HabibaLME

TGoodge

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```
#read in the data
data <- read.csv("C:/Users/thoma/Downloads/Study 2 - Collective Results.xlsx - Score Calculation.csv")

#Data Wrangling

#Change data type of columns to factors to be used for analysis
data$ID <- factor(data$ID)

data$Widget <- factor(data$Widget, levels = c("Radio button", "Dropdown", "Slider"))

data$QuestionnaireType <- factor(data$QuestionnaireType, levels = c("GEQ", "GSQ", "CEGEQ"))


#data$Condition <- factor(data$Condition, levels = c("Radio button_CEGEQ", "Radio button_GEQ", "Radio b

#Add a combinatino column for each of the conditions
data$Condition <- paste(data$Widget, data$QuestionnaireType, sep = "_")
```

```
#Summary of the data for each of the widget conditions
dataWSummary <- data %>%
  group_by(Widget) %>%
  summarise(n = n(),
            meanScore = mean(SCORE),
            sdScore = sd(SCORE))

dataWSummary
```

```
## # A tibble: 3 x 4
##   Widget           n meanScore sdScore
##   <fct>        <int>     <dbl>   <dbl>
## 1 Radio button    30      3.78   1.11
## 2 Dropdown        30      4.11   0.737
## 3 Slider          30      4.01   0.639
```

```
#Summarise data by each of the Questionnaires

dataCondSummary <- data %>%
  group_by(Widget, QuestionnaireType) %>%

  summarise(n = n(),
            meanScore = mean(SCORE),
```

```
            sdScore = sd(SCORE)
  )
```

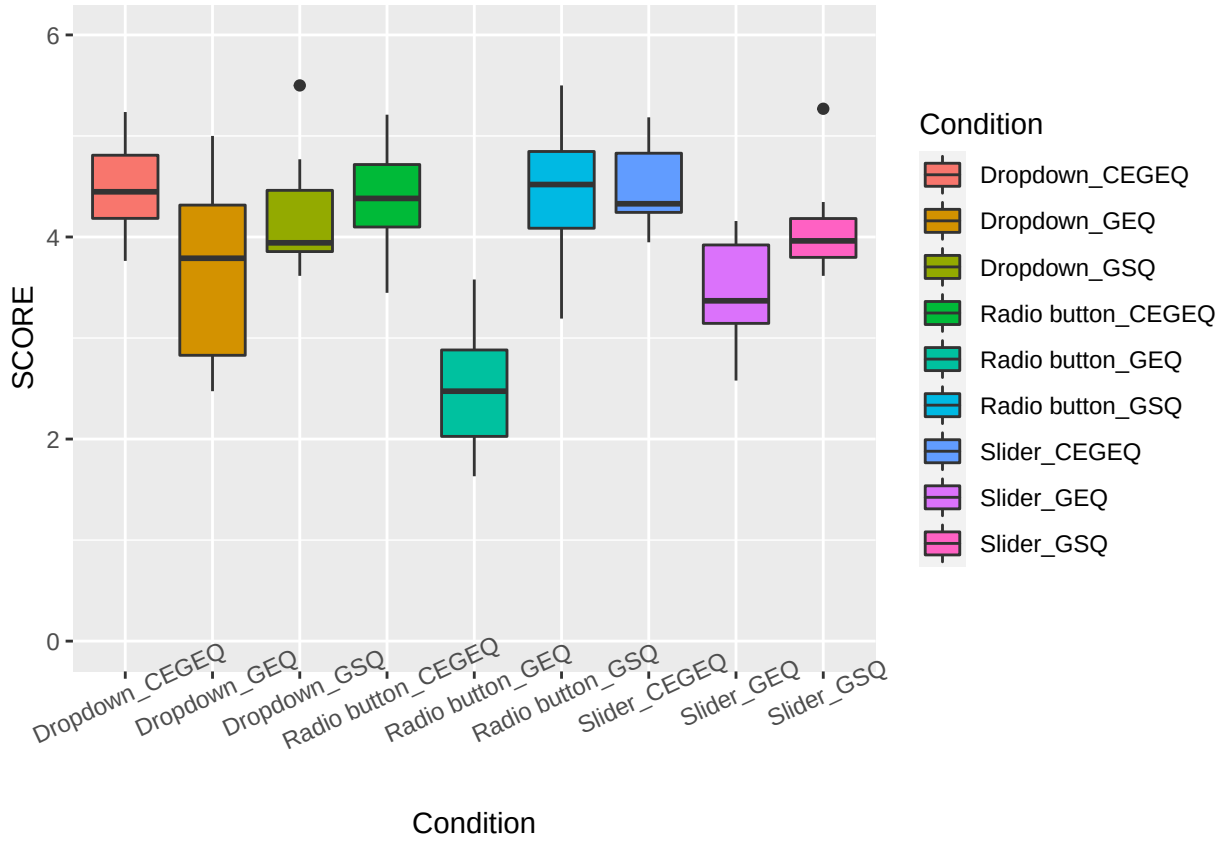
```
## `summarise()` has grouped output by 'Widget'. You can override using the
## `.groups` argument.
```

```
dataCondSummary
```

```
## # A tibble: 9 x 5
## # Groups:   Widget [3]
##   Widget       QuestionnaireType     n meanScore sdScore
##   <fct>        <fct>             <int>     <dbl>   <dbl>
## 1 Radio button GEQ                  10      2.48   0.651
## 2 Radio button GSQ                  10      4.48   0.671
## 3 Radio button CEGEQ                10      4.38   0.540
## 4 Dropdown     GEQ                  10      3.65   0.877
## 5 Dropdown     GSQ                  10      4.20   0.586
## 6 Dropdown     CEGEQ                10      4.47   0.497
## 7 Slider       GEQ                  10      3.45   0.536
## 8 Slider       GSQ                  10      4.08   0.476
## 9 Slider       CEGEQ                10      4.50   0.420
```

```
GEQData <- data %>%
  subset(QuestionnaireType == "GEQ")

dataGEQsummary <- GEQData %>%
  group_by(Widget) %>%
  summarise(GEQ = mean(SCORE))

GSQData <- data %>%
  subset(QuestionnaireType == "GSQ")

dataGSQsummary <- GSQData %>%
  group_by(Widget) %>%
  summarise(GSQ = mean(SCORE))


CEGEQData <- data %>%
  subset(QuestionnaireType == "CEGEQ")

dataCEGEQsummary <- CEGEQData %>%
  group_by(Widget) %>%
  summarise(CEGEQ = mean(SCORE))
```

```
#Plot showing mean score for each of the Widget x Qtype groups

ggplot(data = data, aes(x = Condition, y = SCORE, fill = Condition))+
  geom_boxplot()+
  theme(axis.text.x = element_text(angle = 25))+
  ylim(0,6)
```




