DAE PROJECT PRESENTATION

INSTRUCTOR - NIL KAMAL HAZRA

GROUP 6

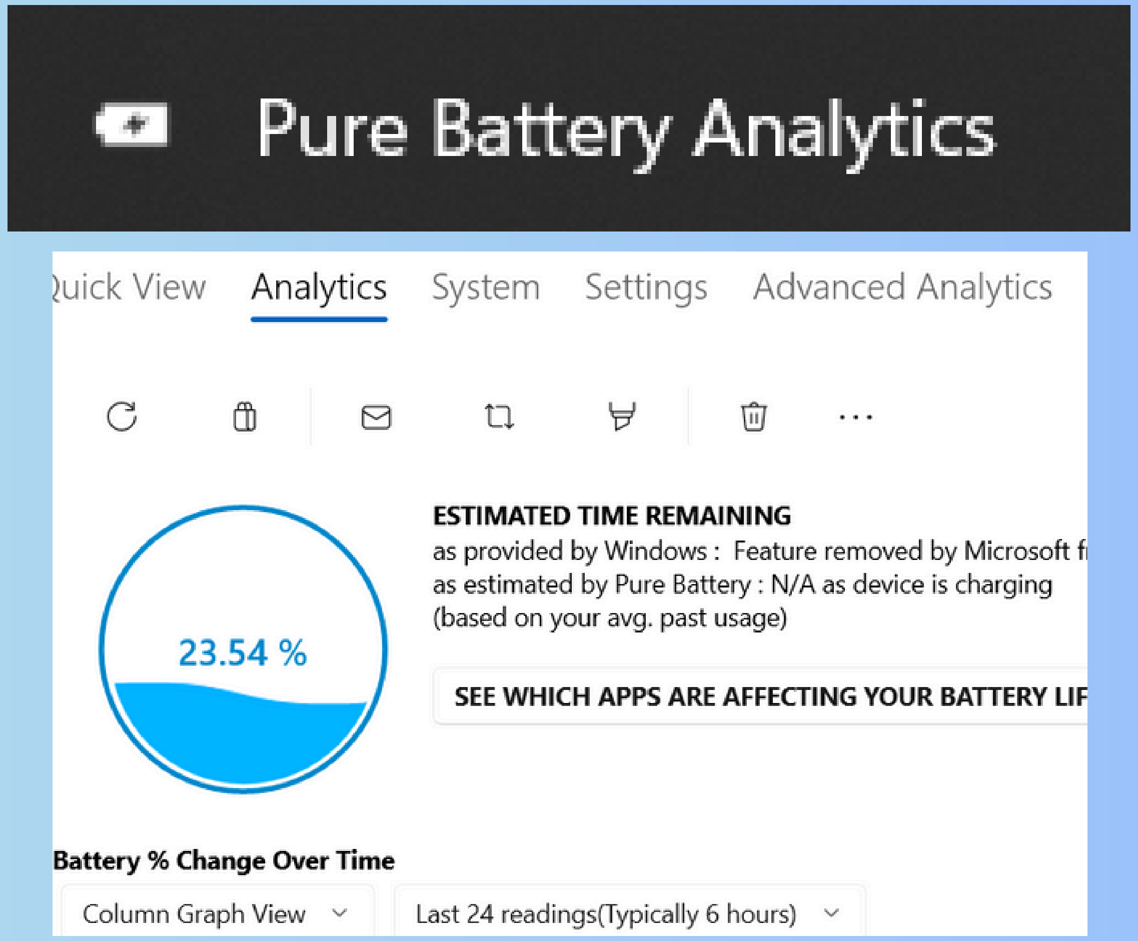
GROUP MEMBERS

TEAM MEMBERS :

