Harsha Kankanamge **PROJECT 6**

Factorial Experiment-Three Factor

In an experiment to determine the removal of dirt from standard loads of laundry, combinations of three factors, brand of detergent (X, Y, Z), type of detergent (powder, liquid) and temperature of water (hot, warm) were used. The experiment yielded three observations of the response variable 'percent dirt removal' at each combination of the treatments. The data is in **PROJ6.sav**.

Using a **Three-Factor design**,

1a) Write the model for the three-factor experiment. What are the values of 'a', 'b', 'c', 'n' in the experimental design that you are using?

$$\mathbf{Y_{ijkl} = \mu + \alpha_i + ß_j + \gamma_k + (\alpha ß)_{ij} + (\alpha\gamma)_{ik} + (ß\gamma)_{jk} + (\alpha ß\gamma)_{ijk} + \varepsilon_{ijkl}}$$

i = 1……..a = 3
j=1……b=2
k=1….c=2
l=1…….n=3
n= number of replication

total data point =2*2*3*3=36

$$\sum_{i=1}^{3} \alpha i = \sum_{j=1}^{2} ßj = \sum_{k=1}^{2} \gamma k = 0$$

$$\sum_{i=1}^{3} (\alpha ß)ij = \sum_{i=1}^{3} (\alpha\gamma)ik = \sum_{j=1}^{2} (ß\gamma)jk = \sum_{j=1}^{2} (\alpha ß)ij = \sum_{k=1}^{2} (\alpha\gamma)ik = \sum_{k=1}^{2} (ß\gamma)jk = 0$$

$$\sum_{i=1}^{3} (\alpha ß\gamma)ijk = \sum_{j=1}^{2} (\alpha ß\gamma)ijk = \sum_{k=1}^{2} (\alpha ß\gamma)ijk = 0$$

a=3 b=2 c=2 n=3

Factor A: Number of level of 'brand' =3 (X, Y, Z)

Factor B: Number of level of 'type of detergent' = 2 (powder, liquid)

Factor C: Number of level of 'temperature of water' = 2 (hot, warm)

1b) Identify the number of treatments and describe them.

number of treatments = 3*2*2 = 12

X, powder, hot X, powder, warm X, liquid, hot X, liquid, warm

Y, powder, hot Y, powder, warm Y, liquid, hot Y, liquid, warm

Z, powder, hot Z, powder, warm Z, liquid, hot Z, liquid, warm

2)Test if the response variable is normally distributed in all levels of the three factors.

H0: 'percent dirt removal' is normally distributed among all three level (X, Y, Z) of brand.
H1: 'percent dirt removal' is not normally distributed among all three level (X, Y, Z) of brand.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	brand of detergent	Statistic	df	Sig.	Statistic	df	Sig.
percent dirt removal	X	.204	12	.179	.934	12	.420
	Y	.218	12	.119	.882	12	.093
	Z	.145	12	.200*	.922	12	.302

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

X KS Test statistics 0.204 p_value 0.179 > 0.01 Do not reject H0

Y KS Test statistics 0.218 p_value 0.119 > 0.01 Do not reject H0

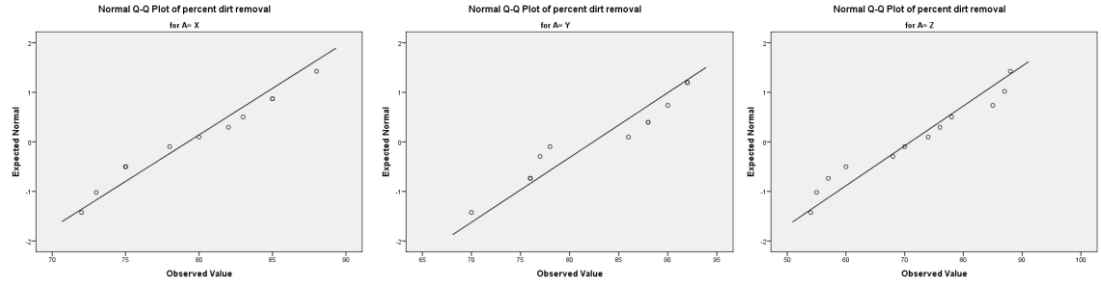
Z KS Test statistics 0.145 p_value 0.200 > 0.01 Do not reject H0

All the P_values > 0.01 Do not reject H0

'percent dirt removal' is normally distributed among all three levels (X, Y, Z) of brand.

Descriptives

brand of detergent				Statistic	Std. Error
percent dirt removal	X	Mean		79.25	1.538
		99% Confidence Interval for Mean	Lower Bound	74.47	
			Upper Bound	84.03	
		5% Trimmed Mean		79.17	
		Median		79.00	
		Variance		28.386	
		Std. Deviation		5.328	
		Minimum		72	
		Maximum		88	
		Range		16	
		Interquartile Range		10	
		Skewness		.192	.637
		Kurtosis		-1.379	1.232
	Y	Mean		82.42	2.207
		99% Confidence Interval for Mean	Lower Bound	75.56	
			Upper Bound	89.27	
		5% Trimmed Mean		82.57	
		Median		82.00	
		Variance		58.447	
		Std. Deviation		7.645	
		Minimum		70	
		Maximum		92	
		Range		22	
		Interquartile Range		14	
		Skewness		-.088	.637
		Kurtosis		-1.617	1.232
	Z	Mean		71.00	3.584
		99% Confidence Interval for Mean	Lower Bound	59.87	
			Upper Bound	82.13	
		5% Trimmed Mean		71.00	
		Median		72.00	
		Variance		154.182	
		Std. Deviation		12.417	
		Minimum		54	
		Maximum		88	
		Range		34	
		Interquartile Range		26	
		Skewness		-.049	.637
		Kurtosis		-1.430	1.232



All the data points are fitting onto the line. Which mean data are randomly distributed among all three brand.

