Disruption Example: Unreplicated four factor design

"Unreplicated" means that there is just a single observation for each treatment combination. Use this type of design with caution, but some analysis can be done.

```
library(car)
library(emmeans)
Disruption <- read.csv("C:/hess/STAT512/RNotes/ExpDesign3/ED3_DisruptionUnreplicated.csv")
#Important: Need to define dayspost as.factors!!!!
Disruption$dayspost<-as.factor(Disruption$dayspost)
#Calculate Ratio and log(Ratio)
Disruption$Ratio = Disruption$BATcpm/Disruption$LHcpm
Disruption$logRatio = log(Disruption$Ratio)
str(Disruption)
```

```
## 'data.frame':    36 obs. of  8 variables:
##  $ agent   : Factor w/ 3 levels "AIB","DEX70",..: 1 1 1 3 3 3 2 2 2 1 ...
##  $ trt     : Factor w/ 2 levels "BD","NS": 2 2 2 2 2 2 2 2 2 1 ...
##  $ route   : Factor w/ 2 levels "IA","IV": 2 2 2 2 2 2 2 2 2 2 ...
##  $ dayspost: Factor w/ 3 levels "8","12","16": 1 2 3 1 2 3 1 2 3 1 ...
##  $ BATcpm  : int  12025 10327 15852 3995 1786 1828 6097 4684 7927 70034 ...
##  $ LHcpm   : int  10510 10345 13255 1285 1077 1731 7997 5721 7120 10611 ...
##  $ Ratio   : num  1.144 0.998 1.196 3.109 1.658 ...
##  $ logRatio: num  0.13466 -0.00174 0.17892 1.13428 0.5058 ...
```

Original Scale: Full Model

```
options(contrasts=c("contr.sum", "contr.poly"))
Model1 <- lm(Ratio ~ agent*trt*route*dayspost, data = Disruption)
#Rmarkdown won't let me run this code because it generates an error.
#Error in Anova.lm(Model1, type = 3) : residual df = 0
#Anova(Model1, type = 3)
anova(Model1)
```

```
## Warning in anova.lm(Model1): ANOVA F-tests on an essentially perfect fit
## are unreliable
```

```
## Analysis of Variance Table
##
## Response: Ratio
##                          Df Sum Sq Mean Sq F value Pr(>F)
## agent                     2   7.27    3.64
## trt                       1 342.62  342.62
## route                     1 116.14  116.14
## dayspost                  2   6.49    3.24
## agent:trt                 2   3.96    1.98
## agent:route               2   0.90    0.45
## trt:route                 1  37.12   37.12
## agent:dayspost            4  23.95    5.99
## trt:dayspost              2   6.72    3.36
## route:dayspost            2  31.84   15.92
## agent:trt:route           2   1.80    0.90
```

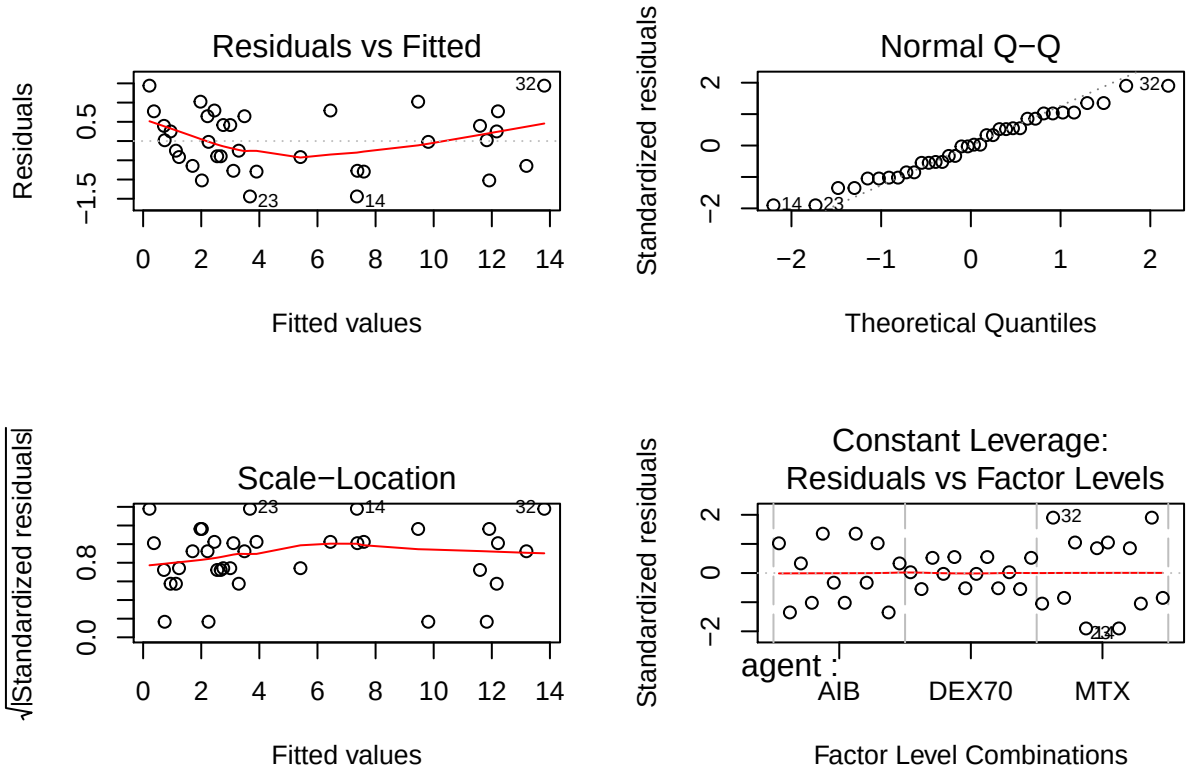
```
## agent:trt:dayspost        4  42.75   10.69
## agent:route:dayspost      4  15.17    3.79
## trt:route:dayspost        2  20.51   10.25
## agent:trt:route:dayspost  4  20.64    5.16
## Residuals                 0   0.00
```