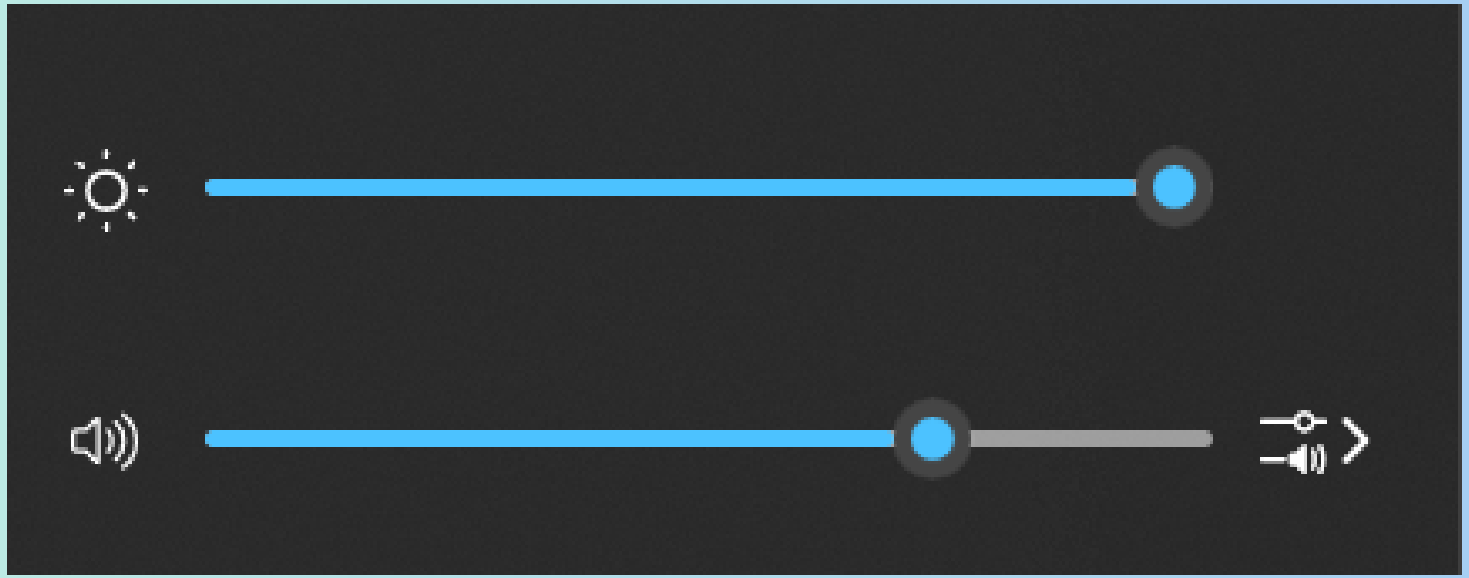
1. Aditya Anand (B21ES003)
2. Vinit (B22ES026)
3. Aditya Padhy (B22ES005)
4. Harsh (B22ES027)
5. Karan (B22ES019)
6. Ayush Goel (B22ES013)
7. Girish (B22CY002)

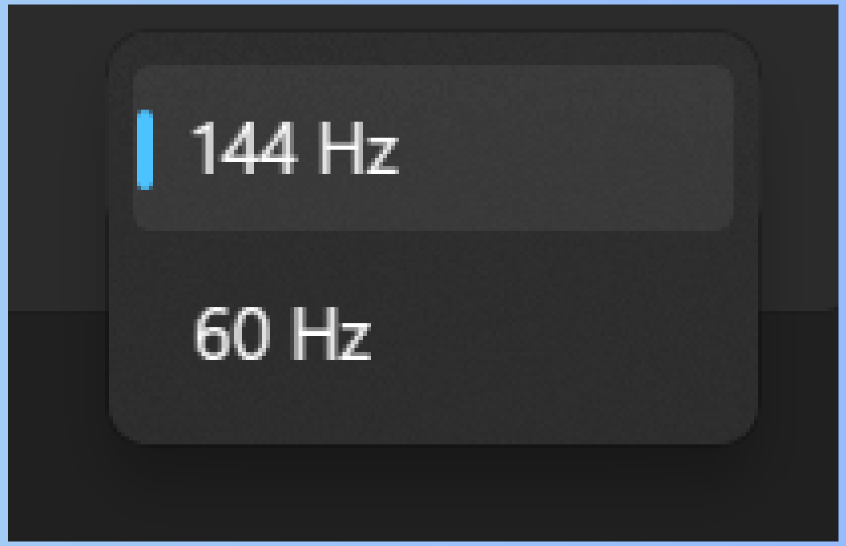
EXP - INTRO

+


Pure Battery Analytics
uick View
Analytics
System
Settings
Advanced Analytics
ESTIMATED TIME REMAINING
as provided by Windows : Feature removed by Microsoft f
as estimated by Pure Battery : N/A as device is charging
(based on your avg. past usage)
23.54 %
SEE WHICH APPS ARE AFFECTING YOUR BATTERY LIF
Battery % Change Over Time
Column Graph View
Last 24 readings(Typically 6 hours)


1920 × 1080 (Recommended)
1760 × 990
1680 × 1050
1600 × 900
1366 × 768
1280 × 1024
1280 × 720
1128 × 634
1024 × 768
800 × 600




144 Hz
60 Hz

Objective: Analyzing various factors and their impact on LAPTOP Battery life .

Through our experiment we came across various factors which affect the battery life of the laptop , but we will be considering **refresh rate, brightness, resolution and speaker** for our experiment.

Tools Used:

- **RStudio**
- **Battery Analytics Application**
- **Stopwatch**
- **Hp Laptop**

NOTATIONS:

A = Refresh Rate
B = Brightness
C = RESOLUTION
D = SPEAKER VOL.

2^k Factorial Design **Dataset:**

	A-Refresh Rate		B-Brightness		C-RESOLUTION		D-SPEAKER.		RATE
	60Hz(Low)	144Hz(High)	0(Low)	100(High)	900x600p	1920x1080p	NO(MUTE)	YES(VOL)	(%DISCHARGE /Hrs.)
1									31.08
a									39.84
b									37.68
ab									59.68
c									31.32
ac									37.32
bc									35.4
abc									56.72
d									34.2
ad									43.08
bd									38.52
abd									61.36
cd									32.76
acd									39
bcd									37.08
abcd									60.04

There are 4 factors and 2 levels of each high on low.

Based on different combination of factor levels the observations have been made.