H0: 'percent dirt removal' is normally distributed among all two levels (powder, liquid) of 'type of detergent'.
H1: 'percent dirt removal' is not normally distributed among all two levels (powder, liquid) of 'type of detergent'.

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	type of detergent	Statistic	df	Sig.	Statistic	df	Sig.
percent dirt removal	Powder	.180	18	.129	.938	18	.267
	liquid	.219	18	.022	.807	18	.002

a. Lilliefors Significance Correction

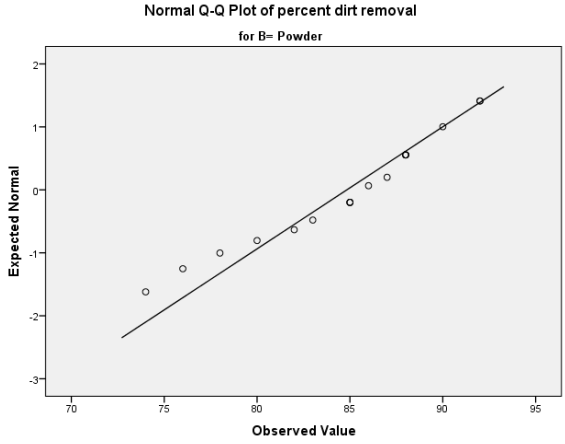
Powder: KS Test statistics 0.180 p_value 0.129 > 0.01 Do not reject H0
Liquid: KS Test statistics 0.219 p_value 0.022 > 0.01 Do not reject H0 (border line)

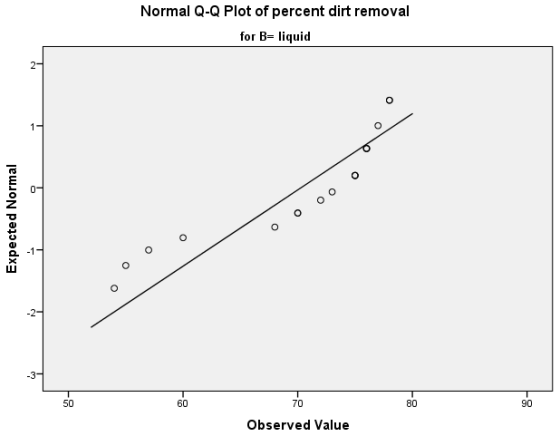
All P_value >0.01 Do not reject H0

'percent dirt removal' is normally distributed among all two levels (powder, liquid) of 'type of detergent'

Descriptives

type of detergent				Statistic	Std. Error
percent dirt removal	Powder	Mean		84.83	1.216
		99% Confidence Interval for Mean	Lower Bound	81.31	
			Upper Bound	88.36	
		5% Trimmed Mean		85.04	
		Median		85.50	
		Variance		26.618	
		Std. Deviation		5.159	
		Minimum		74	
		Maximum		92	
		Range		18	
		Interquartile Range		7	
		Skewness		-.679	.536
		Kurtosis		-.172	1.038
	liquid	Mean		70.28	1.918
		99% Confidence Interval for Mean	Lower Bound	64.72	
			Upper Bound	75.84	
		5% Trimmed Mean		70.75	
		Median		74.00	
		Variance		66.212	
		Std. Deviation		8.137	
		Minimum		54	
		Maximum		78	
		Range		24	
		Interquartile Range		10	
		Skewness		-1.129	.536
		Kurtosis		-.154	1.038





All the data points are fitting onto the line. Which mean data are randomly distributed among all two 'type of detergent'

H0: 'percent dirt removal' is normally distributed among all two levels (hot, warm) of 'temperature of water'.
H1: 'percent dirt removal' is not normally distributed among all two levels (hot, warm) of 'temperature of water'

Tests of Normality

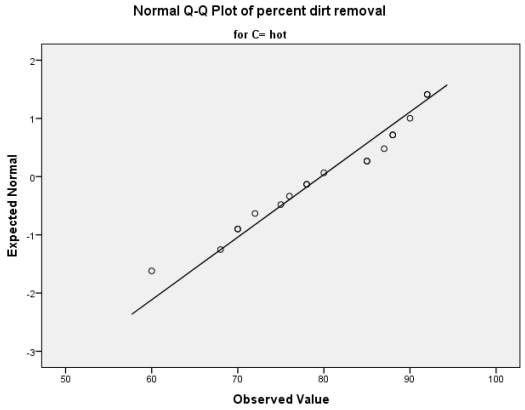
		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	temperature	Statistic	df	Sig.	Statistic	df	Sig.
percent dirt removal	hot	.161	18	.200*	.947	18	.375
	warm	.241	18	.007	.852	18	.009

*. This is a lower bound of the true significance.

