

# marks\_proj\_work

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## Exploratory Analysis (Original)

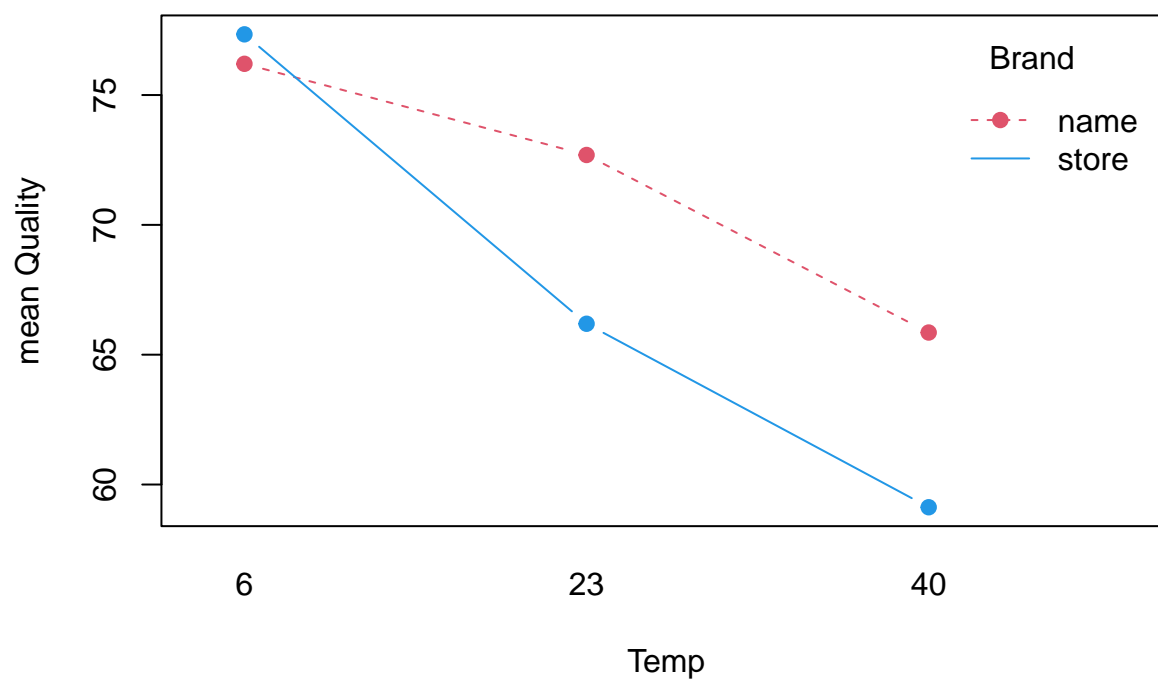
```
#using Halid's code to keep data frame consistent
library(tidyverse)
df_eff <- read_csv('effervescence.csv', col_types = 'ffnmm')
df_eff %>% head()
```

```
## # A tibble: 6 x 6
##   Brand Temp Stirred Order  Time OrgTime
##   <fct> <fct> <fct>   <dbl> <dbl>   <dbl>
## 1 name   6     yes       8  77.2    75.5
## 2 name  23     yes       3  75.4    68.1
## 3 name  40     yes       7  68.1    44.8
## 4 store 6     yes       1  77.9    78.4
## 5 store 23     yes       2  66.4    40.6
## 6 store 40     yes      18  59.8    27.4
```

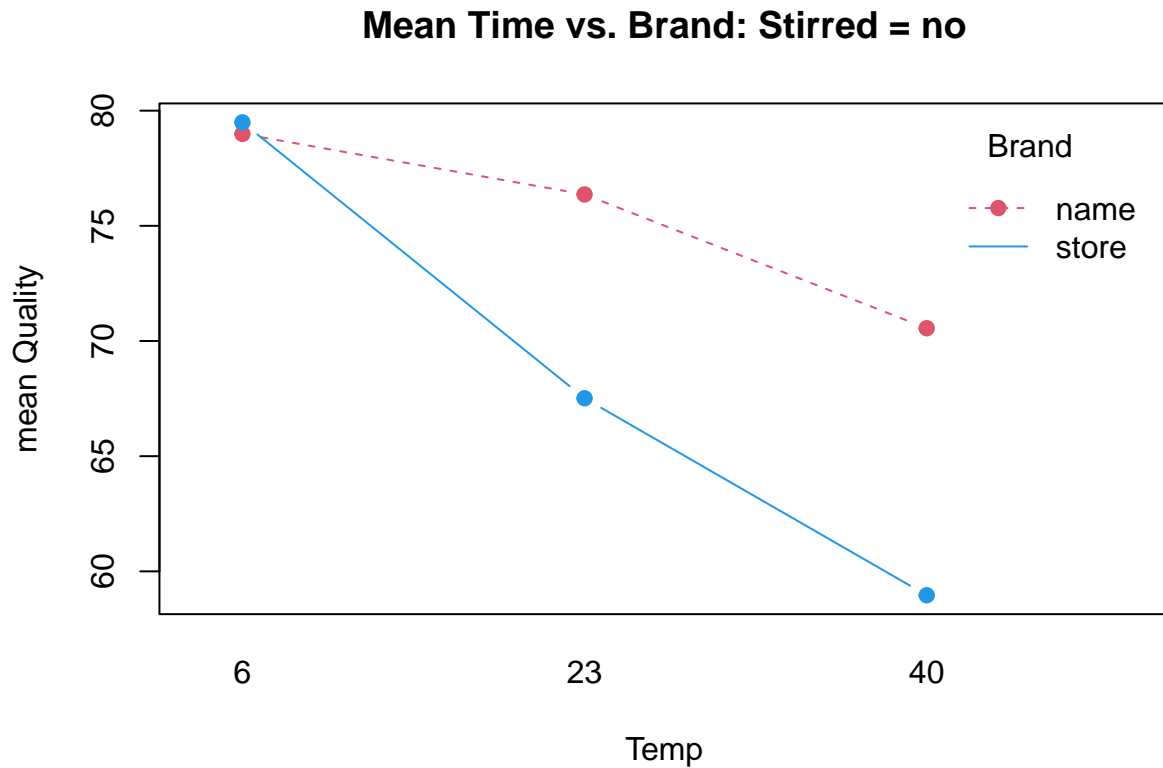
```
##3 factor interaction plot based on HW7 code
```

```
with(df_eff%>%filter(Stirred=="yes"),interaction.plot(Temp,Brand,Time,
  type="b", pch=19, col=c(2,4), ylab="mean Quality",
  main="Mean Time vs. Brand: Stirred = yes"))
```

### Mean Time vs. Brand: Stirred = yes



```
with(df_eff%>%filter(Stirred=="no"),interaction.plot(Temp,Brand,Time,  
  type="b", pch=19, col=c(2,4), ylab="mean Quality",  
  main="Mean Time vs. Brand: Stirred = no"))
```



From the three factor interaction plots, does the 3 factor interaction look obvious here? The brand by temp interaction is clear.

## Analysis and Results

```
#model with stirred as block effect without interaction
aov_block_eff <- aov(lm_block_eff <- lm(Time ~ Brand * Temp + Stirred, data = df_eff))
summary(lm_block_eff)
```