```
#Anova looking at interaction between Q type & Widget, + Tukey pairwise comparisons
FullANOVA <- aov(SCORE ~ QuestionnaireType * Widget, data = data,)

summary(FullANOVA)
```

```
##                          Df Sum Sq Mean Sq F value  Pr(>F)
## QuestionnaireType         2 27.639  13.820  38.695 1.6e-12 ***
## Widget                    2  1.669   0.834   2.336 0.10315
## QuestionnaireType:Widget  4  7.057   1.764   4.940 0.00129 **
## Residuals                81 28.929   0.357
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
TukeyHSD(FullANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = SCORE ~ QuestionnaireType * Widget, data = data)
##
## $QuestionnaireType
##                 diff        lwr       upr     p adj
## GSQ-GEQ    1.0664642  0.6980558 1.4348727 0.0000000
## CEGEQ-GEQ  1.2605263  0.8921178 1.6289348 0.0000000
## CEGEQ-GSQ  0.1940621 -0.1743464 0.5624706 0.4231703
```

```
##
## $Widget
##                              diff         lwr       upr     p adj
## Dropdown-Radio button  0.32483131 -0.04357717 0.6932398 0.0951120
## Slider-Radio button    0.22807018 -0.14033831 0.5964787 0.3067651
## Slider-Dropdown       -0.09676113 -0.46516962 0.2716473 0.8057038
##
## $`QuestionnaireType:Widget`
##                                           diff           lwr         upr
## GSQ:Radio button-GEQ:Radio button    2.00566802  1.1538466320  2.85748940
## CEGEQ:Radio button-GEQ:Radio button  1.90526316  1.0534417737  2.75708454
## GEQ:Dropdown-GEQ:Radio button        1.16842105  0.3165996684  2.02024244
## GSQ:Dropdown-GEQ:Radio button        1.72489879  0.8730774012  2.57672017
## CEGEQ:Dropdown-GEQ:Radio button      1.99210526  1.1402838790  2.84392665
## GEQ:Slider-GEQ:Radio button          0.96842105  0.1165996685  1.82024244
## GSQ:Slider-GEQ:Radio button          1.60566802  0.7538466319  2.45748940
## CEGEQ:Slider-GEQ:Radio button        2.02105263  1.1692312473  2.87287402
## CEGEQ:Radio button-GSQ:Radio button -0.10040486 -0.9522262426  0.75141653
## GEQ:Dropdown-GSQ:Radio button       -0.83724696 -1.6890683479  0.01457442
## GSQ:Dropdown-GSQ:Radio button       -0.28076923 -1.1325906151  0.57105215
## CEGEQ:Dropdown-GSQ:Radio button     -0.01356275 -0.8653841373  0.83825863
## GEQ:Slider-GSQ:Radio button         -1.03724696 -1.8890683478 -0.18542558
## GSQ:Slider-GSQ:Radio button         -0.40000000 -1.2518213844  0.45182138
## CEGEQ:Slider-GSQ:Radio button        0.01538462 -0.8364367690  0.86720600
## GEQ:Dropdown-CEGEQ:Radio button     -0.73684211 -1.5886634896  0.11497928
## GSQ:Dropdown-CEGEQ:Radio button     -0.18036437 -1.0321857568  0.67145701
## CEGEQ:Dropdown-CEGEQ:Radio button    0.08684211 -0.7649792790  0.93866349
## GEQ:Slider-CEGEQ:Radio button       -0.93684211 -1.7886634895 -0.08502072
## GSQ:Slider-CEGEQ:Radio button       -0.29959514 -1.1514165261  0.55222624
## CEGEQ:Slider-CEGEQ:Radio button      0.11578947 -0.7360319107  0.96761086
## GSQ:Dropdown-GEQ:Dropdown            0.55647773 -0.2953436515  1.40829912
## CEGEQ:Dropdown-GEQ:Dropdown          0.82368421 -0.0281371737  1.67550559
## GEQ:Slider-GEQ:Dropdown             -0.20000000 -1.0518213842  0.65182138
## GSQ:Slider-GEQ:Dropdown              0.43724696 -0.4145744208  1.28906835
## CEGEQ:Slider-GEQ:Dropdown            0.85263158  0.0008101946  1.70445296
## CEGEQ:Dropdown-GSQ:Dropdown          0.26720648 -0.5846149065  1.11902786
## GEQ:Slider-GSQ:Dropdown             -0.75647773 -1.6082991170  0.09534365
## GSQ:Slider-GSQ:Dropdown             -0.11923077 -0.9710521536  0.73259062
## CEGEQ:Slider-GSQ:Dropdown            0.29615385 -0.5556675382  1.14797523
## GEQ:Slider-CEGEQ:Dropdown           -1.02368421 -1.8755055948 -0.17186283
## GSQ:Slider-CEGEQ:Dropdown           -0.38643725 -1.2382586314  0.46538414
## CEGEQ:Slider-CEGEQ:Dropdown          0.02894737 -0.8228740160  0.88076875
## GSQ:Slider-GEQ:Slider                0.63724696 -0.2145744209  1.48906835
## CEGEQ:Slider-GEQ:Slider              1.05263158  0.2008101945  1.90445296
## CEGEQ:Slider-GSQ:Slider              0.41538462 -0.4364367689  1.26720600
##                                         p adj
## GSQ:Radio button-GEQ:Radio button   0.0000000
## CEGEQ:Radio button-GEQ:Radio button 0.0000000
## GEQ:Dropdown-GEQ:Radio button       0.0011581
## GSQ:Dropdown-GEQ:Radio button       0.0000003
## CEGEQ:Dropdown-GEQ:Radio button     0.0000000
## GEQ:Slider-GEQ:Radio button         0.0141563
## GSQ:Slider-GEQ:Radio button         0.0000018
## CEGEQ:Slider-GEQ:Radio button       0.0000000
```

```
## CEGEQ:Radio button-GSQ:Radio button 0.9999876
## GEQ:Dropdown-GSQ:Radio button       0.0578307
## GSQ:Dropdown-GSQ:Radio button       0.9793753
## CEGEQ:Dropdown-GSQ:Radio button     1.0000000
## GEQ:Slider-GSQ:Radio button         0.0062472
## GSQ:Slider-GSQ:Radio button         0.8539014
## CEGEQ:Slider-GSQ:Radio button       1.0000000
## GEQ:Dropdown-CEGEQ:Radio button     0.1449119
## GSQ:Dropdown-CEGEQ:Radio button     0.9989734
## CEGEQ:Dropdown-CEGEQ:Radio button   0.9999960
## GEQ:Slider-CEGEQ:Radio button       0.0202503
## GSQ:Slider-CEGEQ:Radio button       0.9693449
## CEGEQ:Slider-CEGEQ:Radio button     0.9999626
## GSQ:Dropdown-GEQ:Dropdown           0.4925323
## CEGEQ:Dropdown-GEQ:Dropdown         0.0660411
## GEQ:Slider-GEQ:Dropdown             0.9978540
## GSQ:Slider-GEQ:Dropdown             0.7821381
## CEGEQ:Slider-GEQ:Dropdown           0.0495930
## CEGEQ:Dropdown-GSQ:Dropdown         0.9848959
## GEQ:Slider-GSQ:Dropdown             0.1225572
## GSQ:Slider-GSQ:Dropdown             0.9999532
## CEGEQ:Slider-GSQ:Dropdown           0.9714029
## GEQ:Slider-CEGEQ:Dropdown           0.0073687
## GSQ:Slider-CEGEQ:Dropdown           0.8762702
## CEGEQ:Slider-CEGEQ:Dropdown         1.0000000
## GSQ:Slider-GEQ:Slider               0.3066628
## CEGEQ:Slider-GEQ:Slider             0.0051688
## CEGEQ:Slider-GSQ:Slider             0.8260172
```