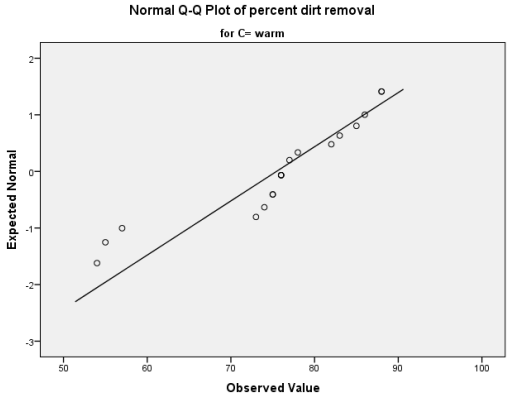
a. Lilliefors Significance Correction

Hot: KS Test statistics 0.161 p_value 0.200 > 0.01 Do not reject H0
Warm: KS Test statistics 0.241 p_value 0.007 < 0.01 Reject H0

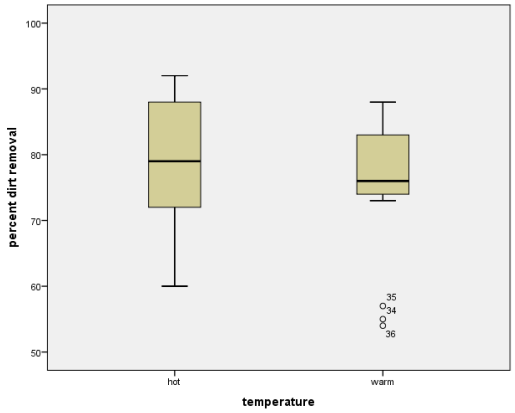
'percent dirt removal' is normally distributed among level hot of 'temperature of water' and is not normally distributed among level warm of 'temperature of water'.



All the data points are fitting onto the line. Which mean data are randomly distributed.



All the data points are not fitting onto the line well. Which mean data are not randomly distributed.



Three outliers showing under worm. That may be the reason why it is not normally distributed.

Descriptives

temperature				Statistic	Std. Error
percent dirt removal	hot	Mean		79.67	2.192
		99% Confidence Interval for Mean	Lower Bound	73.31	
			Upper Bound	86.02	
		5% Trimmed Mean		80.07	
		Median		79.00	
		Variance		86.471	
		Std. Deviation		9.299	
		Minimum		60	
		Maximum		92	
		Range		32	
		Interquartile Range		17	
		Skewness		-.403	.536
		Kurtosis		-.680	1.038
	warm	Mean		75.44	2.462
		99% Confidence Interval for Mean	Lower Bound	68.31	
			Upper Bound	82.58	
		5% Trimmed Mean		75.94	
		Median		76.00	
		Variance		109.085	
		Std. Deviation		10.444	
		Minimum		54	
		Maximum		88	
		Range		34	
		Interquartile Range		10	
		Skewness		-1.043	.536
		Kurtosis		.456	1.038

3) Test for main effects.

Tests of Between-Subjects Effects

Dependent Variable: percent dirt removal

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3312.889[a]	11	301.172	42.024	.000
Intercept	216535.111	1	216535.111	30214.202	.000
A	833.722	2	416.861	58.167	.000
B	1906.778	1	1906.778	266.062	.000
C	160.444	1	160.444	22.388	.000
A * B	200.722	2	100.361	14.004	.000
A * C	187.056	2	93.528	13.050	.000
B * C	9.000	1	9.000	1.256	.274
A * B * C	15.167	2	7.583	1.058	.363
Error	172.000	24	7.167		
Total	220020.000	36			
Corrected Total	3484.889	35			

a. R Squared = .951 (Adjusted R Squared = .928)

H0: $\alpha 1=\alpha 2=\alpha 3=0$
H1: At least one of the 'Brand' treatment effect (α_i) is not equal to zero.

F statistic A (brand)) = 58.167p-value=0.000
p-value (0.000) < 0.01 Reject H0

At 0.01 level of significant at least one of the 'Brand' treatment effect (α_i) is not equal to zero. Which means 'percent dirt removal' mean among all three 'brand' levels are not the same.

H0: ß1=ß2=0
H1: At least one of the 'type of detergent' treatment effect ($ß_j$) is not equal to zero.

F statistic B (type of detergent) = 266.062 p-value=0.000
p-value (0.000) < 0.01 Reject H0

At 0.01 level of significant at least one of the 'type of detergent' treatment effect ($ß_j$) is not equal to zero. Which means 'percent dirt removal' mean among all two 'type of detergent' levels are not the same.

H0: γ1=γ2=0
H1: At least one of the 'temperature of water' treatment effect ($γ_k$) is not equal to zero.

F statistic C (temperature of water) = 22.388 p-value=0.000
p-value (0.000) < 0.01 Reject H0

At 0.01 level of significant at least one of the 'temperature of water' treatment effect ($γ_k$) is not equal to zero. Which means 'percent dirt removal' mean among all two 'temperature of water' levels are not the same.

4)Conduct appropriate multiple comparison tests.