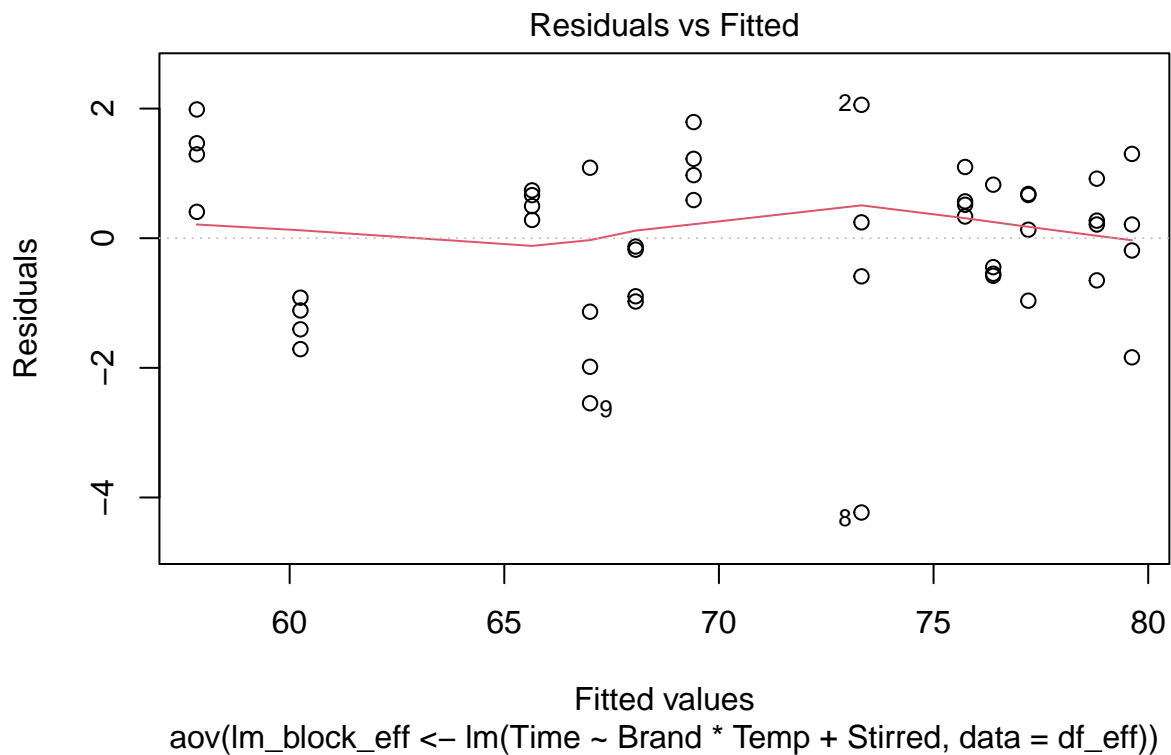
```
##
## Call:
## lm(formula = Time ~ Brand * Temp + Stirred, data = df_eff)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -4.2315 -0.7120  0.2577  0.7596  2.0577
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    76.3899     0.5035  151.710 < 2e-16 ***
## Brandstore       0.8182     0.6593   1.241   0.222
## Temp23         -3.0690     0.6593  -4.655 3.38e-05 ***
## Temp40         -9.3922     0.6593 -14.246 < 2e-16 ***
## Stirredno       2.4133     0.3806   6.340 1.42e-07 ***
## Brandstore:Temp23 -8.4923     0.9323  -9.108 2.11e-11 ***
```

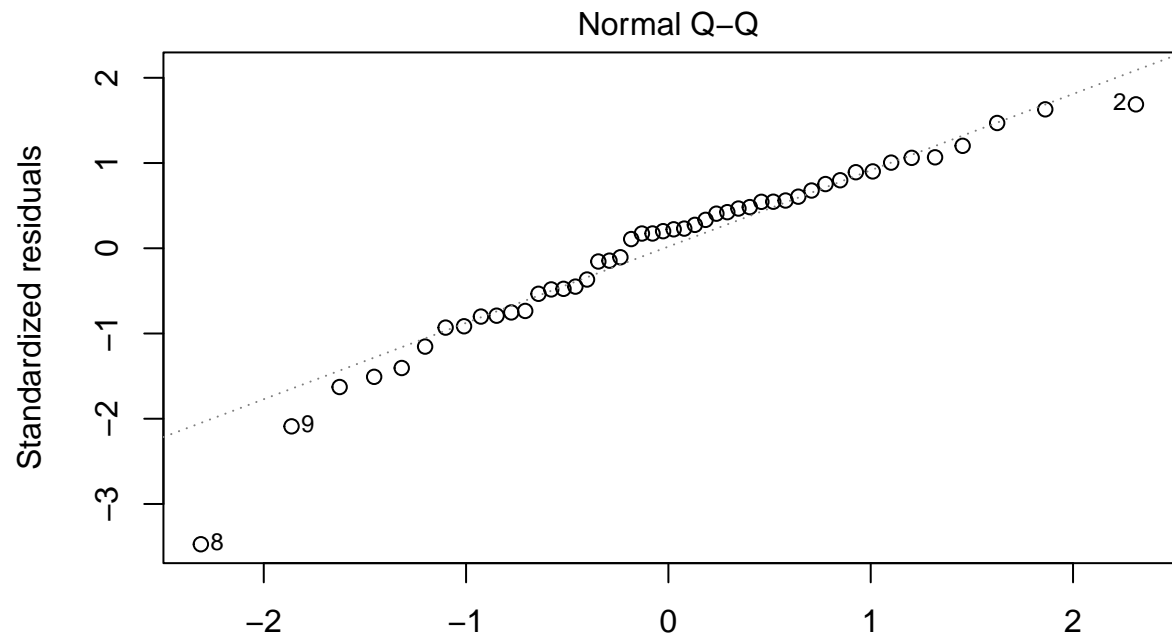
```
## Brandstore:Temp40 -9.9781      0.9323 -10.702 1.93e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.319 on 41 degrees of freedom
## Multiple R-squared:  0.9699, Adjusted R-squared:  0.9655
## F-statistic: 220.3 on 6 and 41 DF,  p-value: < 2.2e-16
```

```
summary(aov_block_eff)
```

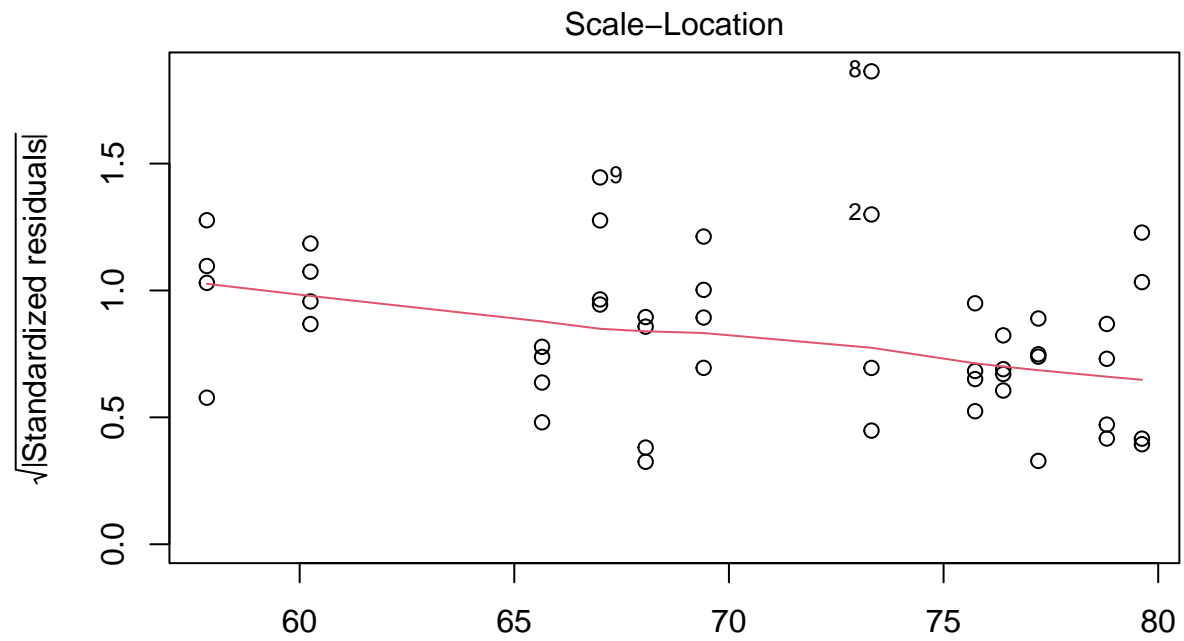
```
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Brand       1  342.0   342.0   196.72 < 2e-16 ***
## Temp       2 1654.7   827.4   475.89 < 2e-16 ***
## Stirred     1   69.9    69.9    40.20 1.42e-07 ***
## Brand:Temp  2  231.9   115.9    66.68 1.30e-13 ***
## Residuals  41   71.3     1.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
plot(aov_block_eff)
```