```
pairwise.t.test(data$SCORE, data$Condition, p.adjust.method="holm")
```

```
##
##  Pairwise comparisons using t tests with pooled SD
##
## data:  data$SCORE and data$Condition
##
##                    Dropdown_CEGEQ Dropdown_GEQ Dropdown_GSQ Radio button_CEGEQ
## Dropdown_GEQ       0.0618         -            -            -
## Dropdown_GSQ       1.0000         0.7288       -            -
## Radio button_CEGEQ 1.0000         0.1441       1.0000       -
## Radio button_GEQ   3.0e-09        0.0011       2.4e-07      1.3e-08
## Radio button_GSQ   1.0000         0.0555       1.0000       1.0000
## Slider_CEGEQ       1.0000         0.0485       1.0000       1.0000
## Slider_GEQ         0.0068         1.0000       0.1230       0.0187
## Slider_GSQ         1.0000         1.0000       1.0000       1.0000
##                    Radio button_GEQ Radio button_GSQ Slider_CEGEQ Slider_GEQ
## Dropdown_GEQ       -                -                -            -
## Dropdown_GSQ       -                -                -            -
## Radio button_CEGEQ -                -                -            -
## Radio button_GEQ   -                -                -            -
## Radio button_GSQ   2.5e-09          -                -            -
## Slider_CEGEQ       2.0e-09          1.0000           -            -
## Slider_GEQ         0.0132           0.0059           0.0050       -
## Slider_GSQ         1.6e-06          1.0000           1.0000       0.3695
```

```
##
## P value adjustment method: holm
```

```
#ANOVA for scores in the GEQ

GEQANOVA <- aov(SCORE ~  Widget, data = GEQData)
summary(GEQANOVA)
```

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## Widget       2   7.81   3.905   7.914 0.00197 **
## Residuals   27  13.32   0.493
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(GEQANOVA)
```

```
##             Df Sum Sq Mean Sq F value  Pr(>F)
## Widget       2   7.81   3.905   7.914 0.00197 **
## Residuals   27  13.32   0.493
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#ANOVA for scores in the GSQ
GSQANOVA <- aov(SCORE ~  Widget, data = GSQData,)

summary(GSQANOVA)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Widget       2  0.843  0.4217   1.242  0.305
## Residuals   27  9.172  0.3397
```

```
TukeyHSD(GSQANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = SCORE ~ Widget, data = GSQData)
##
## $Widget
##                              diff        lwr       upr     p adj
## Dropdown-Radio button -0.2807692 -0.9270315 0.3654931 0.5360564
## Slider-Radio button   -0.4000000 -1.0462623 0.2462623 0.2910947
## Slider-Dropdown       -0.1192308 -0.7654931 0.5270315 0.8915267
```

```
#ANOVA for scores in the CEGEQ
CEGEQANOVA <- aov(SCORE ~  Widget, data = CEGEQData,)

summary(CEGEQANOVA)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Widget       2  0.073 0.03631   0.152  0.859
## Residuals   27  6.434 0.23831
```

```
TukeyHSD(CEGEQANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = SCORE ~ Widget, data = CEGEQData)
##
## $Widget
##                               diff        lwr       upr     p adj
## Dropdown-Radio button 0.08684211 -0.4544572 0.6281414 0.9167463
## Slider-Radio button   0.11578947 -0.4255098 0.6570888 0.8571813
## Slider-Dropdown       0.02894737 -0.5123519 0.5702467 0.9903578
```

##LMERs##

First models are including Questionnaire and Widget as main effects. This one isn;t report in the results section of the paper as this one is comparing across questionnaire type which may not make sense. Any Widget comparisons are between subjects and so it is not nested data. (Unless we include order they completed the questionnaires in or something). It's included here for completeness but I don't think it makes sense to report this analysis

```
#NUll Model with ID as a random effect
NullModel <- lmer(data = data, formula = SCORE ~ 0 + (1|ID),REML = FALSE)
#summary(NullModel)
#(NullModel)
```

```
#GEQ
#Main effects model of QType & Widget with ID as random factor
#Refactor Qtype for comparisons
data$QuestionnaireType <- factor(data$QuestionnaireType, levels = c("GSQ", "GEQ", "CEGEQ"))
data$Widget <- factor(data$Widget, levels = c("Radio button", "Dropdown", "Slider"))
print("Model comparing effect of Questionnaire Type on Score, with Widget as a random factor")
```

```
## [1] "Model comparing effect of Questionnaire Type on Score, with Widget as a random factor"
```

```
QMainModel = lmer(data = data, formula = SCORE ~  QuestionnaireType  + (1|ID) + (1|Widget), REML = FALSE
summary(QMainModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: SCORE ~ QuestionnaireType + (1 | ID) + (1 | Widget)
##    Data: data
##
##      AIC      BIC   logLik deviance df.resid
##    171.4    186.4    -79.7    159.4       84
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.19199 -0.57103 -0.00857  0.49270  2.24040
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
```

```
##  ID       (Intercept) 0.1909   0.4369
##  Widget   (Intercept) 0.0147   0.1213
##  Residual             0.2174   0.4662
## Number of obs: 90, groups:  ID, 30; Widget, 3
##
## Fixed effects:
##                        Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)              4.2577     0.1360 15.2621  31.296  2.9e-15 ***
## QuestionnaireTypeGEQ    -1.0665     0.1204 57.6120  -8.859  2.4e-12 ***
## QuestionnaireTypeCEGEQ   0.1941     0.1204 57.6120   1.612    0.112
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) QsTGEQ
## QstnnrTyGEQ -0.442
## QstnnTCEGEQ -0.442  0.500
```

```
print("Model comparing effect of Widget on Score, with Questionnaire Type as a random factor")
```

```
## [1] "Model comparing effect of Widget on Score, with Questionnaire Type as a random factor"
```

```
WMainModel = lmer(data = data, formula = SCORE ~  Widget  + (1|ID) + (1|QuestionnaireType), REML = FALSE
summary(WMainModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: SCORE ~ Widget + (1 | ID) + (1 | QuestionnaireType)
##    Data: data
##
##      AIC      BIC   logLik deviance df.resid
##    179.2    194.2    -83.6    167.2       84
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.09540 -0.59450 -0.05105  0.49527  2.09823
##
## Random effects:
##  Groups            Name        Variance Std.Dev.
##  ID                (Intercept) 0.1962   0.4429
##  QuestionnaireType (Intercept) 0.3060   0.5532
##  Residual                      0.2168   0.4656
## Number of obs: 90, groups:  ID, 30; QuestionnaireType, 3
##
## Fixed effects:
##                Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      3.7826     0.3403  3.6790  11.117 0.000579 ***
## WidgetDropdown   0.3248     0.1202 57.9560   2.702 0.009023 **
## WidgetSlider     0.2281     0.1202 57.9560   1.897 0.062790 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```