1. brand of detergent

Dependent Variable: percent dirt removal

brand of detergent	Mean	Std. Error	99% Confidence Interval	
			Lower Bound	Upper Bound
X	79.250	.773	77.089	81.411
Y	82.417	.773	80.255	84.578
Z	71.000	.773	68.839	73.161

2. type of detergent

Dependent Variable: percent dirt removal

type of detergent	Mean	Std. Error	99% Confidence Interval	
			Lower Bound	Upper Bound
Powder	84.833	.631	83.068	86.598
liquid	70.278	.631	68.513	72.043

3. temperature

Dependent Variable: percent dirt removal

temperature	Mean	Std. Error	99% Confidence Interval	
			Lower Bound	Upper Bound
hot	79.667	.631	77.902	81.432
warm	75.444	.631	73.680	77.209

4. brand of detergent * type of detergent

Dependent Variable: percent dirt removal

brand of detergent	type of detergent	Mean	Std. Error	99% Confidence Interval	
				Lower Bound	Upper Bound
X	Powder	83.833	1.093	80.777	86.890
	liquid	74.667	1.093	71.610	77.723
Y	Powder	89.333	1.093	86.277	92.390
	liquid	75.500	1.093	72.443	78.557
Z	Powder	81.333	1.093	78.277	84.390
	liquid	60.667	1.093	57.610	63.723

5. brand of detergent * temperature

Dependent Variable: percent dirt removal

brand of detergent	temperature	Mean	Std. Error	99% Confidence Interval	
				Lower Bound	Upper Bound
X	hot	79.667	1.093	76.610	82.723
	warm	78.833	1.093	75.777	81.890
Y	hot	83.000	1.093	79.943	86.057
	warm	81.833	1.093	78.777	84.890
Z	hot	76.333	1.093	73.277	79.390
	warm	65.667	1.093	62.610	68.723

6. type of detergent * temperature

Dependent Variable: percent dirt removal

type of detergent	temperature	Mean	Std. Error	99% Confidence Interval	
				Lower Bound	Upper Bound
Powder	hot	87.444	.892	84.949	89.940
	warm	82.222	.892	79.726	84.718
liquid	hot	71.889	.892	69.393	74.385
	warm	68.667	.892	66.171	71.163

Multiple Comparisons

Dependent Variable: percent dirt removal

	(I) brand of detergent	(J) brand of detergent	Mean Difference (I-J)	Std. Error	Sig.	99% Confidence Interval	
						Lower Bound	Upper Bound
Tukey HSD	X	Y	-3.17	1.093	.021	-6.68	.35
		Z	8.25*	1.093	.000	4.74	11.76
	Y	X	3.17	1.093	.021	-.35	6.68
		Z	11.42*	1.093	.000	7.90	14.93
	Z	X	-8.25*	1.093	.000	-11.76	-4.74
		Y	-11.42*	1.093	.000	-14.93	-7.90
Bonferroni	X	Y	-3.17	1.093	.024	-6.73	.39
		Z	8.25*	1.093	.000	4.69	11.81
	Y	X	3.17	1.093	.024	-.39	6.73
		Z	11.42*	1.093	.000	7.86	14.98
	Z	X	-8.25*	1.093	.000	-11.81	-4.69
		Y	-11.42*	1.093	.000	-14.98	-7.86

Based on observed means.
The error term is Mean Square(Error) = 7.167.

*. The mean difference is significant at the .01 level.

H0: $\mu_i = \mu_j$ i, j=1,2,3
H1: $\mu_i \neq \mu_j$ i≠j

α=0.01

Tukey HSD: Means differences of "percent dirt removal" in 'Brand of detergent' between 'X', 'Z' and 'Y' 'Z' are significant.

Means difference of "percent dirt removal "between "X" and "Z" (p-value= 0.000 <0.01 and difference= 8.25, Reject H0) is significant.

Means difference of "percent dirt removal "between "Y" and "Z" (p-value= 0.000 <0.01 and difference= 11.42, Reject H0) is significant.

Means difference of "percent dirt removal "between "Y" and "X" (p-value= 0.021 >0.01(border line) and difference= 3.17, Do not reject H0) is not significant.

Bonferroni: Means differences of "percent dirt removal" in 'Brand of detergent' between 'X', 'Z' and 'Y' 'Z' are significant.

Means difference of "percent dirt removal "between "X" and "Z" (p-value= 0.000 <0.01 and difference= 8.25, Reject H0) is significant.

Means difference of "percent dirt removal "between "Y" and "Z" (p-value= 0.000 <0.01 and difference= 11.42, Reject H0) is significant.

Means difference of "percent dirt removal "between "Y" and "X" (p-value= 0.024 >0.01(border line) and difference= 3.17, Do not reject H0) is not significant.

5) Test for first-order and second-order interaction effects.

Tests of Between-Subjects Effects

Dependent Variable: percent dirt removal

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3312.889[a]	11	301.172	42.024	.000
Intercept	216535.111	1	216535.111	30214.202	.000
A	833.722	2	416.861	58.167	.000
B	1906.778	1	1906.778	266.062	.000
C	160.444	1	160.444	22.388	.000
A * B	200.722	2	100.361	14.004	.000
A * C	187.056	2	93.528	13.050	.000
B * C	9.000	1	9.000	1.256	.274
A * B * C	15.167	2	7.583	1.058	.363
Error	172.000	24	7.167		
Total	220020.000	36			
Corrected Total	3484.889	35			

a. R Squared = .951 (Adjusted R Squared = .928)

H0: $(\alpha*ß)_{11} = \ldots\ldots\ldots\ldots = (\alpha*ß)_{32} = 0$ a=1,2,3 b=1,2
H1: At least one of the treatment interaction (brand* type of detergent) effect $((\alpha*ß)_{ij})$ is not equal to zero.