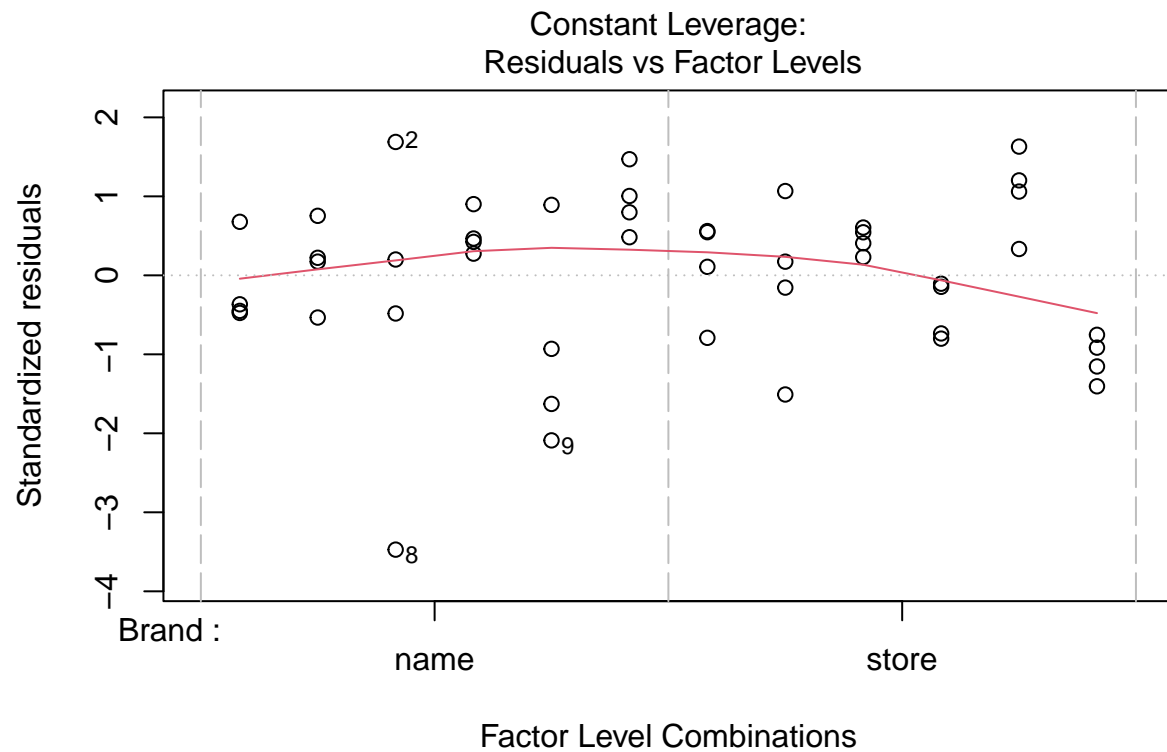




aov(lm\_block\_eff <- lm(Time ~ Brand \* Temp + Stirred, data = df\_eff))



Fitted values  
`aov(lm_block_eff <- lm(Time ~ Brand * Temp + Stirred, data = df_eff))`



```
library(olsrr)
```

```
##
```

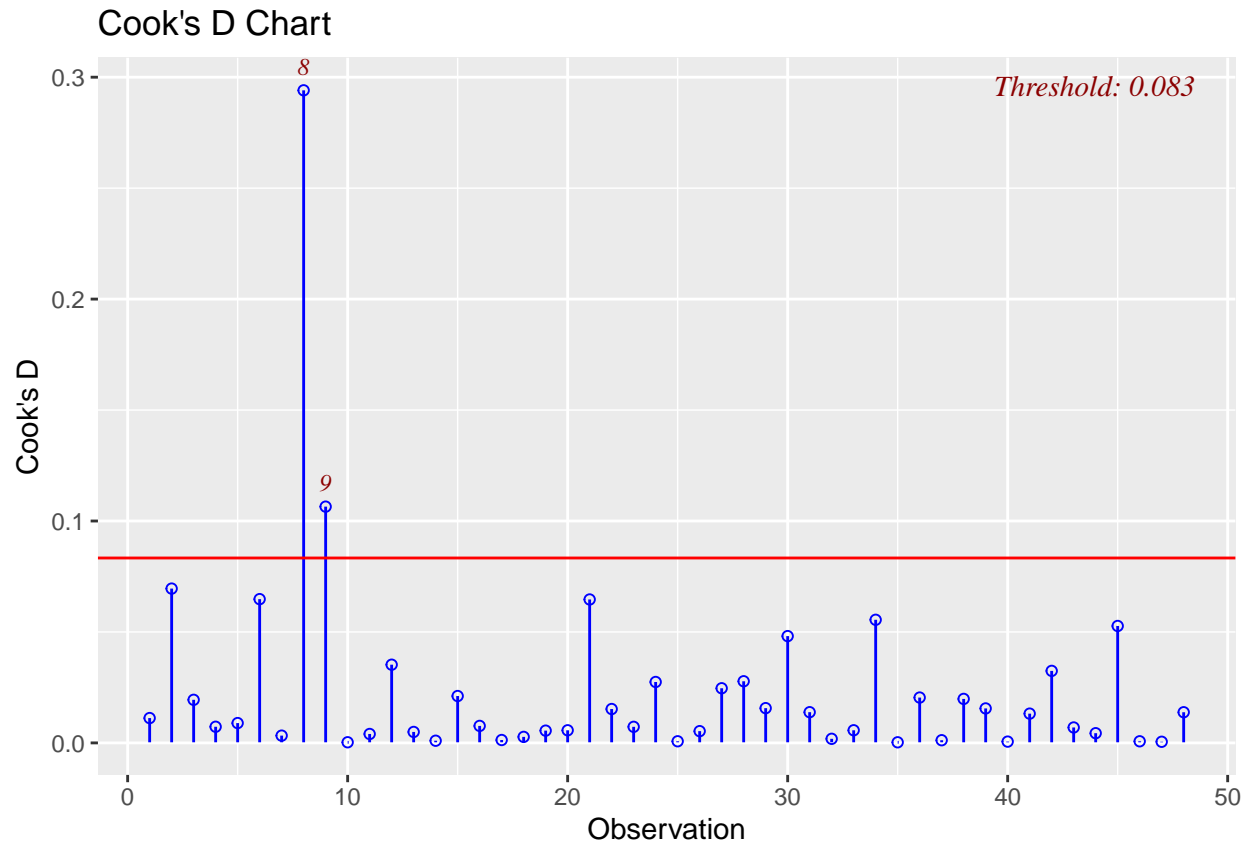
```
## Attaching package: 'olsrr'
```

```
## The following object is masked from 'package:datasets':
```

```
##
```

```
## rivers
```

```
ols_plot_cooksd_chart(lm_block_eff)
```



```
#added covariate Order model with stirred as block effect without interaction
aov_block_order_eff <- aov(lm_block_order_eff <- lm(Time ~ Brand * Temp + Stirred + Order, data = df_eff))
summary(lm_block_order_eff)
```

```
##
## Call:
## lm(formula = Time ~ Brand * Temp + Stirred + Order, data = df_eff)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.9257 -0.7714  0.0969  0.8613  2.4030
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    75.76840    0.66484  113.965 < 2e-16 ***
## Brandstore      0.95630    0.65881   1.452  0.1544
## Temp23         -2.91120    0.66104  -4.404 7.73e-05 ***
## Temp40         -9.17522    0.66943 -13.706 < 2e-16 ***
## Stirredno       1.46630    0.77003   1.904  0.0641 .
## Order           0.03946    0.02800   1.409  0.1664
## Brandstore:Temp23 -8.64026    0.92729  -9.318 1.42e-11 ***
## Brandstore:Temp40 -10.22471    0.93780 -10.903 1.51e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.303 on 40 degrees of freedom
```



```
## Multiple R-squared:  0.9713, Adjusted R-squared:  0.9663
## F-statistic: 193.7 on 7 and 40 DF,  p-value: < 2.2e-16
```

```
summary(aov_block_order_eff)
```

```
##              Df Sum Sq Mean Sq F value    Pr(>F)
## Brand          1  342.0    342.0 201.452 < 2e-16 ***
## Temp           2 1654.7    827.4 487.344 < 2e-16 ***
## Stirred        1   69.9     69.9 41.166 1.23e-07 ***
## Order          1    0.9      0.9  0.534   0.469
## Brand:Temp     2  234.3    117.2 69.010 1.08e-13 ***
## Residuals     40   67.9      1.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
library(car)
```

```
## Loading required package: carData
```

```
##
```

```
## Attaching package: 'car'
```

```
## The following object is masked from 'package:dplyr':
```

```
##
```

```
##      recode
```

```
## The following object is masked from 'package:purrr':
```

```
##
```

```
##      some
```

```
Anova(aov_block_order_eff, type=3) # type 3 SS
```

```
## Anova Table (Type III tests)
```

```
##
```