INDICATORS :

LOW LEVEL	HIGH LEVEL

As it can be seen in the table when all the factors are high the battery drainage is highest and least when all are at low level.

```
> Design.matrix
```

	I	A	B	AB	C	AC	BC	ABC	D	AD	BD	ABD	CD	ACD	BCD	ABCD	Rate
(1)	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1	1	-1	-1	1	31.08
a	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1	1	1	-1	-1	39.84
b	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1	1	-1	1	-1	37.68
ab	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	1	59.68
c	1	-1	-1	1	1	-1	-1	1	-1	1	1	-1	-1	1	1	-1	31.32
ac	1	1	-1	-1	1	1	-1	-1	-1	-1	1	1	-1	-1	1	1	37.32
bc	1	-1	1	-1	1	-1	1	-1	-1	1	-1	1	-1	1	-1	1	35.40
abc	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	56.72
d	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1	1	-1	34.20
ad	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	1	1	43.08
bd	1	-1	1	-1	-1	1	-1	1	1	-1	1	-1	-1	1	-1	1	38.52
abd	1	1	1	1	-1	-1	-1	-1	1	1	1	1	-1	-1	-1	-1	61.36
cd	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	32.76
acd	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1	39.00
bcd	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	1	-1	37.08
abcd	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	60.04

This is the design matrix for our experiment

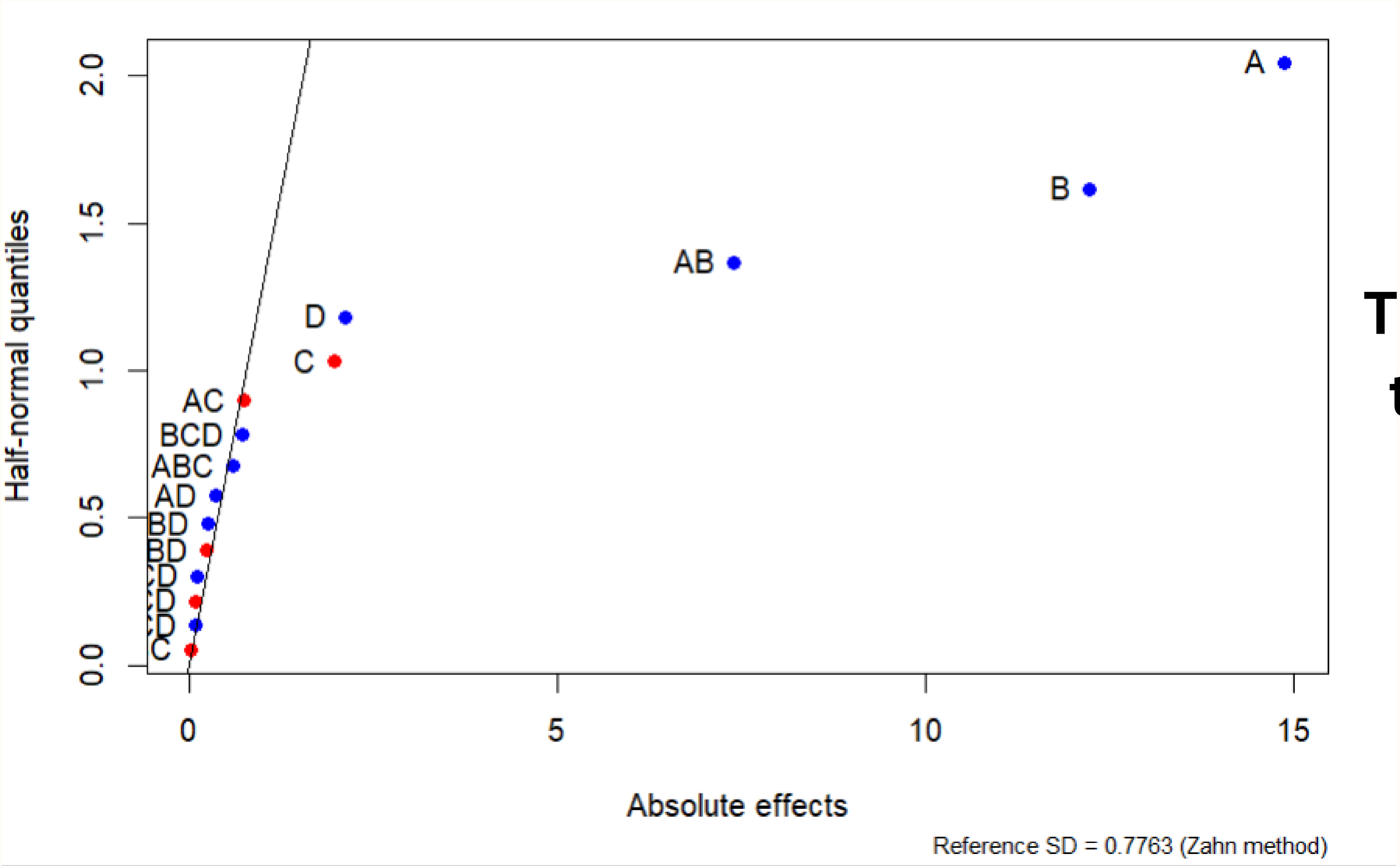
A design matrix organizes data for regression analysis. Rows represent observations, columns represent predictors, and one column is for the response variable. It helps estimate coefficients for predictors and interpret their relationship with the response.

```
> eff=cbind(Ieff,Feff)
> eff
            I      A      B    AB      C     AC     BC
Rate 42.1925 14.875 12.235 7.405 -1.975 -0.745 -0.025

  ABC     D    AD     BD   ABD     CD   ACD   BCD  ABCD
0.605 2.125 0.355 -0.245 0.265 -0.095 0.115 0.715 0.085
```

>> **FROM ABOVE RESULT WE CAN SEE WE HAVE BOTH +VE AND -VE EFFECT OF FACTORS ON RATE OF DISCHARGE**

TO GET VISUAL DIFF. WE USE Half normal plot

A half-normal plot assesses if data follow a normal distribution. Points form a straight line if data are normal. Deviations suggest non-normality, requiring further examination or alternative methods.