F statistic (brand* type of detergent) = 14.004 p-value=0.000
p-value (0.000) < 0.01 Reject H0

At 0.01 level of significant there is evidence to say that at least one of the treatment interaction (brand* type of detergent) effect ((α*ß)ij) is not equal to zero. Which mean There is a first-order significant interaction between brand and type of detergent.

H0: $(\alpha*\gamma)_{11} = \ldots\ldots\ldots\ldots = (\alpha*\gamma)_{32} = 0$ a=1,2,3 c=1,2
H1: At least one of the treatment interaction (brand* temperature of water) effect $((\alpha*\gamma)_{ik})$ is not equal to zero.

F statistic (brand* temperature of water) = 13.050 p-value=0.000
p-value (0.000) < 0.01 Reject H0

At 0.01 level of significant there is evidence to say that at least one of the treatment interaction (brand* temperature of water) effect ((α*γ)ik) is not equal to zero. Which mean There is a significant interaction between brand and temperature of water.

H0: $(ß*\gamma)_{11} = \ldots\ldots\ldots\ldots = (ß*\gamma)_{22} = 0$ b=1,2 c=1,2
H1: At least one of the treatment interaction (type of detergent * temperature of water) effect $((ß*\gamma)_{jk})$ is not equal to zero.

F statistic (type of detergent * temperature of water) = 1.256 p-value=0.274
p-value (0.274) > 0.01 Do not reject H0

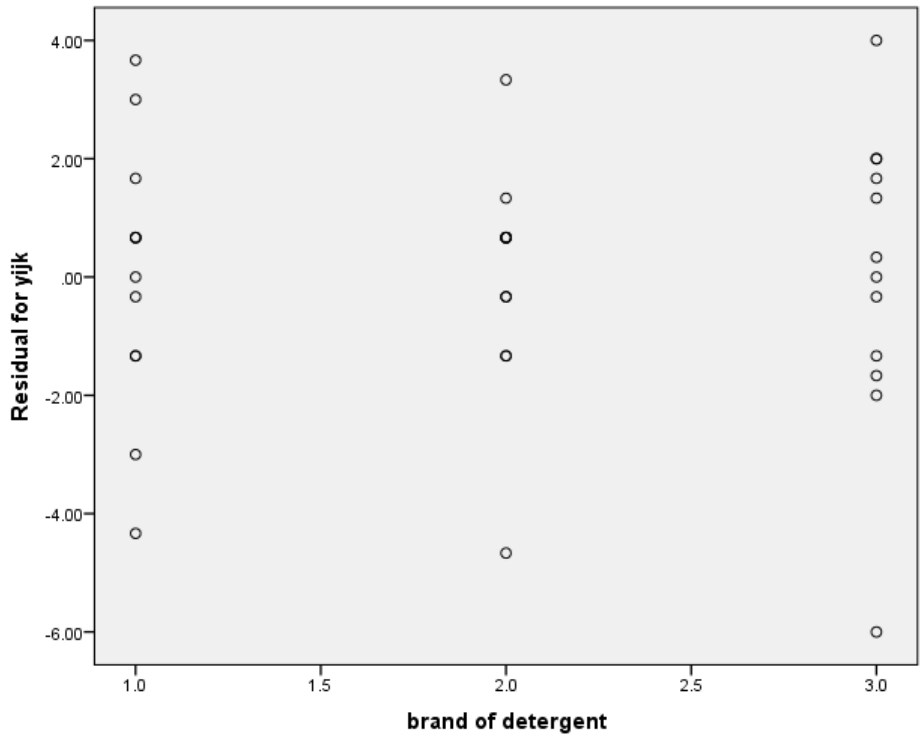
At 0.01 level of significant there is no evidence to say that at least one of the treatment interaction (type of detergent * temperature of water) effect ((ß*γ)jk) is not equal to zero. Which mean There is not a significant interaction between type of detergent and temperature of water.

H0: $(\alpha*\beta*\gamma)_{111} = \ldots\ldots\ldots\ldots\ldots\ldots = (\alpha*\beta*\gamma)_{322} = 0$ a=1,2,3 b=1,2 c=1,2
H1: At least one of the treatment interaction (brand*type of detergent * temperature of water) effect $((\alpha*\beta*\gamma)_{ijk})$ is not equal to zero.