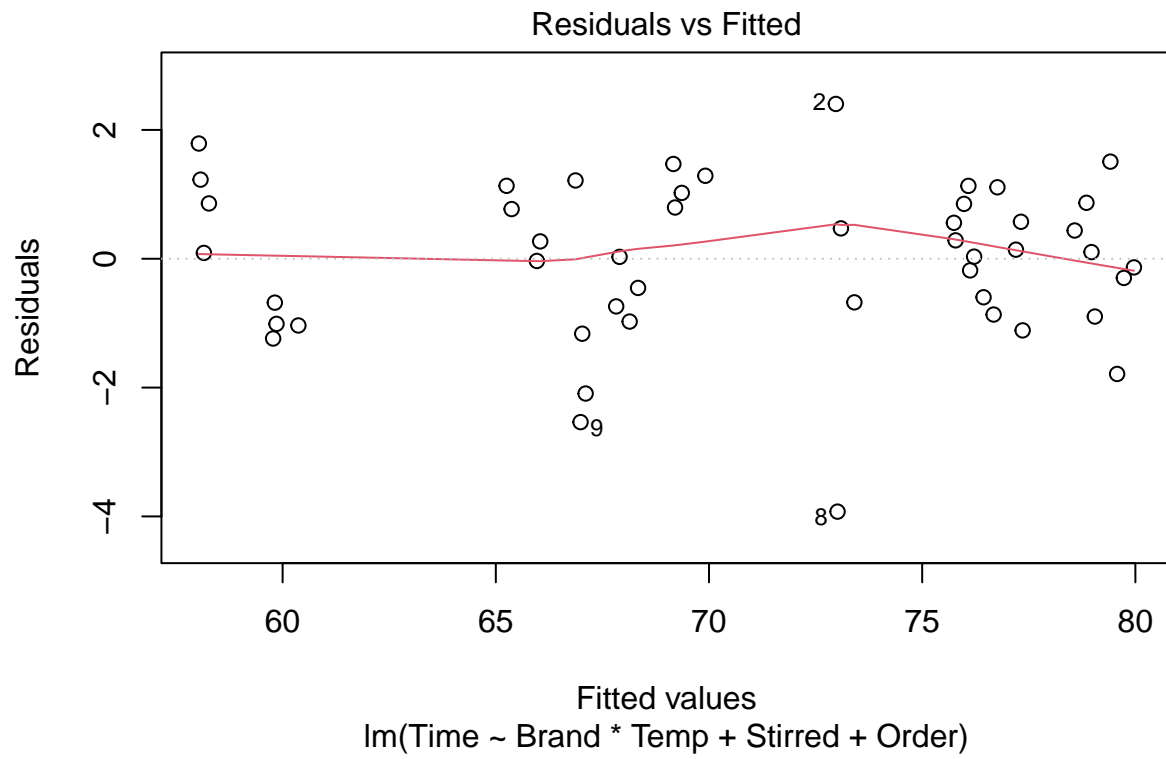
```
## Response: Time
```

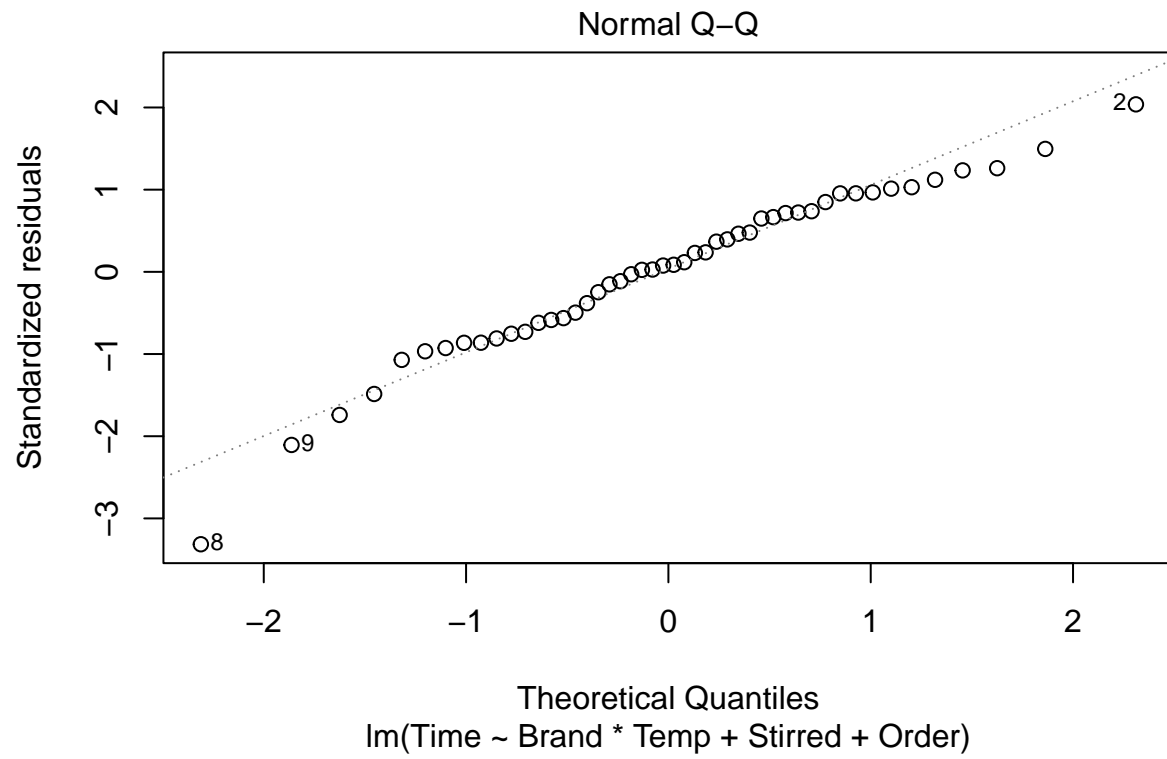
```
##              Sum Sq Df    F value    Pr(>F)
## (Intercept) 22049.8  1 12987.9591 < 2.2e-16 ***
## Brand         3.6   1    2.1070   0.15442
## Temp        335.9   2   98.9237 3.275e-16 ***
## Stirred       6.2   1    3.6261   0.06409 .
## Order        3.4   1    1.9864   0.16645
## Brand:Temp   234.3   2   69.0102 1.076e-13 ***
## Residuals    67.9  40
```