```
##             (Intr) WdgtDr
## WidgtDrpdwn -0.177
## WidgetSlidr -0.177  0.500
```

```
anova(QMainModel, WMainModel)
```

```
## Data: data
## Models:
## QMainModel: SCORE ~ QuestionnaireType + (1 | ID) + (1 | Widget)
## WMainModel: SCORE ~ Widget + (1 | ID) + (1 | QuestionnaireType)
##            npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## QMainModel    6 171.43 186.42 -79.713   159.43
## WMainModel    6 179.24 194.23 -83.617   167.24     0  0
```

```
#GEQMainModel = lmer(data = GEQData, formula = SCORE ~  Widget  + (1|ID), REML = FALSE)
```

```
#Model looking at the main effects of Questionnaire Type and Widget on Score, with ID as a random effec
print("Intercept is Radio button - GSQ")
```

```
## [1] "Intercept is Radio button - GSQ"
```

```
data$QuestionnaireType <- factor(data$QuestionnaireType, levels = c("GSQ", "GEQ", "CEGEQ"))
data$Widget <- factor(data$Widget, levels = c("Radio button", "Dropdown", "Slider"))
MainModel = lmer(data = data, formula = SCORE ~  QuestionnaireType + Widget + (1|ID), REML = FALSE)

#Change factoring to get all comparisons")
print("Intercept is Slider - GEQ")
```

```
## [1] "Intercept is Slider - GEQ"
```

```
data$QuestionnaireType <- factor(data$QuestionnaireType, levels = c("GEQ", "GSQ", "CEGEQ"))
data$Widget <- factor(data$Widget, levels = c("Slider", "Radio button", "Dropdown"))

MainModel2 = lmer(data = data, formula = SCORE ~  QuestionnaireType + Widget + (1|ID), REML = FALSE)
summary(MainModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: SCORE ~ QuestionnaireType + Widget + (1 | ID)
##    Data: data
##
##      AIC      BIC   logLik deviance df.resid
##    168.2    185.7    -77.1    154.2       83
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.09147 -0.61153 -0.06993  0.53024  2.17309
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
```

```
##  ID       (Intercept) 0.1904   0.4363
##  Residual             0.2095   0.4577
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                         Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)               4.0734     0.1341 81.8283  30.376  < 2e-16 ***
## QuestionnaireTypeGEQ     -1.0665     0.1182 60.0000  -9.025 8.97e-13 ***
## QuestionnaireTypeCEGEQ    0.1941     0.1182 60.0000   1.642  0.10578
## WidgetDropdown            0.3248     0.1182 60.0000   2.749  0.00789 **
## WidgetSlider              0.2281     0.1182 60.0000   1.930  0.05834 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) QsTGEQ QTCEGE WdgtDr
## QstnnrTyGEQ -0.441
## QstnnTCEGEQ -0.441  0.500
## WidgtDrpdwn -0.441  0.000  0.000
## WidgetSlidr -0.441  0.000  0.000  0.500
```

```
summary(MainModel2)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: SCORE ~ QuestionnaireType + Widget + (1 | ID)
##    Data: data
##
##      AIC      BIC   logLik deviance df.resid
##    168.2    185.7    -77.1    154.2       83
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.09147 -0.61153 -0.06993  0.53024  2.17309
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.1904   0.4363
##  Residual             0.2095   0.4577
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                         Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)              3.23500    0.13410 81.82830  24.124  < 2e-16 ***
## QuestionnaireTypeGSQ     1.06646    0.11817 60.00000   9.025 8.97e-13 ***
## QuestionnaireTypeCEGEQ   1.26053    0.11817 60.00000  10.667 1.75e-15 ***
## WidgetRadio button      -0.22807    0.11817 60.00000  -1.930   0.0583 .
## WidgetDropdown           0.09676    0.11817 60.00000   0.819   0.4161
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) QsTGSQ QTCEGE WdgtRb
## QstnnrTyGSQ -0.441
```

```
## QstnnTCEGEQ -0.441  0.500
## WidgtRdbttn -0.441  0.000  0.000
## WidgtDrpdwn -0.441  0.000  0.000  0.500
```

```
#lsmeans(MainModel, pairwise ~ QuestionnaireType | Widget)
```

```
#Compare the Null and Main Model
anova(NullModel, MainModel)
```

```
## Data: data
## Models:
## NullModel: SCORE ~ 0 + (1 | ID)
## MainModel: SCORE ~ QuestionnaireType + Widget + (1 | ID)
##           npar    AIC    BIC   logLik deviance  Chisq Df Pr(>Chisq)
## NullModel    2 353.96 358.96 -174.981   349.96
## MainModel    7 168.19 185.69  -77.094   154.19 195.77  5  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