Half normal plot

The red points in the plot show that the factors have Negative effects.
The blue points in show that the factors have Positive effects.

From the obtained plot, we get that the main factor **effects A and B are highly significant. Others C & D are less significant**

The Interaction **Effect AB** is also far from the line to be considered as significant Here

```
> pilotEff
     A      B     AB      C     AC     BC    ABC      D     AD     BD    ABD     CD    ACD    BCD   ABCD
14.875 12.235  7.405 -1.975 -0.745 -0.025  0.605  2.125  0.355 -0.245  0.265 -0.095  0.115  0.715  0.085
attr(,"mean")

42.1925
> hnplot(pilotEff,ID=0)
```

Regression Model

Factor effects refer to the influence or impact that each factor has on the response variable.

In a regression model, the coefficients indicate how much the response variable is expected to change for a one-unit change in the corresponding factor, while holding all other factors constant. Hence the coefficients turn out to be (factor effect)/2.

For example, in a 2^2 factorial design (where k = 2), if you have factors A and B, the regression model might look like this:

$Y=\beta_0+\beta_1 A+\beta_2 B+\beta_{12} AB+\epsilon$

Here, $\beta_0$represents the intercept, β_1 represents the effect of factor A, β_2 represents the effect of factor B, and β_{12} represents the interaction effect between factors A and B.

```
Call:
lm.default(formula = Factors ~ B * A, data = data.rate)

Residuals:
   Min     1Q Median     3Q    Max 
 -2.73  -1.08   0.13   0.78   3.27 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)  42.1925     0.4595  91.822  < 2e-16 ***
B             6.1175     0.4595  13.313 1.51e-08 ***
A             7.4375     0.4595  16.186 1.62e-09 ***
B:A           3.7025     0.4595   8.058 3.49e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.838 on 12 degrees of freedom
Multiple R-squared:  0.9768,	Adjusted R-squared:  0.9709 
F-statistic: 168.1 on 3 and 12 DF,  p-value: 4.585e-10
```

Low P -value means the null hypothesis that coefficients of model is zero is rejected.

In this case

yp= 42.1925 + 7.4375 **x1** + 6.1175 **x2** + 3.7025 **x1.x3**

Here x1, x2 are levels of A and B respectively for each exp.

>Residuals are the differences between the observed values and the predicted values from the regression model that represent the errors or unexplained variance

>>e(x) = yactual – ypredicted

```
> residuals=mod$res
> residuals
    1     2     3     4     5     6     7     8     9    10    11    12    13 
-1.26  0.03  0.51  0.23 -1.02 -2.49 -1.77 -2.73  1.86  3.27  1.35  1.91  0.42 
   14    15    16 
-0.81 -0.09  0.59 
```

The coefficient of **multiple determination R^2** is defined by

$R^2 = SSR/SST = 1 - SSE/SST$ (Given value for the model = **0.9768**)