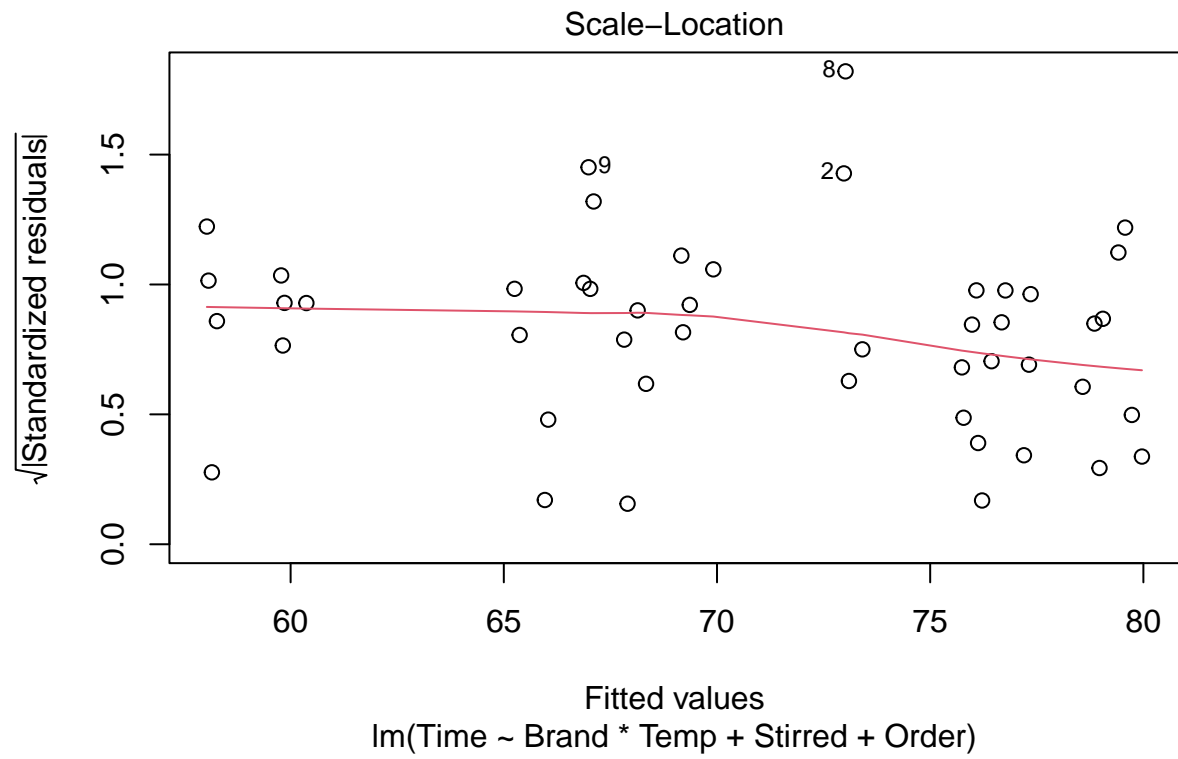
```
## ---
```

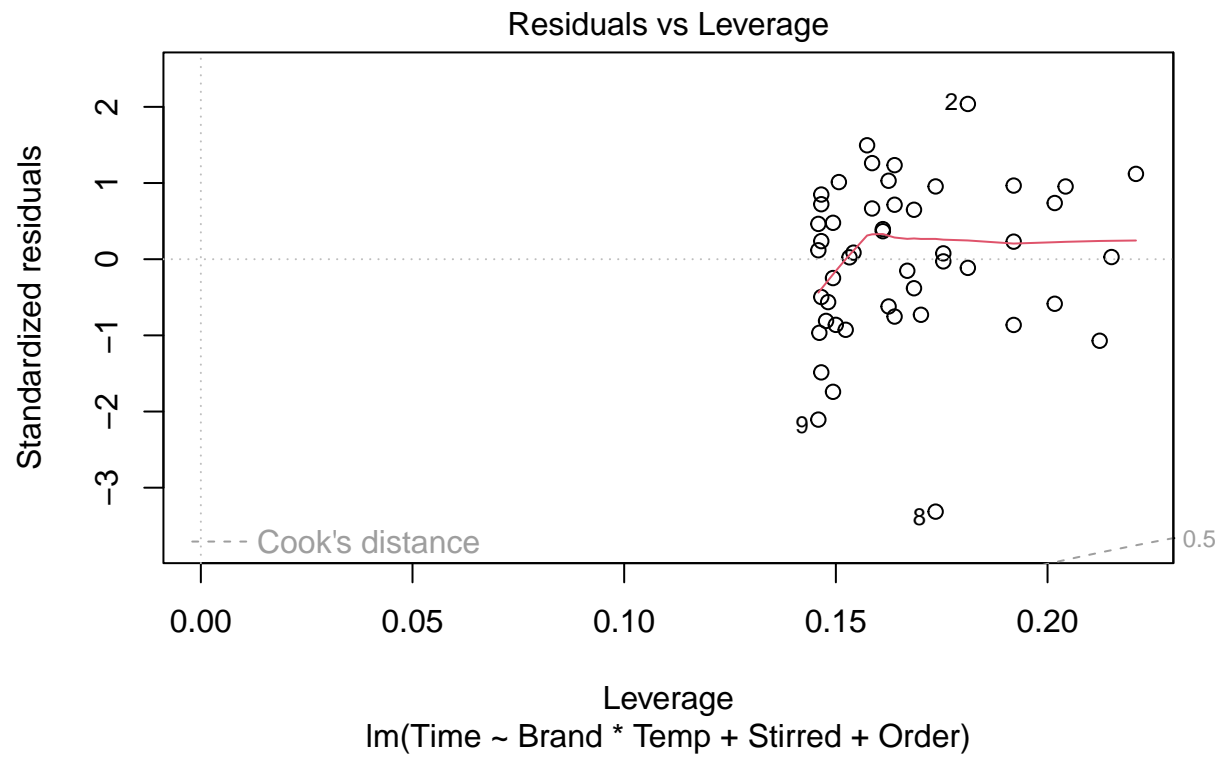
```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
plot(lm_block_order_eff)
```

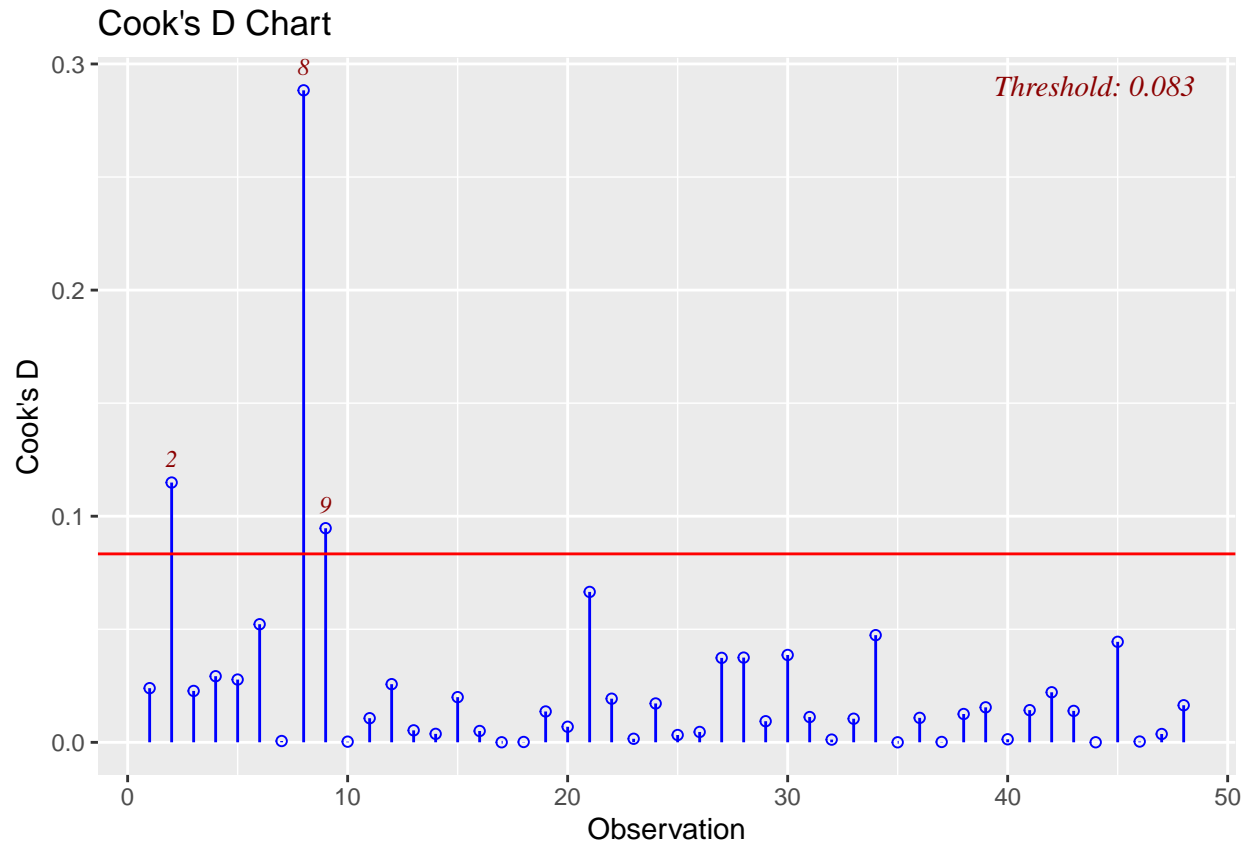








```
ols_plot_cooksd_chart(lm_block_order_eff)
```



*#added covariate Order to model with 3 factor interaction*

```
aov_three_order_eff <- aov(lm_three_order_eff <- lm(Time ~ Brand * Temp*Stirred + Order, data = df_eff))
summary(lm_three_order_eff)
```

```
##
## Call:
## lm(formula = Time ~ Brand * Temp * Stirred + Order, data = df_eff)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.6373 -0.3259  0.0077  0.4420  2.6391
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      76.3849    0.6759  113.009 < 2e-16 ***
## Brandstore         1.0930    0.7740   1.412  0.16673
## Temp23            -3.6070    0.7971  -4.525 6.67e-05 ***
## Temp40           -10.4002    0.7768 -13.389 2.47e-15 ***
## Stirredno          3.1339    1.0819   2.897  0.00646 **
## Order             -0.0128    0.0282  -0.454  0.65270
## Brandstore:Temp23  -7.5228    1.1145  -6.750 8.06e-08 ***
## Brandstore:Temp40  -7.6899    1.1517  -6.677 1.00e-07 ***
## Brandstore:Stirredno -0.6392    1.0870  -0.588  0.56026
## Temp23:Stirredno    0.9735    1.1047   0.881  0.38420
## Temp40:Stirredno    1.8751    1.0902   1.720  0.09427 .
## Brandstore:Temp23:Stirredno -1.8430    1.5628  -1.179  0.24622
```

```
## Brandstore:Temp40:Stirredno -4.4163      1.5906 -2.777  0.00876 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.087 on 35 degrees of freedom
## Multiple R-squared:  0.9826, Adjusted R-squared:  0.9766
## F-statistic: 164.3 on 12 and 35 DF,  p-value: < 2.2e-16
```