Original Scale: 3way Interactions

```
Model2 <- lm(Ratio ~ (agent + trt + route + dayspost)^3, data = Disruption)
Anova(Model2, type = 3)
```

```
## Anova Table (Type III tests)
##
## Response: Ratio
##                       Sum Sq Df  F value    Pr(>F)
## (Intercept)           967.14  1 187.4469 0.0001649 ***
## agent                   7.27  2   0.7045 0.5468631
## trt                   342.62  1  66.4059 0.0012341 **
## route                 116.14  1  22.5103 0.0090072 **
## dayspost                6.49  2   0.6288 0.5788172
## agent:trt               3.96  2   0.3839 0.7038611
## agent:route             0.90  2   0.0868 0.9185347
## agent:dayspost         23.95  4   1.1602 0.4444689
## trt:route              37.12  1   7.1936 0.0551086 .
## trt:dayspost            6.72  2   0.6512 0.5690768
## route:dayspost         31.84  2   3.0855 0.1546660
## agent:trt:route         1.80  2   0.1746 0.8458709
## agent:trt:dayspost     42.75  4   2.0715 0.2489738
## agent:route:dayspost   15.17  4   0.7350 0.6136458
## trt:route:dayspost     20.51  2   1.9871 0.2516159
## Residuals              20.64  4
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
par(mfrow = c(2,2))
plot(Model2)
```



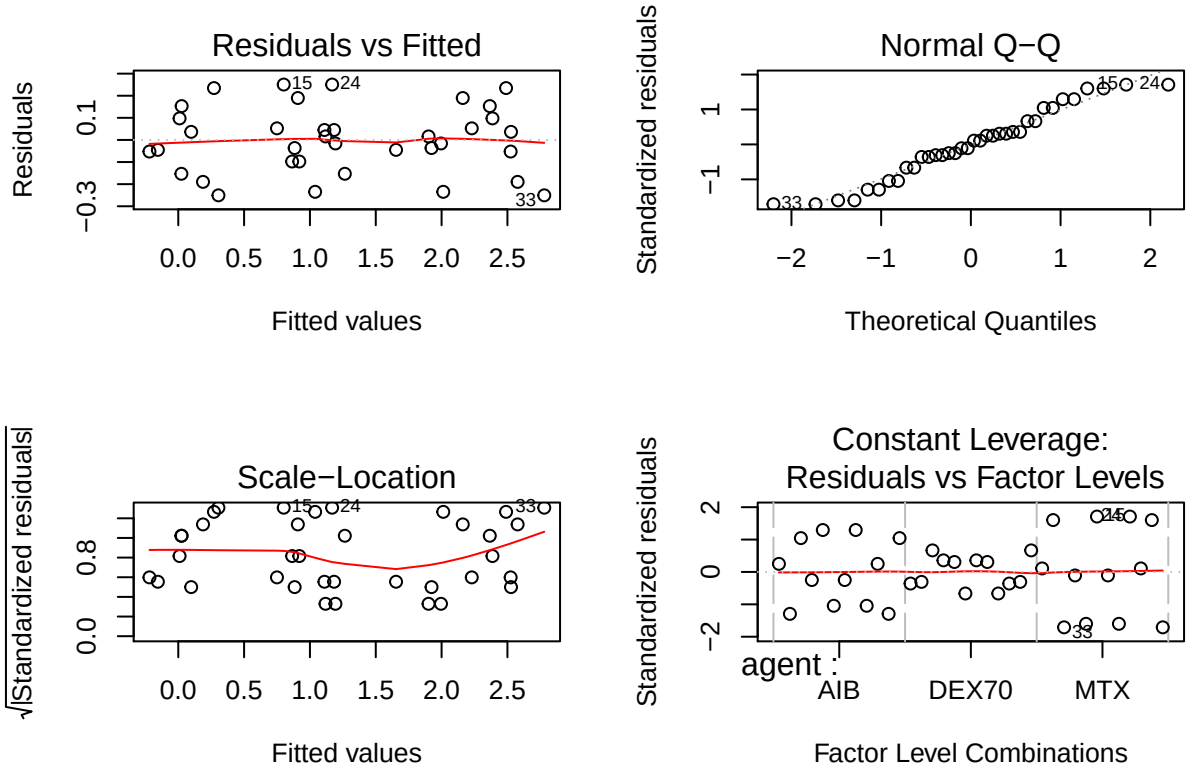
Log Scale: 3way Interactions

```
Model3 <- lm(logRatio ~ (agent + trt + route + dayspost)^3, data = Disruption)
Anova(Model3, type = 3)
```

```
## Anova Table (Type III tests)
##
## Response: logRatio
##                       Sum Sq Df  F value    Pr(>F)
## (Intercept)           56.957  1 294.9571 6.743e-05 ***
## agent                  0.610  2   1.5797 0.3121573
## trt                   15.176  1  78.5888 0.0008942 ***
## route                  6.894  1  35.7025 0.0039420 **
## dayspost               0.685  2   1.7738 0.2808720
## agent:trt              0.103  2   0.2674 0.7780557
## agent:route            0.187  2   0.4832 0.6486843
## agent:dayspost         0.442  4   0.5725 0.6988478
## trt:route              0.005  1   0.0249 0.8822593
## trt:dayspost           0.661  2   1.7117 0.2903497
## route:dayspost         1.734  2   4.4910 0.0949385 .
## agent:trt:route        0.124  2   0.3200 0.7431938
## agent:trt:dayspost     1.530  4   1.9805 0.2621721
## agent:route:dayspost   0.368  4   0.4768 0.7545928
## trt:route:dayspost     0.912  2   2.3602 0.2104047
```

```
## Residuals             0.772  4
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
par(mfrow = c(2,2))
plot(Model3)
```