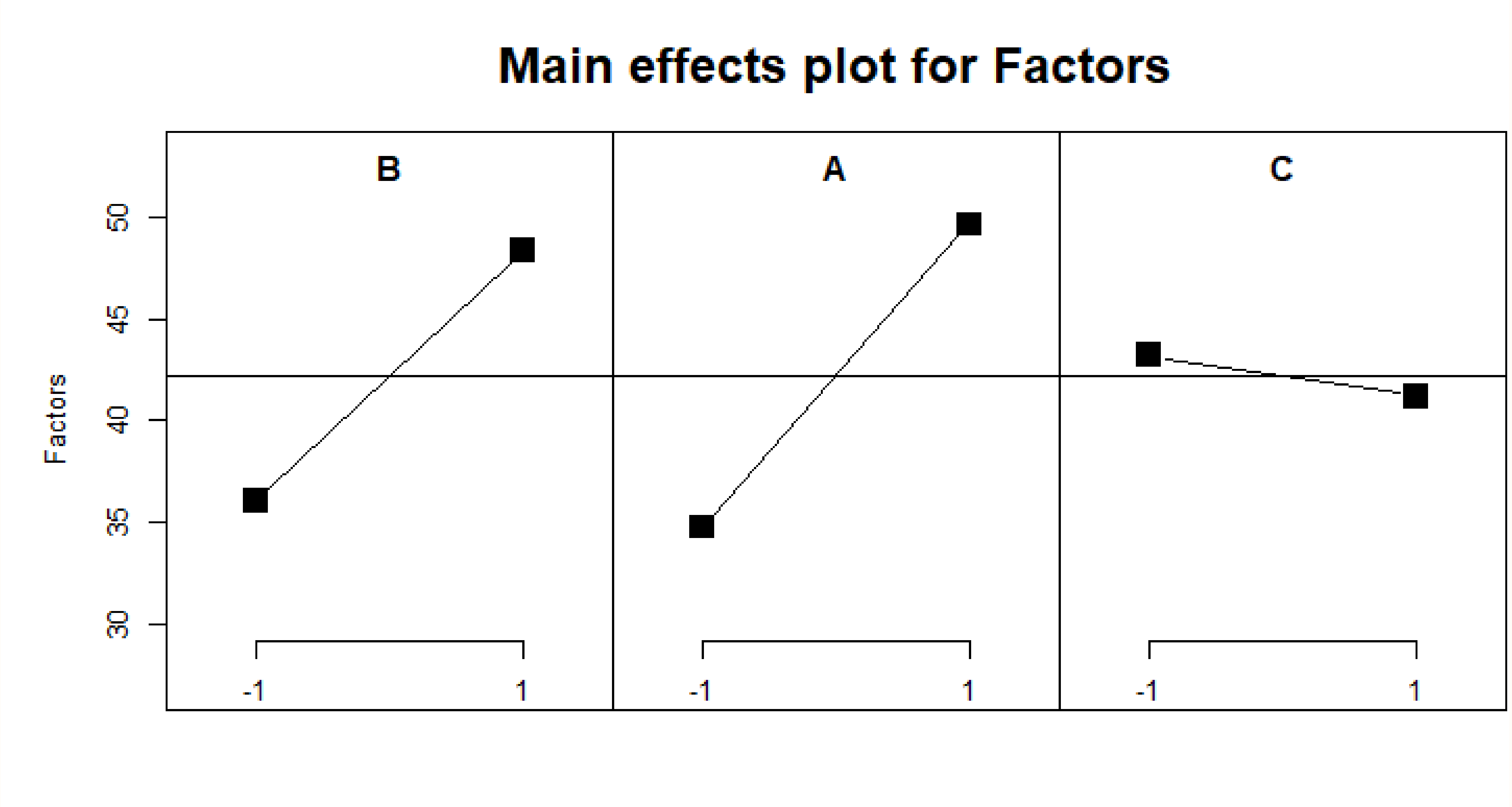
.Drawbacks: A large value of R^2 does not necessarily imply that the regression model is a good one. Adding a variable to the model will always increase R^2, regardless of whether the additional variable is statistically significant or not.

The coefficient of **adjusted R^2** is defined by

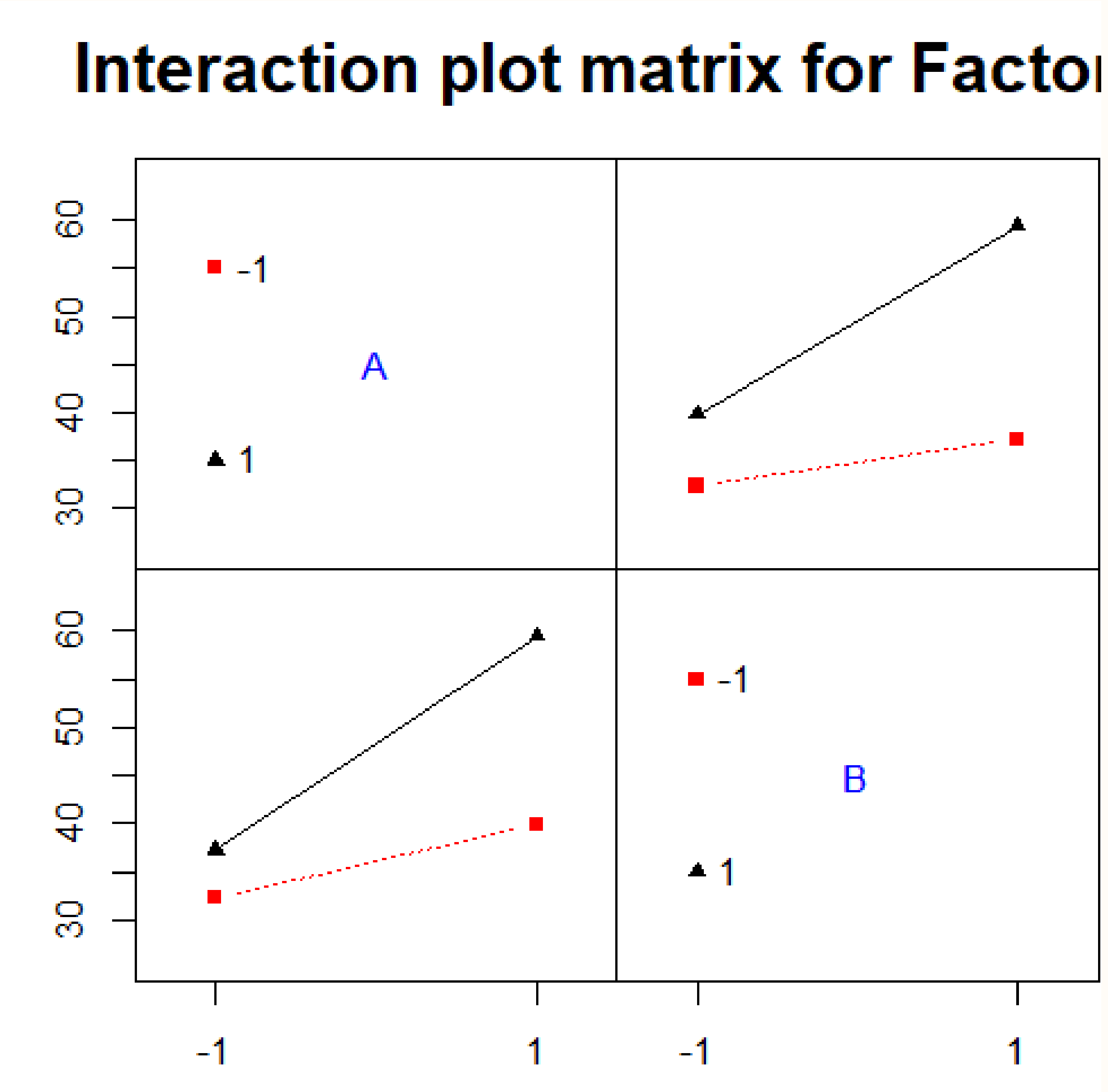
$R^2 = 1 - SSE/SST*(n-1)/(n-k-1)$ (Given value for the model = **0.9709**)