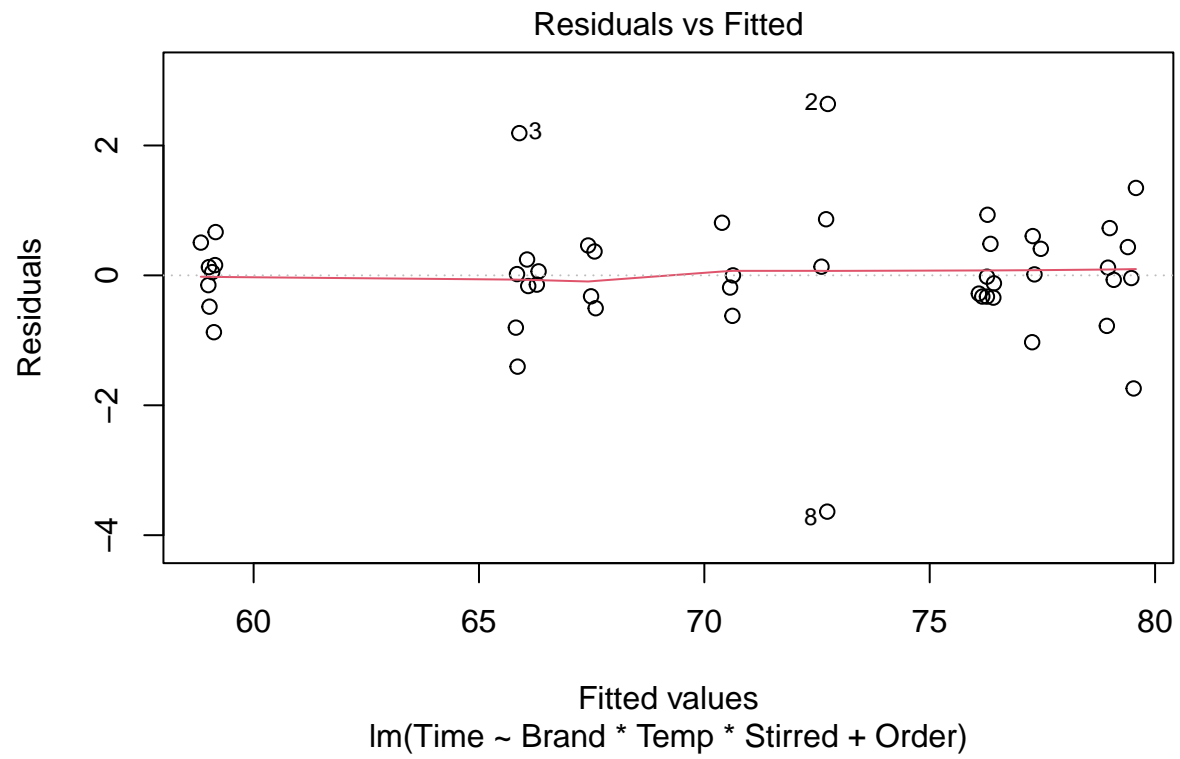
```
summary(aov_three_order_eff)
```

```
##              Df Sum Sq Mean Sq F value    Pr(>F)
## Brand           1  342.0   342.0 289.512 < 2e-16 ***
## Temp            2 1654.7   827.4 700.374 < 2e-16 ***
## Stirred         1   69.9    69.9  59.161 5.01e-09 ***
## Order           1    0.9     0.9   0.767 0.387161
## Brand:Temp       2  234.3   117.2  99.176 3.81e-15 ***
## Brand:Stirred    1   17.3    17.3  14.641 0.000514 ***
## Temp:Stirred     2    0.0     0.0   0.018 0.982371
## Brand:Temp:Stirred 2    9.2     4.6   3.904 0.029469 *
## Residuals       35   41.3     1.2
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

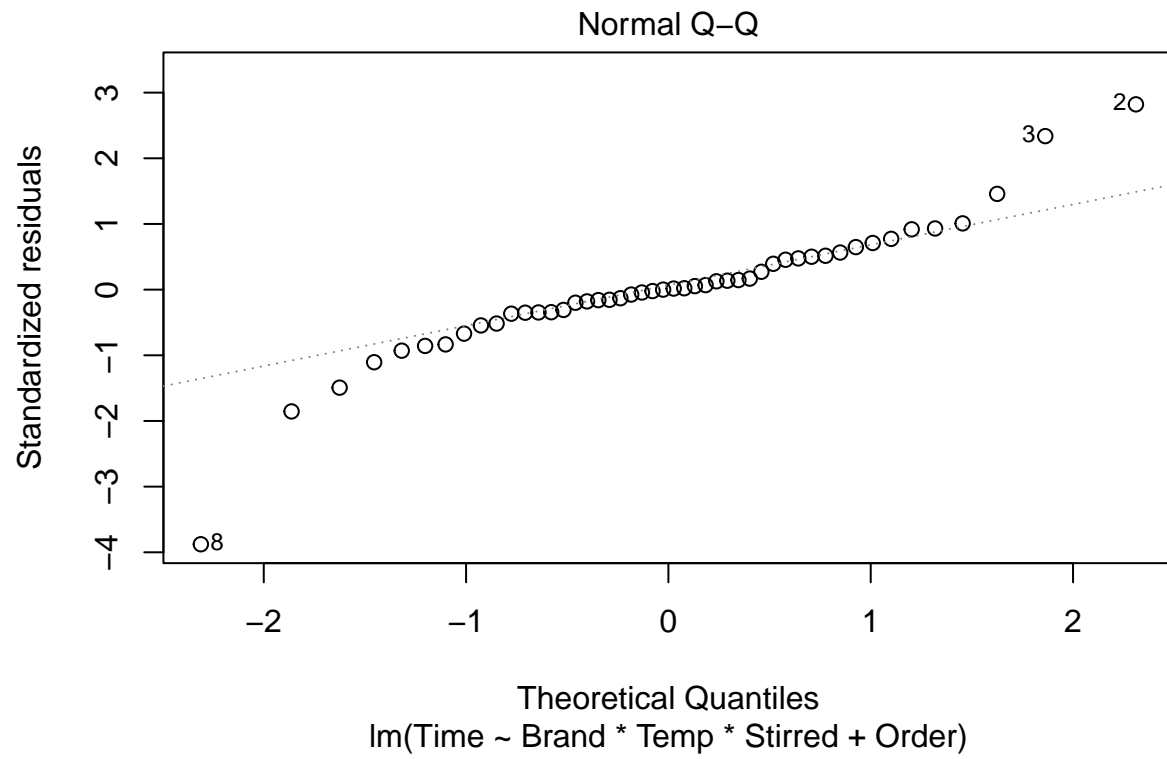
```
library(car)
Anova(aov_three_order_eff, type=3) # type 3 SS
```

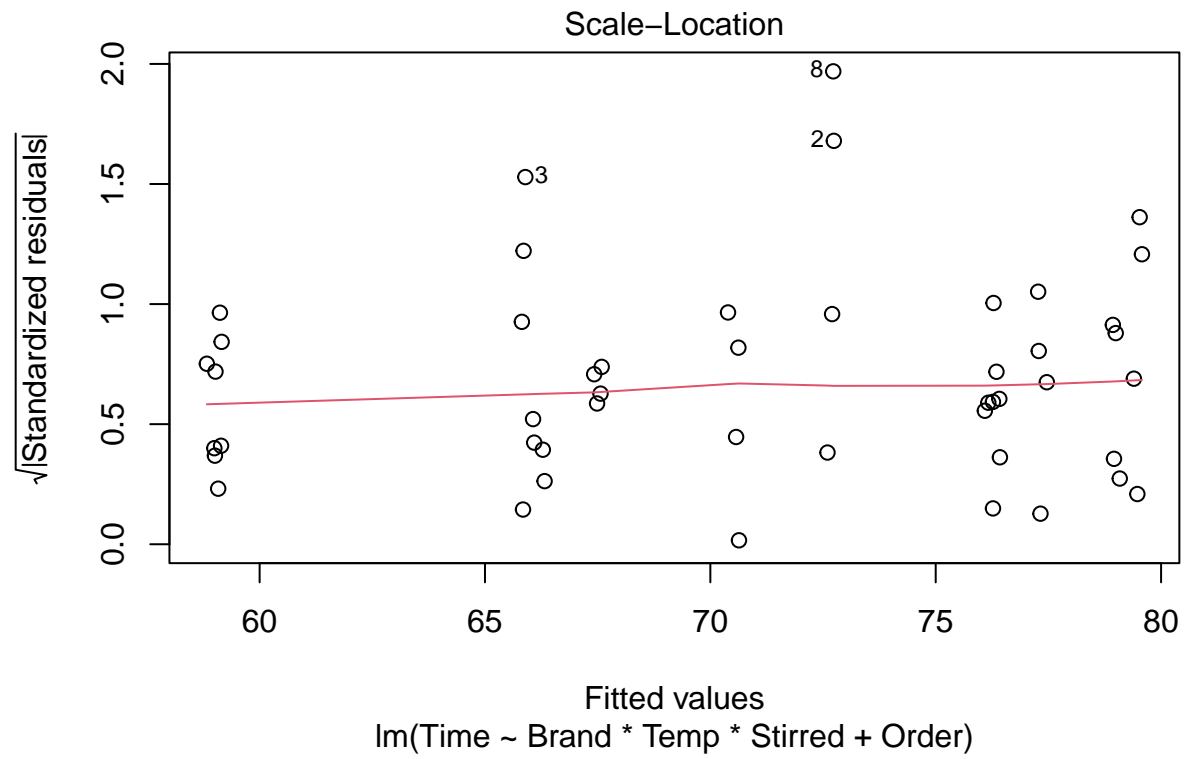
```
## Anova Table (Type III tests)
##
## Response: Time
##              Sum Sq Df    F value    Pr(>F)
## (Intercept) 15086.6  1 12770.9606 < 2.2e-16 ***
## Brand         2.4    1    1.9942  0.166731
## Temp        220.9    2   93.4777 9.153e-15 ***
## Stirred       9.9    1    8.3899 0.006465 **
## Order         0.2    1    0.2060 0.652697
## Brand:Temp    69.5    2   29.3957 3.224e-08 ***
## Brand:Stirred  0.4    1    0.3458 0.560255
## Temp:Stirred   3.5    2    1.4816 0.241180
## Brand:Temp:Stirred 9.2    2    3.9044 0.029469 *
## Residuals    41.3   35
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