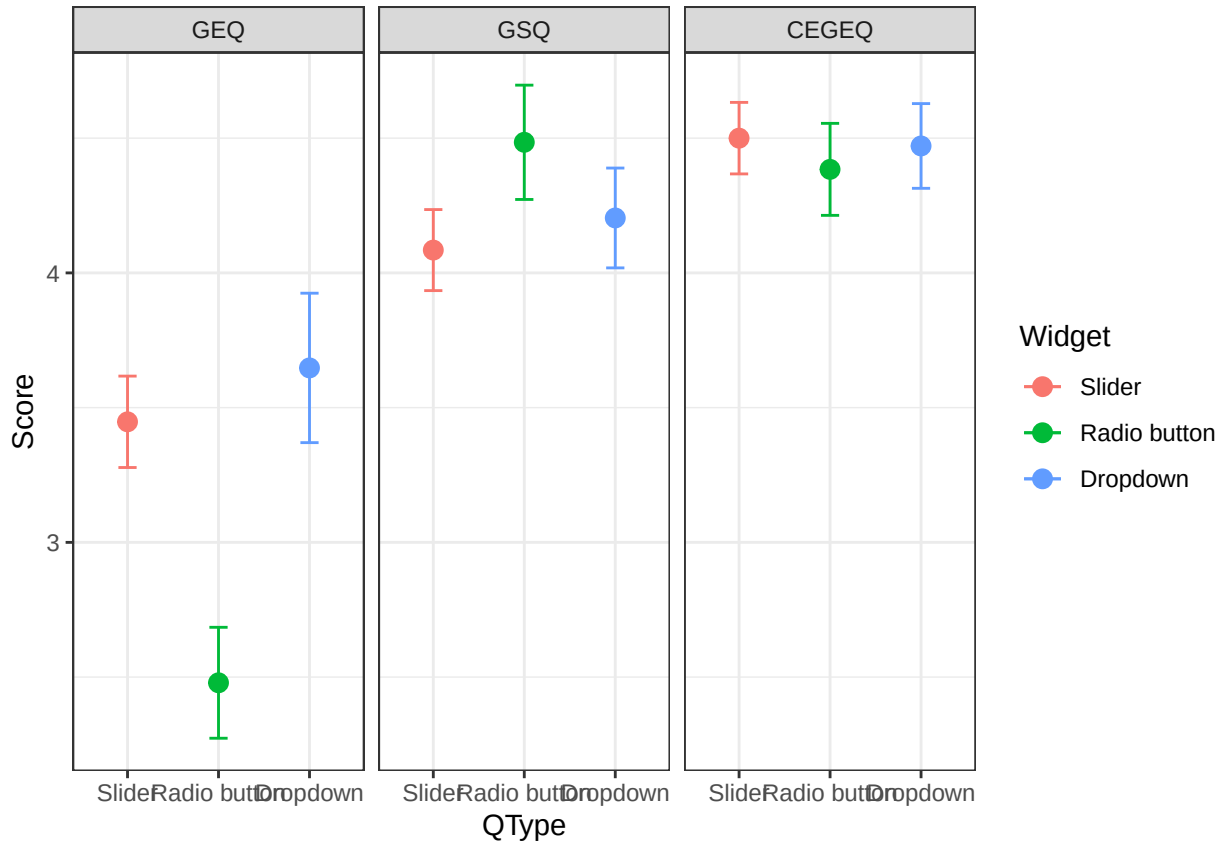
```
IntModel <- lmer(data = data, formula = SCORE ~ QuestionnaireType * Widget + (1|ID), REML = FALSE)
summary(IntModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: SCORE ~ QuestionnaireType * Widget + (1 | ID)
##    Data: data
##
##      AIC      BIC   logLik deviance df.resid
##    155.4    182.9    -66.7    133.4       79
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.08578 -0.60396 -0.04108  0.57457  2.11474
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.1572   0.3965
##  Residual             0.1642   0.4053
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                                          Estimate Std. Error       df t value
## (Intercept)                               3.44737    0.17929 60.87997  19.228
## QuestionnaireTypeGSQ                      0.63725    0.25355 60.87997   2.513
## QuestionnaireTypeCEGEQ                    1.05263    0.25355 60.87997   4.152
## WidgetRadio button                       -0.96842    0.25355 60.87997  -3.819
## WidgetDropdown                            0.20000    0.25355 60.87997   0.789
## QuestionnaireTypeGSQ:WidgetRadio button   1.36842    0.40001 45.96688   3.421
## QuestionnaireTypeCEGEQ:WidgetRadio button  0.85263    0.40001 45.96688   2.132
## QuestionnaireTypeGSQ:WidgetDropdown       -0.08077    0.40001 45.96688  -0.202
## QuestionnaireTypeCEGEQ:WidgetDropdown     -0.22895    0.40001 45.96688  -0.572
##                                          Pr(>|t|)
```

```
## (Intercept)                                  < 2e-16 ***
## QuestionnaireTypeGSQ                        0.014623 *
## QuestionnaireTypeCEGEQ                      0.000104 ***
## WidgetRadio button                          0.000316 ***
## WidgetDropdown                              0.433286
## QuestionnaireTypeGSQ:WidgetRadio button     0.001319 **
## QuestionnaireTypeCEGEQ:WidgetRadio button 0.038426 *
## QuestionnaireTypeGSQ:WidgetDropdown         0.840873
## QuestionnaireTypeCEGEQ:WidgetDropdown       0.569875
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) QsTGSQ QsTCEGEQ WdgtRb WdgtDr QTGSQb QTCEGb QTGSQ:
## QstnnrTyGSQ -0.707
## QstnnTCEGEQ -0.707  0.500
## WidgtRdbttn -0.707  0.745  0.500
## WidgtDrpdwn -0.707  0.500  0.745    0.500
## QstTGSQ:WRb  0.448 -0.789 -0.162   -0.789 -0.162
## QTCEGEQ:WRb  0.667 -0.627 -0.789   -0.789 -0.627  0.500
## QstnTGSQ:WD  0.667 -0.789 -0.627   -0.627 -0.789  0.500  0.692
## QsTCEGEQ:WD  0.448 -0.162 -0.789   -0.162 -0.789 -0.192  0.500  0.500
```