R^2 adj will increase only by adding a variable that reduces the MSE , i.e., enhances MSR i.e., the addition of the variable has a significant contribution in the response.

Factor C(Resolution) has a Negative effect Surprising. Means better resolution is good for battery life. May be due to inbuilt internal optimization

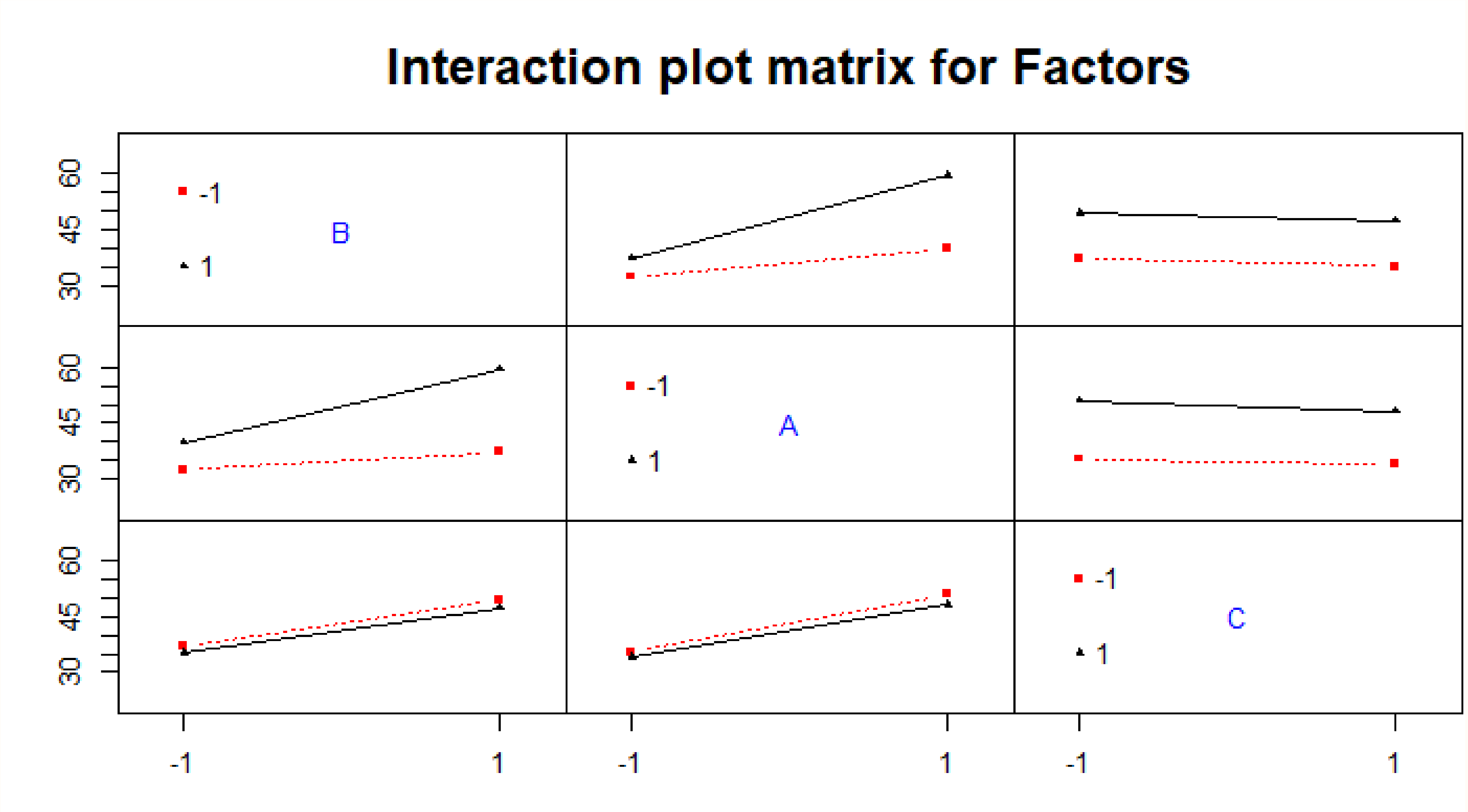


Here also we see that the factor C has lesser (as compared to A and B) and inverse impact on the battery drainage.