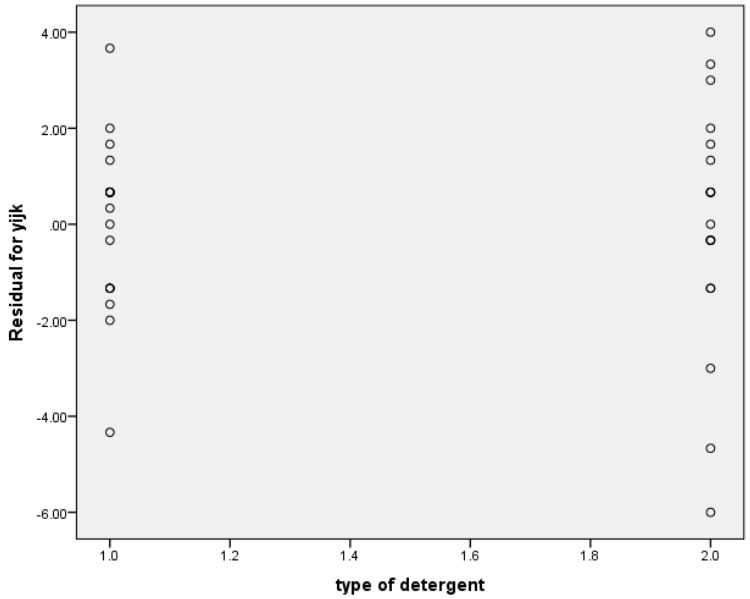
F statistic (brand*type of detergent * temperature of water) = 1.058 p-value=0.363
p-value (0.363) > 0.01 Do not reject H0

At 0.01 level of significant there is no evidence to say that at least one of the treatment interaction (brand*type of detergent * temperature of water) effect ((α*ß*γ)ijk) is not equal to zero. Which mean there is not a significant second-order interaction between type of brand and detergent and temperature of water.

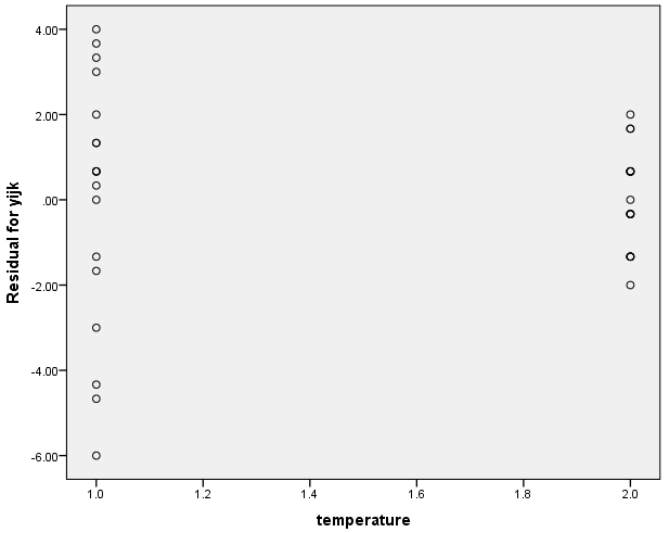
6) Comment on the residual variances (four residual plots and Levene's test).



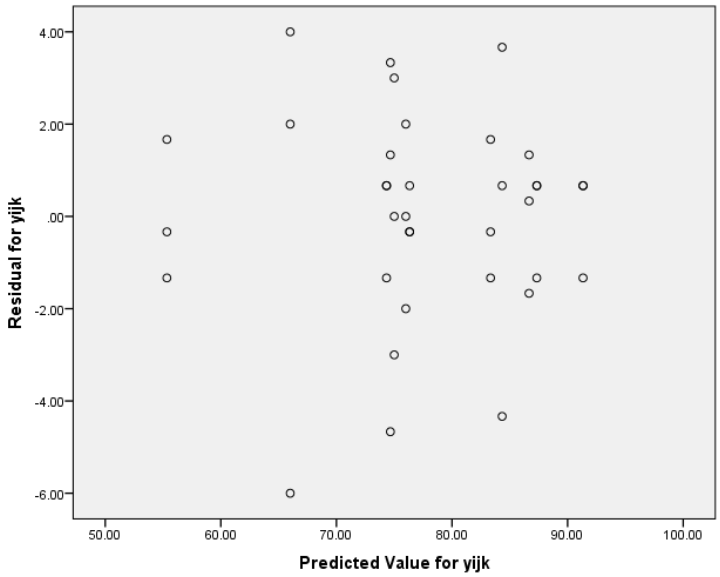
The residual plot (Brand of detergent vs residual for percent dirt removal) show that most of the points are within the band -4 to +4(Except few points. could be outlier). As well as residuals don't show a pattern. Which means plot of residuals verses 'Brand of detergent' indicate variance of residuals may be the same for the different 'Brand of detergent'. Therefore, variances of residuals are homogeneous with respect to 'Brand of detergent'.



The residual plot (type of detergent vs residual for percent dirt removal) show that most of the points are within the band -4 to +4(Except few points, could be outlier). As well as residuals don't show a pattern. Which means plot of residuals verses 'type of detergent' indicate variance of residuals may be the same for the different 'type of detergent'. Therefore, variances of residuals are homogeneous with respect to 'type of detergent'.



The residual plot (temperature vs residual for percent dirt removal) show that most of the points are within the band -4 to +4(Except few points). But residuals are showing a pattern. Variance of residuals with respect to 'temperature' 2 ('warm') is very low compare with 'hot' (1). Which means plot of residuals verses 'temperature' indicate variance of residuals may not be the same for the different 'temperatures'. Therefore, variances of residuals are not homogeneous with respect to temperature.