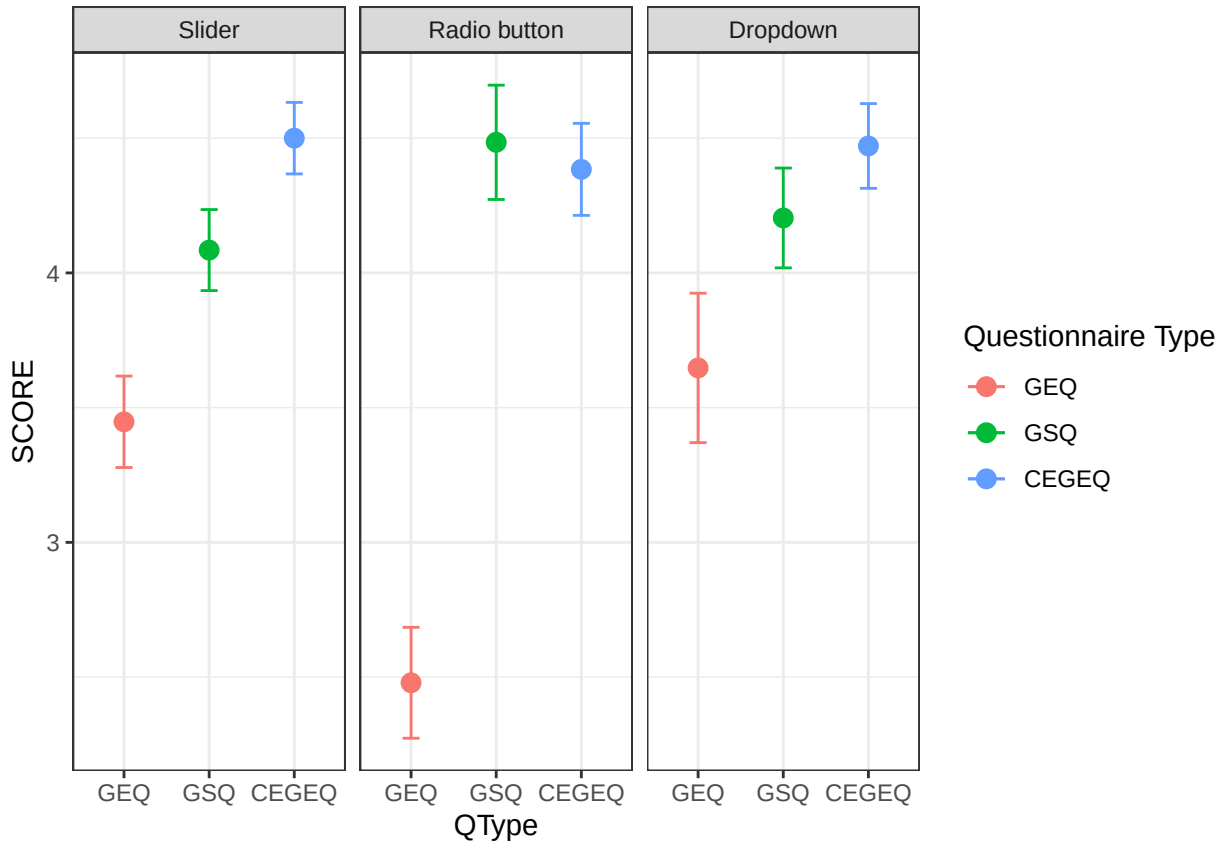
```
#Graph plotting the average Score for each questionnaire and each widget
ggplot(data, aes(x = Widget, y = SCORE, color=Widget)) +
  facet_wrap(~ QuestionnaireType) +
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  stat_summary(aes(y=fitted(IntModel)), fun=mean, geom="line") +
  labs(x="QType", y="Score",
       color="Widget") +
  #ylim(0,5)+
  theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```




```
#Graph plotting the average Score for each widget by each questionnaire (inverse of the graph above)
ggplot(data, aes(x = QuestionnaireType, y = SCORE, color=QuestionnaireType)) +
  facet_wrap(~ Widget) +
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  stat_summary(aes(y=fitted(IntModel)), fun=mean, geom="line") +
  labs(x="QType", y="SCORE",
       color="Questionnaire Type") +
  theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```



##########################UX Data#####################################

It seems this is the data that we can do lmers on, if we compare average ratings for each of the Widgets and include Questionnaire type as a random factor

```
UXdata <- read.csv("C:/Users/thoma/Downloads/Study 2 - Collective Results.xlsx - UX details.csv")

#Data Wrangling

#Change data type to factors for analysis
UXdata$ID <- factor(UXdata$ID)

UXdata$Widget <- factor(UXdata$Widget, levels = (c("Radio Button", "Dropdown", "Slider")))
UXdata$Qtype <- factor(data$QuestionnaireType, levels = c("GEQ", "GSQ", "CEGEQ"))


#Create an identical dataset with different factor levels for comparisons
UXdata2 <- UXdata
UXdata2$Widget <- factor(UXdata2$Widget, levels = c("Dropdown", "Slider", "Radio Button"))
```

```
#Summarise data by Widget
UXdataSummary <- UXdata %>%
  group_by(Widget, Qtype) %>%
  summarise(n = n(),
            FormatSatisfaction = mean(FormatSatisfaction),
            StDevSatisfication =sd(FormatSatisfaction, na.rm = T),
            ClarityInMeaning = mean(ClarityInMeaning),
```