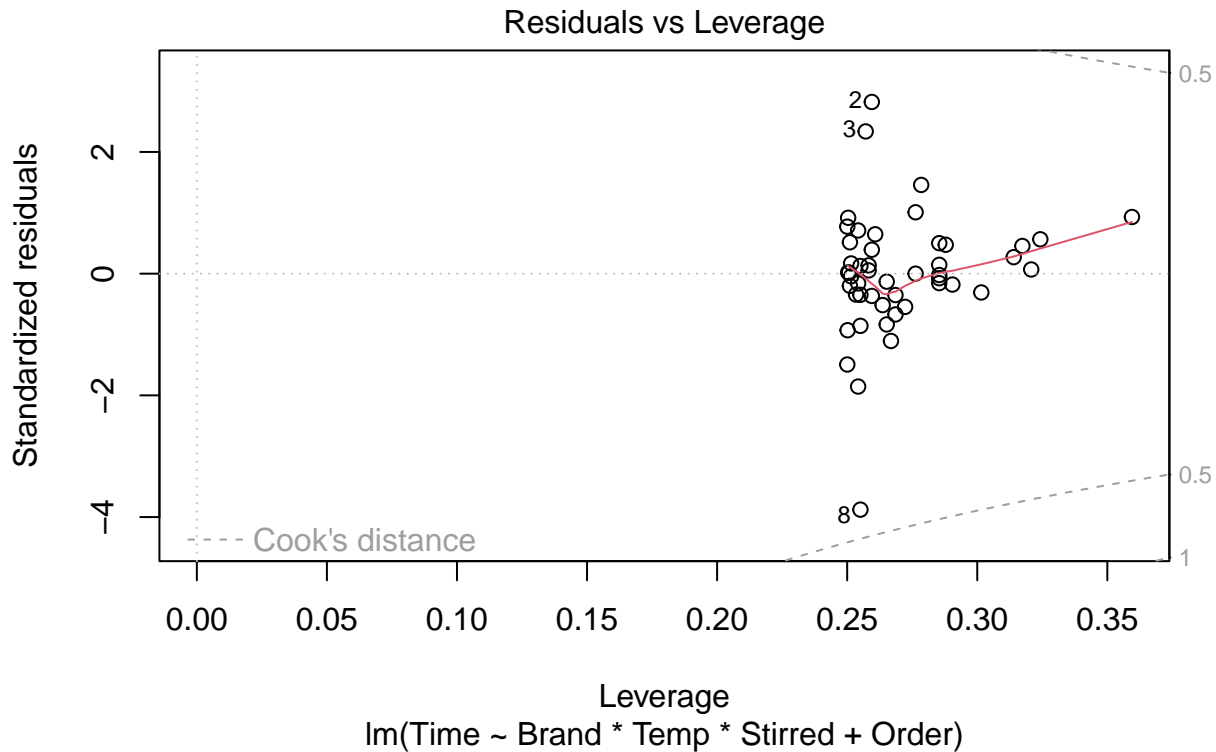
```
plot(lm_three_order_eff)
```











```
#adding Halid's code to see how full 3 factor interaction compares
aov_eff <- aov(lm_eff <- lm(Time ~ Brand * Temp * Stirred, data = df_eff))
summary(lm_eff)
```

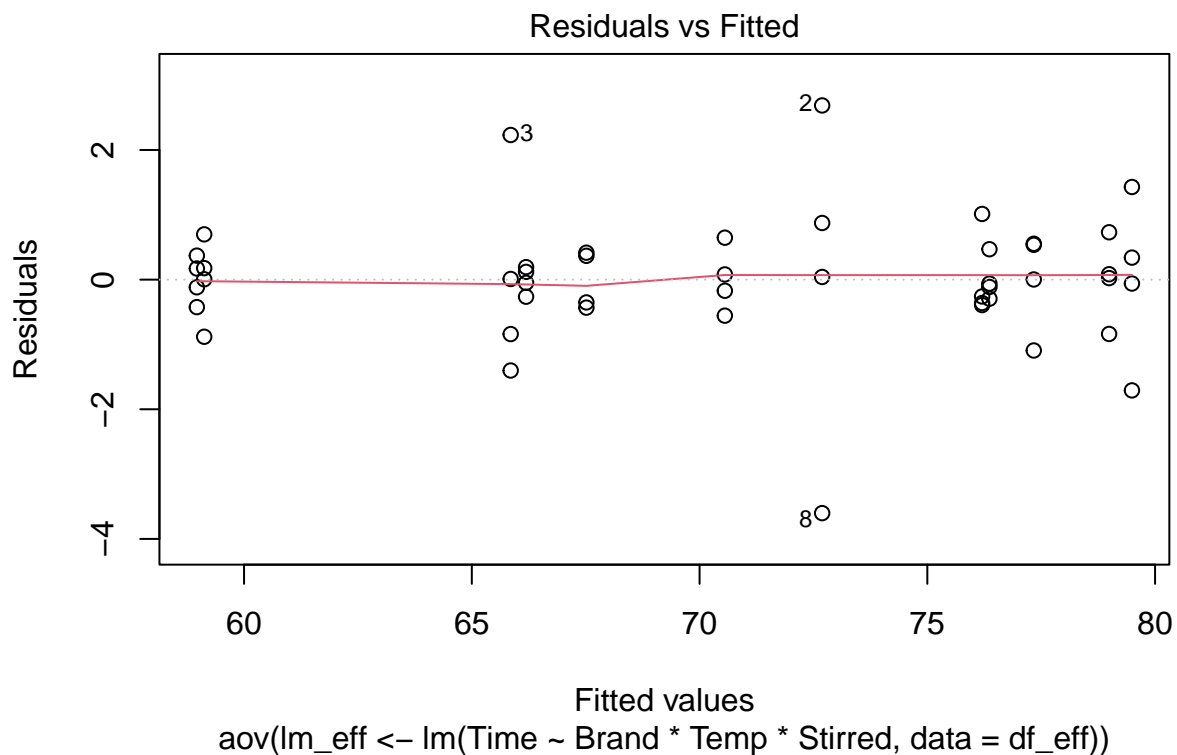
```
##
## Call:
## lm(formula = Time ~ Brand * Temp * Stirred, data = df_eff)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.6021 -0.3538  0.0077  0.3816  2.6871
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      76.2024    0.5374 141.794 < 2e-16 ***
## Brandstore         1.1346    0.7600   1.493 0.144185
## Temp23            -3.5110    0.7600  -4.620 4.78e-05 ***
## Temp40           -10.3490    0.7600 -13.617 9.05e-16 ***
## Stirredno         2.7882    0.7600   3.669 0.000783 ***
## Brandstore:Temp23  -7.6348    1.0748  -7.103 2.40e-08 ***
## Brandstore:Temp40  -7.8628    1.0748  -7.315 1.27e-08 ***
## Brandstore:Stirredno -0.6328    1.0748  -0.589 0.559694
## Temp23:Stirredno    0.8839    1.0748   0.822 0.416308
## Temp40:Stirredno    1.9135    1.0748   1.780 0.083476 .
## Brandstore:Temp23:Stirredno -1.7150    1.5200  -1.128 0.266685
```

