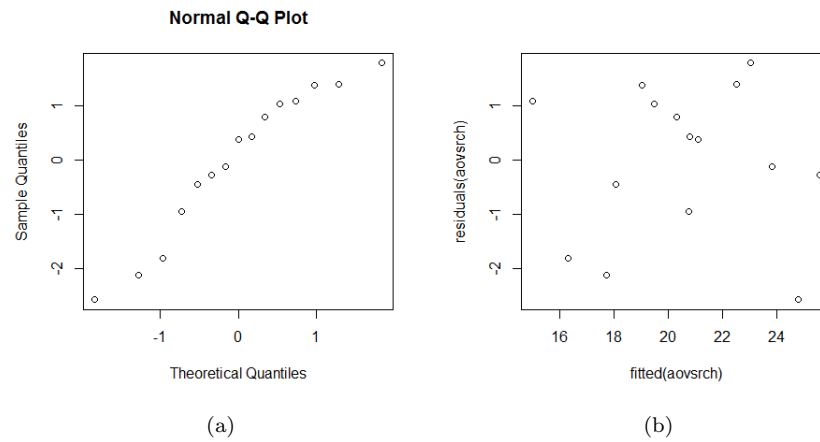


Figure 5: Diagnostic Plots

It is difficult to say for certain, there may be a slight curve in the qq-plot 5(a) but it looks approximately normal, and the fitted value plot 5(b) suggests there is no significant difference in the population variances.

6

Friedman **rank sum** test

data: **time**, interface and skill

Friedman chi-squared = 6.4, **df** = 2, p-value = 0.04076

With a p-value of 0.04076 we reject the null hypothesis, thus we conclude there is an effect of interfaces.

7

Testing the null hypothesis that the search time is the same for all interface by a ANOVA test, ignoring skill we obtain the following:

Analysis of Variance Table

Response: **time**

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
interface	2	50.465	25.233	2.8605	0.09642
Residuals	12	105.852	8.821		

Signif. codes:

0 *** 0.001 ** 0.01 * 0.05 . 0.1 1

With a p-value of 0.09642 we do not reject the null hypothesis, thus the time is not the same for all interfaces. This test is useful to use, if some conditions are met, as of right now, we do not have convincing evidence there is no interaction between skill and interface. It would be more useful to test along with the variable skill, and the interaction between the two as follows:

Analysis of Variance Table

Response: **time**

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
interface	1	49.729	49.729	21.4145	0.0007313	***
skill	1	78.732	78.732	33.9039	0.0001154	***
interface:skill	1	2.312	2.312	0.9956	0.3398204	
Residuals	11	25.544	2.322			

Signif. codes:

0 *** 0.001 ** 0.01 * 0.05 . 0.1 1

This way we are able to measure the interaction between the data sets, and determine whether there is a factor which has a greater effect on our results. From the previous table we see that with a p-value of 0.3398 we accept the null hypothesis that there is no significant interaction between skill in and interface, which is what we require for the one-way ANOVA ignoring skill to be valid.

Exercise 3

1

Analysis of Variance Table

Response: **acidity**

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
starter	4	44.136	11.0340	8.0835	0.001106	**
batch	1	4.855	4.8547	3.5566	0.078826	.
position	4	2.348	0.5870	0.4300	0.784786	
Residuals	15	20.475	1.3650			

Signif. codes: 0 *** 0.001 ** 0.01 * 0.05 . 0.1

2

Call:

lm(formula = acidity ~ starter + batch + position, data = cream)

Residuals :

Min	1Q	Median	3Q	Max
-1.7512	-0.7596	0.0132	0.8816	1.0856

Coefficients :

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	7.8260	0.8586	9.115	1.67e-07 ***
starter2	-0.1500	0.7389	-0.203	0.84186
starter3	-0.9800	0.7389	-1.326	0.20459
starter4	2.8100	0.7389	3.803	0.00173 **
starter5	-0.4840	0.7389	-0.655	0.52238
batch	0.3116	0.1652	1.886	0.07883 .
position2	-0.6180	0.7389	-0.836	0.41608
position3	-0.0380	0.7389	-0.051	0.95966
position4	-0.7640	0.7389	-1.034	0.31755
position5	-0.2640	0.7389	-0.357	0.72586

Signif. codes: 0 *** 0.001 ** 0.01 * 0.05 . 0.1

Residual standard error: 1.168 on 15 degrees of freedom

Multiple R-squared: 0.7149, Adjusted R-squared: 0.5438

F-statistic: 4.179 on 9 and 15 DF, p-value: 0.007304

3

Linear Hypotheses:

	Estimate	Std. Error	t value	Pr(> t)
2 - 1 == 0	-0.1500	0.4673	-0.321	0.997
3 - 1 == 0	-0.9800	0.4673	-2.097	0.282
4 - 1 == 0	2.8100	0.4673	6.013	<0.001 ***
5 - 1 == 0	-0.4840	0.4673	-1.036	0.834
3 - 2 == 0	-0.8300	0.4673	-1.776	0.429
4 - 2 == 0	2.9600	0.4673	6.334	<0.001 ***
5 - 2 == 0	-0.3340	0.4673	-0.715	0.949
4 - 3 == 0	3.7900	0.4673	8.110	<0.001 ***
5 - 3 == 0	0.4960	0.4673	1.061	0.822
5 - 4 == 0	-3.2940	0.4673	-7.048	<0.001 ***

Starter 1 and 4 produce significantly different acidity. This is apparent first from table we obtain: $\mu_1 = 7.8260$ and $\mu_4 = 7.8260 + 2.8100 = 10.636$ which are the estimates for starter 1 and 4 respectively. Furthermore the p-value for starter 1 obtained from of 1.67e-07 suggests that we reject the null hypothesis that our estimate for starter 1 is equal to that of the rest of the population, and the p-values obtained from of 0.001 suggests that we reject the null hypothesis that the estimate for the treatment effect of 4 is equal to each of the other respective treatment effects.

4

The p-value for the test $H_0 : \alpha_2 = \alpha_1$, where α_i is our estimate of the treatment effects is 0.997, whereas in table our p-value for the null hypothesis $H_0 : \alpha_2 = \alpha_1$ is 0.84186. It is no coincidence that the p-value obtained from table

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Linear Hypotheses:

	Estimate	lwr	upr
2 - 1 == 0	-0.1500	-1.6391	1.3391
3 - 1 == 0	-0.9800	-2.4691	0.5091
4 - 1 == 0	2.8100	1.3209	4.2991
5 - 1 == 0	-0.4840	-1.9731	1.0051
3 - 2 == 0	-0.8300	-2.3191	0.6591
4 - 2 == 0	2.9600	1.4709	4.4491
5 - 2 == 0	-0.3340	-1.8231	1.1551
4 - 3 == 0	3.7900	2.3009	5.2791
5 - 3 == 0	0.4960	-0.9931	1.9851
5 - 4 == 0	-3.2940	-4.7831	-1.8049

Exercise 4

1

2

3

4

1 R-Code

1.1 Exercise 1

1.2 Exercise 2

1.3 Exercise 3

1.4 Exercise 4