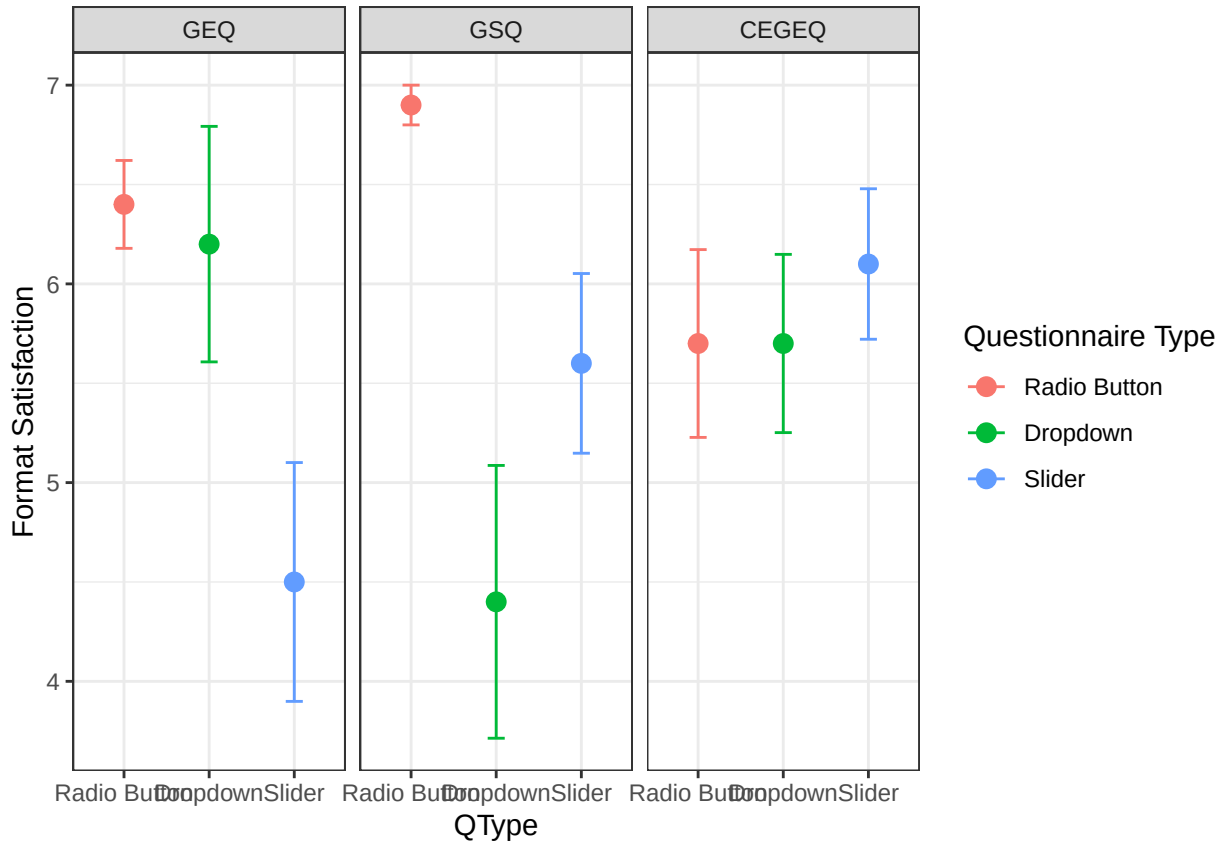
```
            sdClarity = sd(ClarityInMeaning),
            EaseOfSelection = mean(EaseOfSelection),
            sdEase = sd(EaseOfSelection),
            Understanding = mean(Understanding),
            sdUnderstand = sd(Understanding),
            QuickCompletion = mean(QuickCompletion),
            sdComplete = sd(QuickCompletion)


            )
```

```
## `summarise()` has grouped output by 'Widget'. You can override using the
## `.groups` argument.
```

```
UXdataSummary
```

```
## # A tibble: 9 x 13
## # Groups:   Widget [3]
##   Widget       Qtype     n FormatSatisfaction StDevSatisficati~ ClarityInMeaning
##   <fct>        <fct> <int>              <dbl>             <dbl>             <dbl>
## 1 Radio Button GEQ      10                6.4                NA               5.7
## 2 Radio Button GSQ      10                6.9                NA               6.7
## 3 Radio Button CEGEQ    10                5.7                NA               5.5
## 4 Dropdown     GEQ      10                6.2                NA               6.2
## 5 Dropdown     GSQ      10                4.4                NA               5.3
## 6 Dropdown     CEGEQ    10                5.7                NA               6.1
## 7 Slider       GEQ      10                4.5                NA               4.6
## 8 Slider       GSQ      10                5.6                NA               5.3
## 9 Slider       CEGEQ    10                6.1                NA               6.2
## # ... with 7 more variables: sdClarity <dbl>, EaseOfSelection <dbl>,
## #   sdEase <dbl>, Understanding <dbl>, sdUnderstand <dbl>,
## #   QuickCompletion <dbl>, sdComplete <dbl>
```

```
ggplot(UXdata, aes(x = Widget, y = FormatSatisfaction, color=Widget)) +
  facet_wrap(~ Qtype) +
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  labs(x="QType", y="Format Satisfaction",
       color="Questionnaire Type") +
  theme_bw()
```




```
#Null Model
FSNull <- lmer(FormatSatisfaction ~ (1|ID)  + (1|Widget), data = UXdata, REML = FALSE)
#summary(FSNull)

#Model  with ID as a random intercept
FSModel <- lmer(FormatSatisfaction ~ Widget  + (1|ID) , data = UXdata, REML = FALSE)
#Model with ID and Q type as random intercepts
FSModelb <- lmer(FormatSatisfaction ~ Widget  + (1|ID) + (1|Qtype), data = UXdata, REML = FALSE)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
print("ANOVA comparing inclusion of Qtype (Model b)")
```

```
## [1] "ANOVA comparing inclusion of Qtype (Model b)"
```

```
anova(FSModel, FSModelb)
```

```
## Data: UXdata
## Models:
## FSModel: FormatSatisfaction ~ Widget + (1 | ID)
## FSModelb: FormatSatisfaction ~ Widget + (1 | ID) + (1 | Qtype)
##          npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## FSModel     5 335.94 348.44 -162.97   325.94
## FSModelb    6 337.94 352.94 -162.97   325.94     0  1          1
```

```r
#Model with the refactored data set
FSModel2<- lmer(FormatSatisfaction ~ Widget + (1|ID) , data = UXdata2, REML = FALSE)
print("Intercept is Radio Button")
```

```
## [1] "Intercept is Radio Button"
```

```r
summary(FSModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: FormatSatisfaction ~ Widget + (1 | ID)
##    Data: UXdata
##
##      AIC      BIC   logLik deviance df.resid
##    335.9    348.4   -163.0    325.9       85
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.1582 -0.2896  0.2054  0.5658  1.6835
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.8385   0.9157
##  Residual             1.5974   1.2639
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      6.3333     0.2850 72.7573  22.226  < 2e-16 ***
## WidgetDropdown  -0.9000     0.3263 60.0000  -2.758  0.00770 **
## WidgetSlider    -0.9333     0.3263 60.0000  -2.860  0.00582 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtDr
## WidgtDrpdwn -0.573
## WidgetSlidr -0.573  0.500
```

```r
print("Intercept is Dropdown")
```

```
## [1] "Intercept is Dropdown"
```

```r
summary(FSModel2)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: FormatSatisfaction ~ Widget + (1 | ID)
##    Data: UXdata2
##
##      AIC      BIC   logLik deviance df.resid
```

```
##    335.9    348.4   -163.0    325.9       85
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.1582 -0.2896  0.2054  0.5658  1.6835
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.8385   0.9157
##  Residual             1.5974   1.2639
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                     Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)          5.43333    0.28495 72.75735  19.068   <2e-16 ***
## WidgetSlider        -0.03333    0.32633 60.00000  -0.102   0.9190
## WidgetRadio Button   0.90000    0.32633 60.00000   2.758   0.0077 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtSl
## WidgetSlidr -0.573
## WidgtRdBttn -0.573  0.500
```

```
print("ANOVA comparing to null model")
```

```
## [1] "ANOVA comparing to null model"
```

```
anova(FSNull, FSModel)
```

```
## Data: UXdata
## Models:
## FSNull: FormatSatisfaction ~ (1 | ID) + (1 | Widget)
## FSModel: FormatSatisfaction ~ Widget + (1 | ID)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## FSNull     4 340.07 350.07 -166.03   332.07
## FSModel    5 335.94 348.44 -162.97   325.94 6.1316  1    0.01328 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

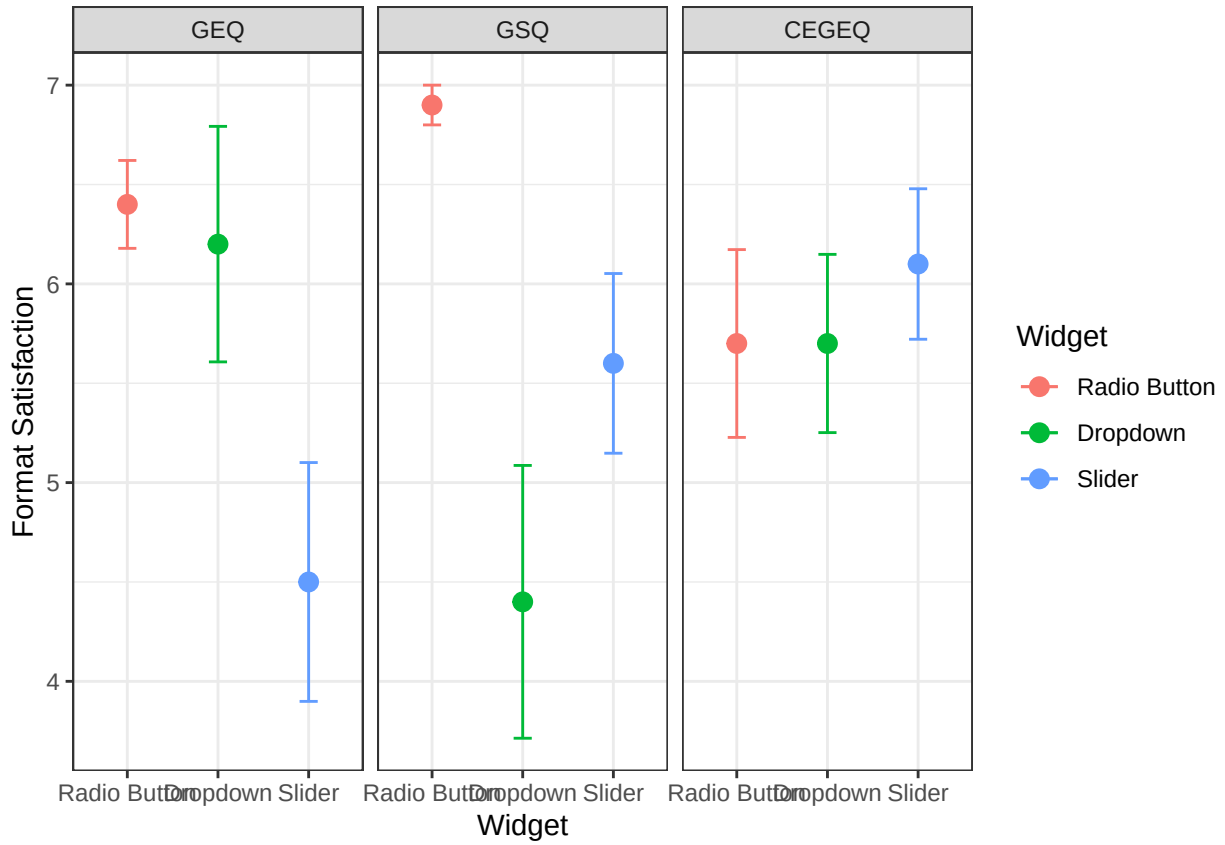
```
FSResults <- report(FSModel, CI = 95)