Log Scale: 2way Interactions

```
Model4 <- lm(logRatio ~ (agent + trt + route + dayspost)^2, data = Disruption)
Anova(Model4, type = 3)
```

```
## Anova Table (Type III tests)
##
## Response: logRatio
##                Sum Sq Df  F value    Pr(>F)
## (Intercept)    56.957  1 245.9332 3.914e-11 ***
## agent           0.610  2   1.3171   0.29544
## trt            15.176  1  65.5268 4.757e-07 ***
## route           6.894  1  29.7685 5.281e-05 ***
## dayspost        0.685  2   1.4790   0.25742
## agent:trt       0.103  2   0.2229   0.80261
## agent:route     0.187  2   0.4029   0.67498
## agent:dayspost  0.442  4   0.4774   0.75189
## trt:route       0.005  1   0.0208   0.88723
```

```
## trt:dayspost    0.661  2   1.4272   0.26895
## route:dayspost  1.734  2   3.7445   0.04635 *
## Residuals       3.706 16
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
emmeans(Model4, pairwise ~ trt)
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
## $emmeans
##  trt    emmean        SE df  lower.CL  upper.CL
##  BD  1.9070975 0.1134302 16 1.6666363 2.1475588
##  NS  0.6085638 0.1134302 16 0.3681026 0.8490251
##
## Results are averaged over the levels of: agent, route, dayspost
## Confidence level used: 0.95
##
## $contrasts
##  contrast estimate        SE df t.ratio p.value
##  BD - NS  1.298534 0.1604145 16   8.095  <.0001
##
## Results are averaged over the levels of: agent, route, dayspost
```

```
emmeans(Model4, pairwise ~ route|dayspost)
```

```
## $emmeans
## dayspost = 8:
##  route    emmean        SE df    lower.CL  upper.CL
##  IA    1.6299939 0.1964668 16  1.21350278 2.0464850
##  IV    1.1910079 0.1964668 16  0.77451681 1.6074990
##
## dayspost = 12:
##  route    emmean        SE df    lower.CL  upper.CL
##  IA    1.6420767 0.1964668 16  1.22558555 2.0585678
##  IV    0.9312684 0.1964668 16  0.51477730 1.3477595
##
## dayspost = 16:
##  route    emmean        SE df    lower.CL  upper.CL
##  IA    1.8142669 0.1964668 16  1.39777576 2.2307580
##  IV    0.3383704 0.1964668 16 -0.07812072 0.7548615
##
## Results are averaged over the levels of: agent, trt
## Confidence level used: 0.95
##
## $contrasts
## dayspost = 8:
##  contrast  estimate        SE df t.ratio p.value
##  IA - IV  0.4389860 0.2778461 16   1.580  0.1337
##
## dayspost = 12:
##  contrast  estimate        SE df t.ratio p.value
##  IA - IV  0.7108083 0.2778461 16   2.558  0.0210
##
## dayspost = 16:
##  contrast  estimate        SE df t.ratio p.value
```

```
##  IA - IV  1.4758965 0.2778461 16   5.312  0.0001
##
## Results are averaged over the levels of: agent, trt
```

```
with(interaction.plot(dayspost, route, logRatio), data = Disruption)
```