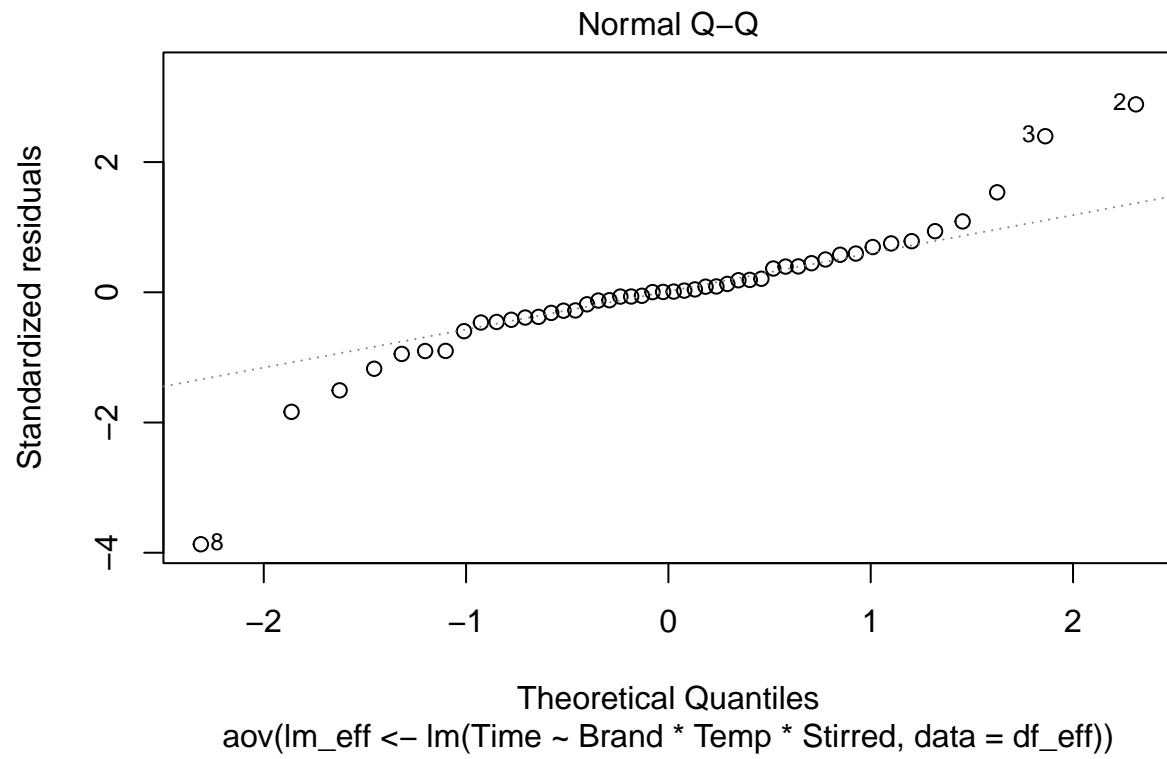
```
## Brandstore:Temp40:Stirredno -4.2307      1.5200 -2.783 0.008519 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.075 on 36 degrees of freedom
## Multiple R-squared:  0.9824, Adjusted R-squared:  0.9771
## F-statistic: 183.2 on 11 and 36 DF,  p-value: < 2.2e-16
```

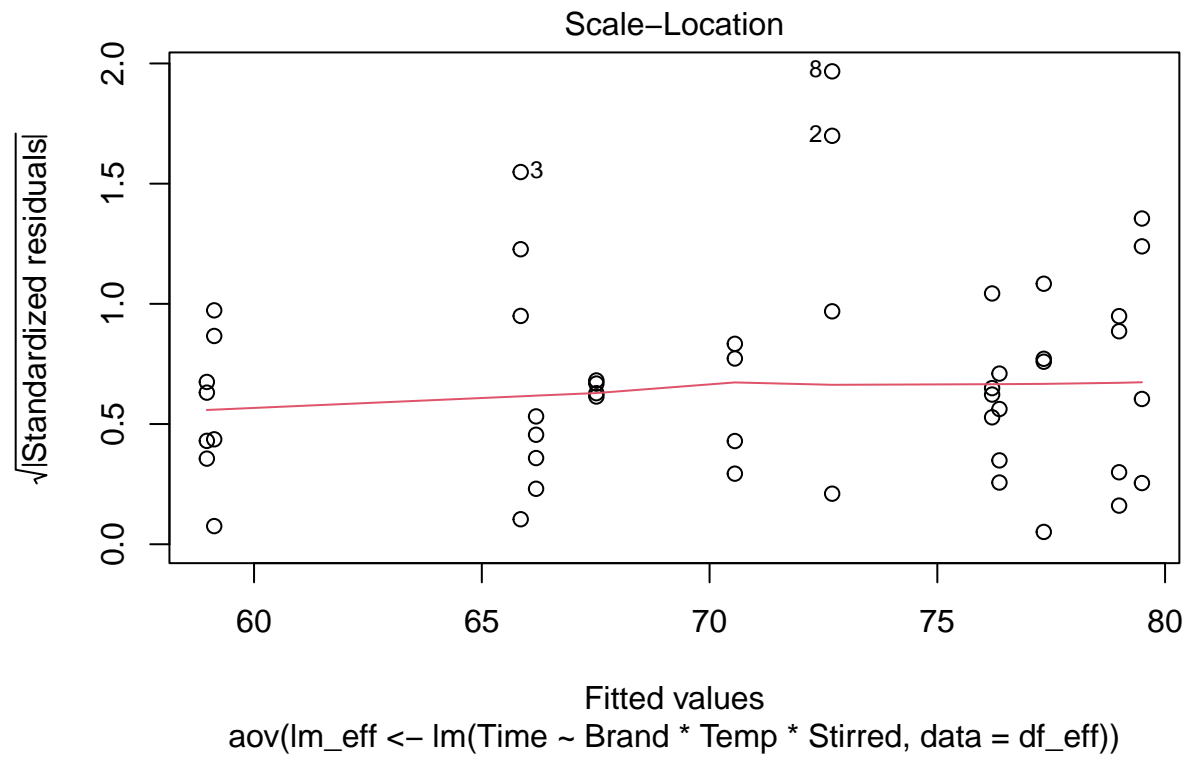
```
summary(aov_eff)
```

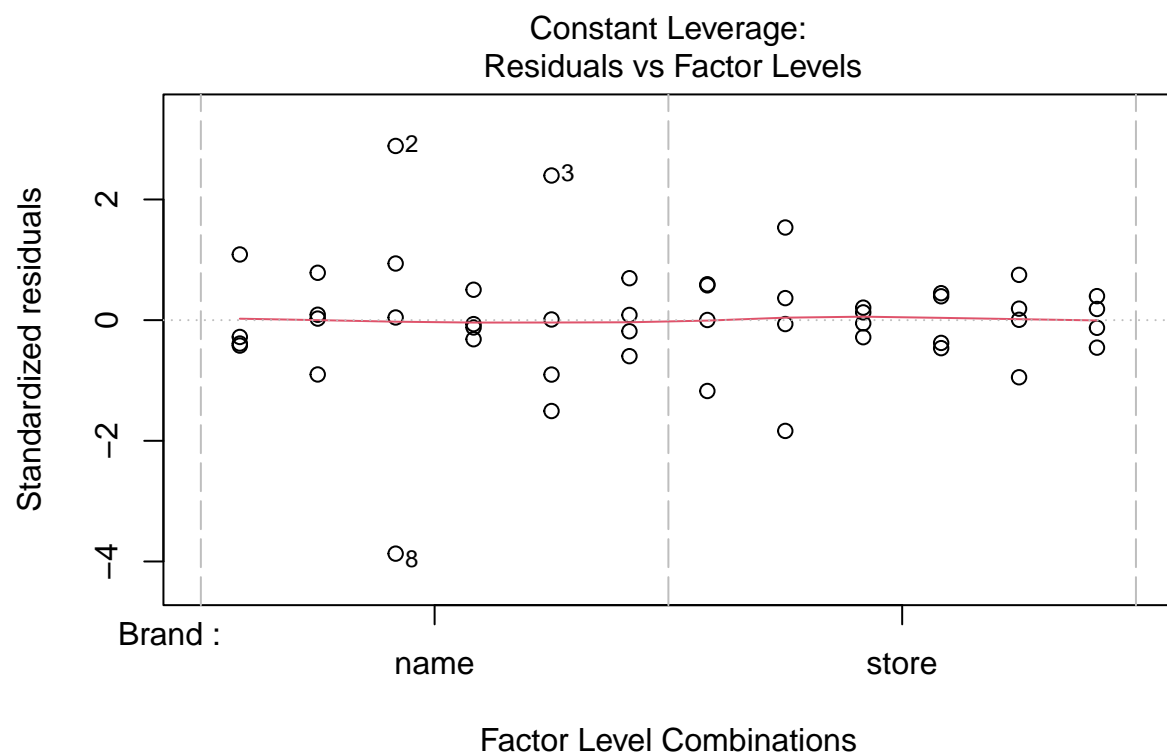
```
##
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Brand      1  342.0   342.0 296.041 < 2e-16 ***
## Temp       2 1654.7   827.4 716.169 < 2e-16 ***
## Stirred    1   69.9    69.9  60.495 3.22e-09 ***
## Brand:Temp  2  231.9   115.9 100.345 1.90e-15 ***
## Brand:Stirred 1   20.5    20.5  17.753 0.000161 ***
## Temp:Stirred 2    0.1     0.1   0.054 0.947535
## Brand:Temp:Stirred 2    9.1     4.5   3.919 0.028838 *
## Residuals  36   41.6     1.2
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
plot(aov_eff)
```









```
#adding Cook's D here  
ols_plot_cooksd_chart(lm_eff)
```