- In GRAPHS, **the black line signifies the high level of factor A and B respectively . The red line signifies the low level of factor A and B respectively .**

- OBSERVATION says as in each block, as **the lines are not parallel to each other, hence, the interactions between these factors A and B are significant.**



- Here we see that keeping B constant at low level when A is changed from -1 to 1 the difference in response is not that large. It is significant when B is high and vice versa.
- Here we see that A and C, also B and **C don’t interact much as the lines are quite parallel.**

Design Projection ANOVA(by omitting factors C and D)

```
####### Design Projection ########
values <- matrix(c(31.08, 31.32, 34.2, 32.76,
                   39.84, 37.32, 43.08, 39,
                   37.68, 35.4, 38.52, 37.08,
                   59.68, 56.72, 61.36, 60.04), byrow = TRUE, ncol = 4)
dimnames(values) <- list(c("(1)", "a", "b", "ab"), c("Rep1", "Rep2", "Rep3", "Rep4"))
```

```
> data.mat <- data.frame(A, B, as.vector(values))
> model <- aov(as.vector(values) ~ A*B, data = data.mat)
> summary(model)
            Df Sum Sq Mean Sq F value   Pr(>F)    
A            1  885.1   885.1  261.99 1.62e-09 ***
B            1  598.8   598.8  177.24 1.51e-08 ***
A:B          1  219.3   219.3   64.92 3.49e-06 ***
Residuals   12   40.5     3.4                     
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Above, shows factors A and B are highly significant.

USING MULTIPLE LEVEL FOR FACTOR A and B

HIGH , MID , LOW

Multiple levels of significant factors			
A-Refresh Rate	B-Brightness		
RATE	L1- 0	L2 -50	L3 -100
144	42.44	50.11	63.2
90	36.3	42.1	49.8
60	34.1	35.7	37.89

```
> data.rate
  refresh_rate brightness_level  rate
1        144Hz               L1 42.44
2         90Hz               L1 36.30
3         60Hz               L1 34.10
4        144Hz               L2 50.11
5         90Hz               L2 42.10
6         60Hz               L2 35.70
7        144Hz               L3 63.20
8         90Hz               L3 49.80
9         60Hz               L3 37.89
```

```
> summary(rate.aov)
                 Df Sum Sq Mean Sq F value Pr(>F)  
refresh_rate      2  387.7  193.86  10.398 0.0260 *
brightness_level  2  244.8  122.39   6.565 0.0545 .
Residuals         4   74.6   18.64                 
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

FROM Above results we find that compared to Brightness (B) Refresh Rate (A) is more significant

LSD

```
$comparison
NULL

$groups
       rate groups
63.2  63.20      a
50.11 50.11     ab
49.8  49.80     ab
42.44 42.44      b
42.1  42.10      b
37.89 37.89      b
36.3  36.30      b
35.7  35.70      b
34.1  34.10      b

attr(,"class")
[1] "group"
>
```

LSD, or Least Significant Difference, is used to compare means of different groups after an ANOVA test.
It determines If the difference between two group means is statistically significant.

>>If the difference Is larger than the LSD value, it suggests a significant difference.

Obtained the rates into groups are as follows into a,b & ab

Where alpha = 0.05

TUKEY HSD

Tukey's HSD (Honestly Significant Difference) compares means of different groups after ANOVA, determining if differences are statistically significant.