The residual plot (predicted value for percent dirt removal vs residual for percent dirt removal) show that most of the points are within the band -4 to +4(Except few points). As well as residuals don't show a pattern. Which means plot of residuals verses 'predicted value for percent dirt removal' indicate variance of residuals may be the same for the different 'predicted value for percent dirt removal'. Therefore, variances of residuals are homogeneous with respect to 'predicted value for percent dirt removal'.

Levene's Test of Equality of Error Variances[a]

Dependent Variable: percent dirt removal

F	df1	df2	Sig.
2.612	11	24	.024

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + A + B + C + A * B + A * C + B * C + A * B * C

H0: $\sigma^2 1 = \sigma^2 2 = \sigma^2 3 = \ldots\ldots\ldots\ldots\ldots = \sigma^2 12$

H1: At least one of the $\sigma^2 i$ of 'percent dirt removal' is different among twelve treatments combinations.

Levene's F test statistic = 2.612 p_value = 0.024 > 0.01 Do not reject H0 (border line)

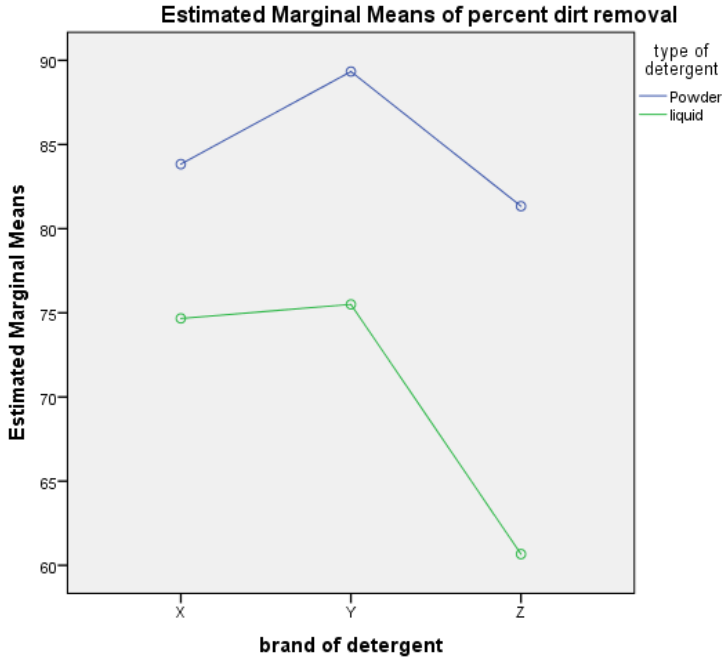
At the 0.01 level of significant there is no evidence to say that at least one of the $\sigma^2 i$ of 'percent dirt removal' is different among twelve treatments combinations. Which means all the variance are the same.

7)Comment on the first-order interaction plots with support from the means tables.

4. brand of detergent * type of detergent

Dependent Variable: percent dirt removal

brand of detergent	type of detergent	Mean	Std. Error	99% Confidence Interval	
				Lower Bound	Upper Bound
X	Powder	83.833	1.093	80.777	86.890
	liquid	74.667	1.093	71.610	77.723
Y	Powder	89.333	1.093	86.277	92.390
	liquid	75.500	1.093	72.443	78.557
Z	Powder	81.333	1.093	78.277	84.390
	liquid	60.667	1.093	57.610	63.723



Brand of detergent/Type of detergent

Mean ‘percent dirt removal’ by ‘brand of detergent’ is not the same for all 2 type of detergent.

For ‘brand of detergent’ X. Y and Z mean ‘percent dirt removal’ is highest for type of detergent powder and lowest for type of detergent liquid.

For type of detergent powder, mean ‘percent dirt removal’ is highest for brand of detergent Y and lowest for brand of detergent Z.

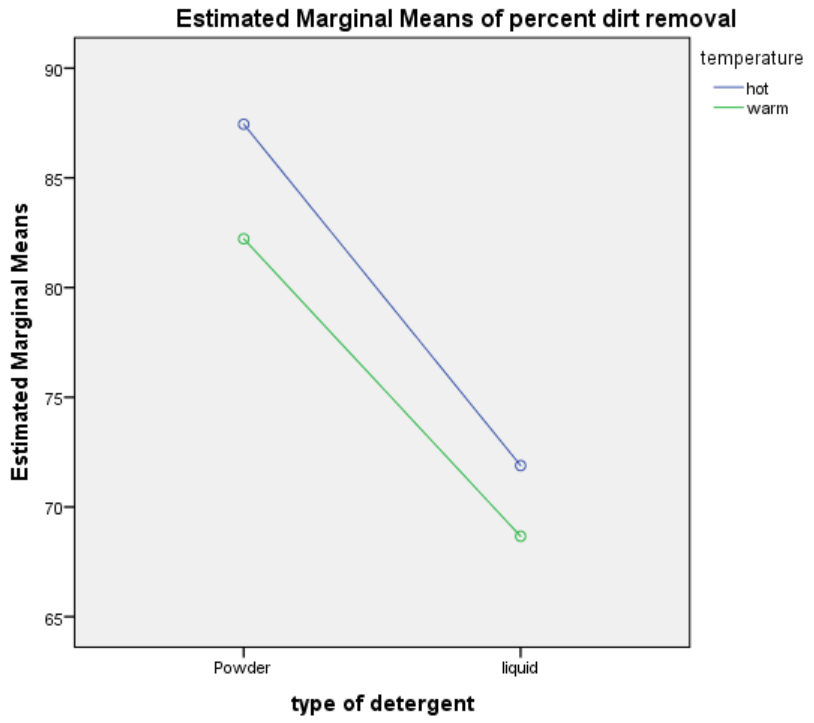
For type of detergent liquid, mean ‘percent dirt removal’ is highest for brand of detergent Y and lowest for brand of detergent Z.