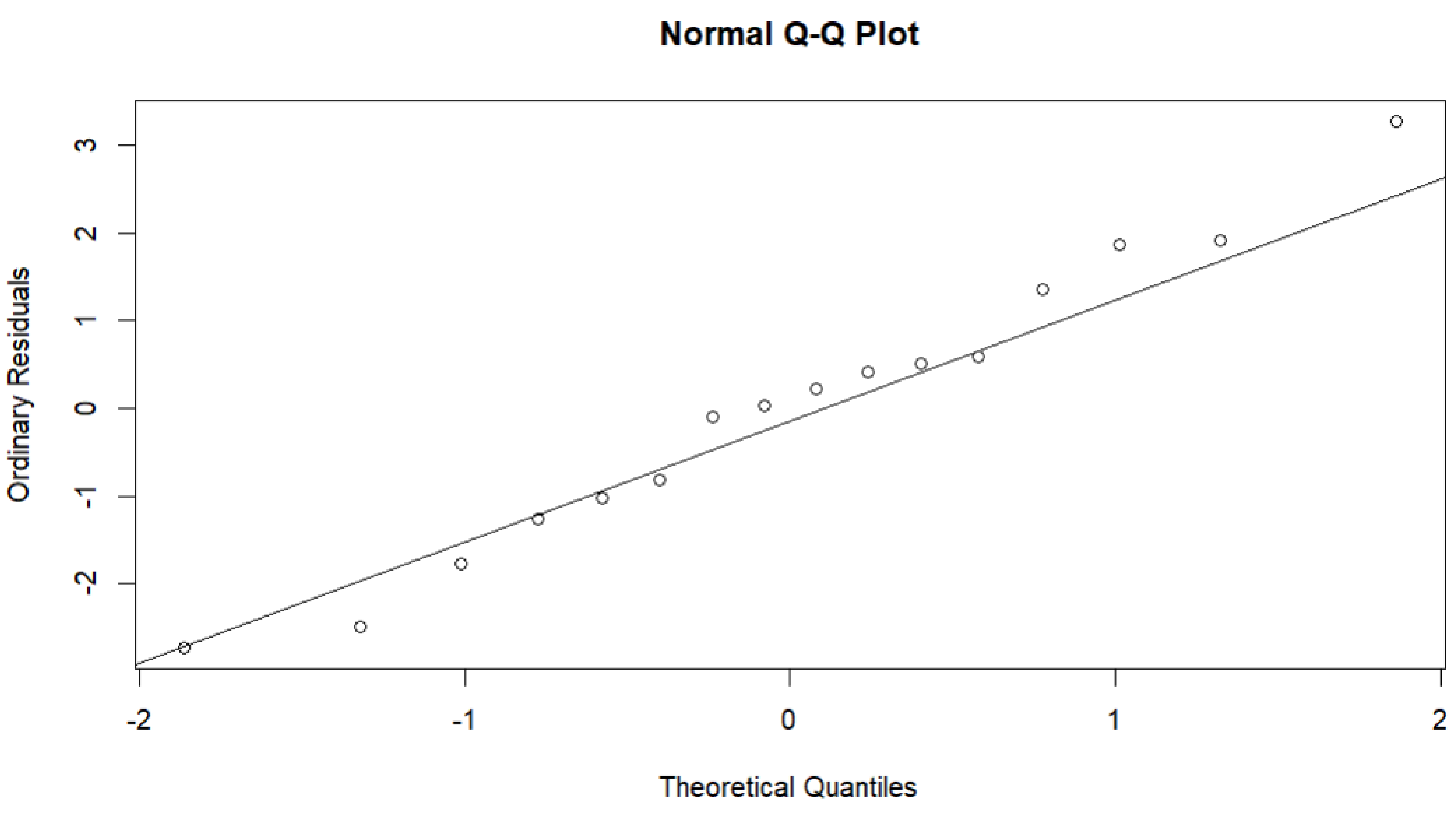
```
$refresh_rate
                 diff       lwr      upr     p adj
90Hz-60Hz    6.836667 -5.728199 19.40153 0.2424679
144Hz-60Hz  16.020000  3.455134 28.58487 0.0226806
144Hz-90Hz   9.183333 -3.381532 21.74820 0.1224995

$brightness_level
           diff        lwr      upr     p adj
L2-L1  5.023333 -7.5415323 17.58820 0.4122775
L3-L1 12.683333  0.1184677 25.24820 0.0485634
L3-L2  7.660000 -4.9048657 20.22487 0.1901441
```

Above, shows factors A & B have impact on each level where conf. Level = 0.95

- **For Factor A-Refresh rate : there more difference between mid to high than low to mid shows there is higher variation on high Refresh rate .**
- **For Factor B-Brightness level : there more difference between mid to high than low to mid shows there is higher variation on high Brightness . >>NOT LINEARLY INCREASING**
- **Rate of Discharging: 144Hz > 90Hz > 60Hz & L3>L2>L1**

qq-plot

A Q-Q plot compares the quantiles of a dataset to those of a theoretical distribution.



Deviations from the line indicate departures from the expected distribution, such as heavier or lighter tails. Outliers may also be identified.

Above , The residuals Exactly follow the normal distribution.

Dunnett’s Test

```
> dunnett= DunnettTest(data.rate$rate,g, control="144Hz", conf.level=0.95)
> dunnett

  Dunnett's test for comparing several treatments with a control :
    95% family-wise confidence level

$`144Hz`
                 diff    lwr.ci   upr.ci   pval
60Hz-144Hz -16.020000 -33.09204 1.052035 0.0625 .
90Hz-144Hz  -9.183333 -26.25537 7.888702 0.2830

---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

144 Hz is our control Group at **95% confidence Interval**.

- In Dunnett’s test, the control group is used to assess whether there are significant differences between the control and other treatments.
- The test compares treatments with a control group and calculates differences, confidence intervals, and p-values for each comparison. Low p-values w.r.t confidence interval suggest significant differences, while high p-values indicate treatments are comparable to the control .

CONCLUSIONS OF ANALYSIS

Effects of Refresh Rate & Brightness are highly significant. Others RESOLUTION & SOUND are less significant .

Factor C(Resolution) has a Negative effect. Means better resolution is good for battery life.

Compared to Brightness (B) Refresh Rate (A) is more significant.

Rate of Discharging: 144Hz > 90Hz > 60Hz & L3>L2>L1

NOT LINEARLY INCREASING

IDEAL CONDITION TO SET FACTORS

REFRESH RATE -60Hz

RESOLUTION - HIGH (RECOMMENDED)

BRIGHTNESS - ON LOWER SIDE

SPEAKER VOL - NOT MATTER MUCH