Non-parallel lines and does not show any intersecting on the graph. But non-parallel lines suggesting interaction between brand of detergent and type of detergent which is significant (F = 14.004, p value = 0.000) in the ANOVA table.

6. type of detergent * temperature

Dependent Variable: percent dirt removal

type of detergent	temperature	Mean	Std. Error	99% Confidence Interval	
				Lower Bound	Upper Bound
Powder	hot	87.444	.892	84.949	89.940
	warm	82.222	.892	79.726	84.718
liquid	hot	71.889	.892	69.393	74.385
	warm	68.667	.892	66.171	71.163



Type of detergent / Temperature

Mean ‘percent dirt removal’ by ‘type of detergent’ is not the same for all 2 temperatures.

For ‘type of detergent’ powder and liquid mean ‘percent dirt removal’ is highest for temperature hot and lowest for temperature warm.

For temperature hot, mean ‘percent dirt removal’ is highest for type of detergent powder and lowest for type of detergent liquid.

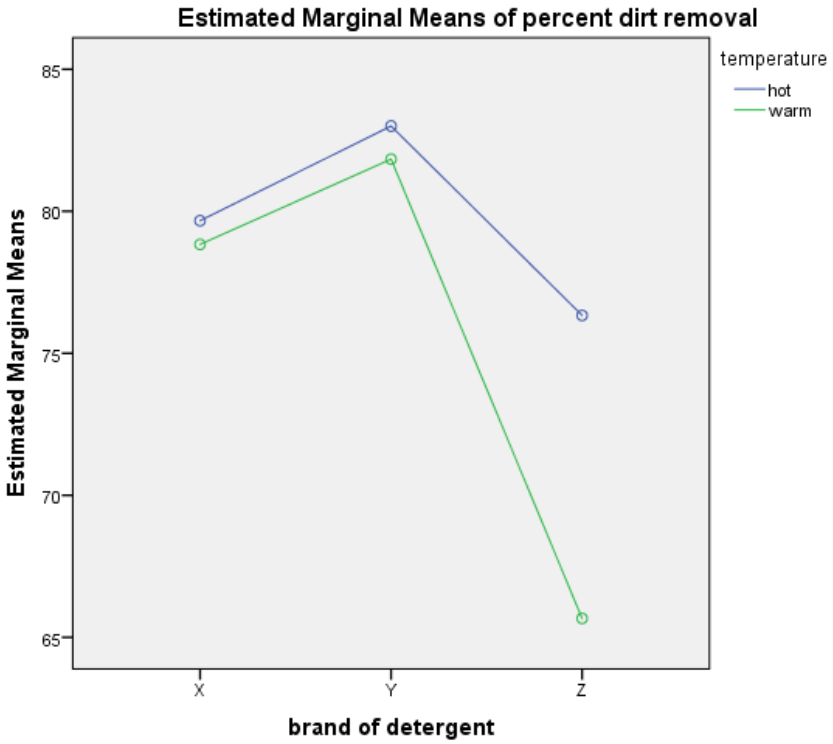
For temperature warm, mean ‘percent dirt removal’ is highest for type of detergent powder and lowest for type of detergent liquid.

Non-parallel lines and does not show any intersecting on the graph. Does not show significant interaction between Type of detergent and Temperature (F = 1.256 p-value=0.274) in the ANOVA table.

5. brand of detergent * temperature

Dependent Variable: percent dirt removal

brand of detergent	temperature	Mean	Std. Error	99% Confidence Interval	
				Lower Bound	Upper Bound
X	hot	79.667	1.093	76.610	82.723
	warm	78.833	1.093	75.777	81.890
Y	hot	83.000	1.093	79.943	86.057
	warm	81.833	1.093	78.777	84.890
Z	hot	76.333	1.093	73.277	79.390
	warm	65.667	1.093	62.610	68.723



Brand of detergent / Temperature

Mean ‘percent dirt removal’ by ‘brand of detergent’ is not the same for all 2 temperatures.

For ‘brand of detergent’ X, Y and Z mean ‘percent dirt removal’ is highest for temperature hot and lowest for temperature warm.

For temperature hot, mean ‘percent dirt removal’ is highest for brand of detergent Y and lowest for brand of detergent Z.

For temperature warm, mean ‘percent dirt removal’ is highest for brand of detergent Y and lowest for brand of detergent Z.

For ‘brand of detergent’ X and Y have very close mean value of ‘percent dirt removal’ for hot and warm. But for ‘brand of detergent’ Z has considerably large difference for hot and warm water on mean for ‘percent dirt removal’

Non-parallel lines and does not show any intersecting on the graph. But non-parallel lines suggesting interaction between brand of detergent and temperature which is significant ($F = 13.050$ p-value=0.000) in the ANOVA table.