print(FSResults)
```

```
## We fitted a linear mixed model (estimated using ML and nloptwrap optimizer) to
## predict FormatSatisfaction with Widget (formula: FormatSatisfaction ~ Widget).
## The model included ID as random effect (formula: ~1 | ID). The model's total
## explanatory power is substantial (conditional R2 = 0.39) and the part related
## to the fixed effects alone (marginal R2) is of 0.07. The model's intercept,
## corresponding to Widget = Radio Button, is at 6.33 (95% CI [5.77, 6.90], t(85)
## = 22.23, p < .001). Within this model:
```

```
##
##   - The effect of Widget [Dropdown] is statistically significant and negative
## (beta = -0.90, 95% CI [-1.55, -0.25], t(85) = -2.76, p = 0.007; Std. beta =
## -0.55, 95% CI [-0.95, -0.15])
##   - The effect of Widget [Slider] is statistically significant and negative (beta
## = -0.93, 95% CI [-1.58, -0.28], t(85) = -2.86, p = 0.005; Std. beta = -0.57,
## 95% CI [-0.97, -0.17])
##
## Standardized parameters were obtained by fitting the model on a standardized
## version of the dataset. 95% Confidence Intervals (CIs) and p-values were
## computed using a Wald t-distribution approximation.
```

```
ggplot(UXdata, aes(x = Widget, y = FormatSatisfaction, color=Widget)) +
  facet_wrap(~Qtype)+
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  stat_summary(aes(y=fitted(FSModel)), fun=mean, geom="line") +
  labs(x="Widget", y="Format Satisfaction",
       color="Widget") +
  theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```




```
CMNull <- lmer(ClarityInMeaning ~ (1|ID) + (1|Widget), data = UXdata)
summary(CMNull)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClarityInMeaning ~ (1 | ID) + (1 | Widget)
##    Data: UXdata
##
## REML criterion at convergence: 323.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.02929 -0.08975  0.19359  0.50438  1.36551
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.77816  0.8821
##  Widget   (Intercept) 0.05211  0.2283
##  Residual             1.53678  1.2397
## Number of obs: 90, groups:  ID, 30; Widget, 3
##
## Fixed effects:
##             Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)   5.7333     0.2457 5.5073   23.33 1.02e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
print("Intercept is Radio Button")
```

```
## [1] "Intercept is Radio Button"
```

```
CMModel <- lmer(ClarityInMeaning ~ Widget + (1|ID), data = UXdata)
           lm(ClarityInMeaning ~ Widget, data = UXdata)
```

```
##
## Call:
## lm(formula = ClarityInMeaning ~ Widget, data = UXdata)
##
## Coefficients:
##    (Intercept)  WidgetDropdown    WidgetSlider
##          5.967          -0.100          -0.600
```

```
CMModelb <- lmer(ClarityInMeaning ~ Widget + (1|ID) + (1|Qtype), data = UXdata)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
           lm(ClarityInMeaning ~ Widget, data = UXdata)
```

```
##
## Call:
## lm(formula = ClarityInMeaning ~ Widget, data = UXdata)
##
## Coefficients:
##    (Intercept)  WidgetDropdown    WidgetSlider
##          5.967          -0.100          -0.600
```

```
print("Anova comparing inclusion of Qtype (model b)")
```

```
## [1] "Anova comparing inclusion of Qtype (model b)"
```

```
anova(CMModel, CMModelb)
```

```
## refitting model(s) with ML (instead of REML)
```

```
## Data: UXdata
## Models:
## CMModel: ClarityInMeaning ~ Widget + (1 | ID)
## CMModelb: ClarityInMeaning ~ Widget + (1 | ID) + (1 | Qtype)
##          npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## CMModel     5 328.75 341.25 -159.37   318.75
## CMModelb    6 330.75 345.75 -159.37   318.75     0  1          1
```

```
print("Intercept is Dropdown")
```

```
## [1] "Intercept is Dropdown"
```

```r
CMModel2 <- lmer(ClarityInMeaning ~  Widget + (1|ID) , data = UXdata2)
print("ANOVA comparing the null molde")
```

```
## [1] "ANOVA comparing the null molde"
```

```r
anova(CMNull,  CMModel)
```

```
## refitting model(s) with ML (instead of REML)

## Data: UXdata
## Models:
## CMNull: ClarityInMeaning ~ (1 | ID) + (1 | Widget)
## CMModel: ClarityInMeaning ~ Widget + (1 | ID)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## CMNull     4 330.46 340.46 -161.23   322.46
## CMModel    5 328.75 341.25 -159.37   318.75 3.7143  1    0.05395 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
summary(CMModel)
```

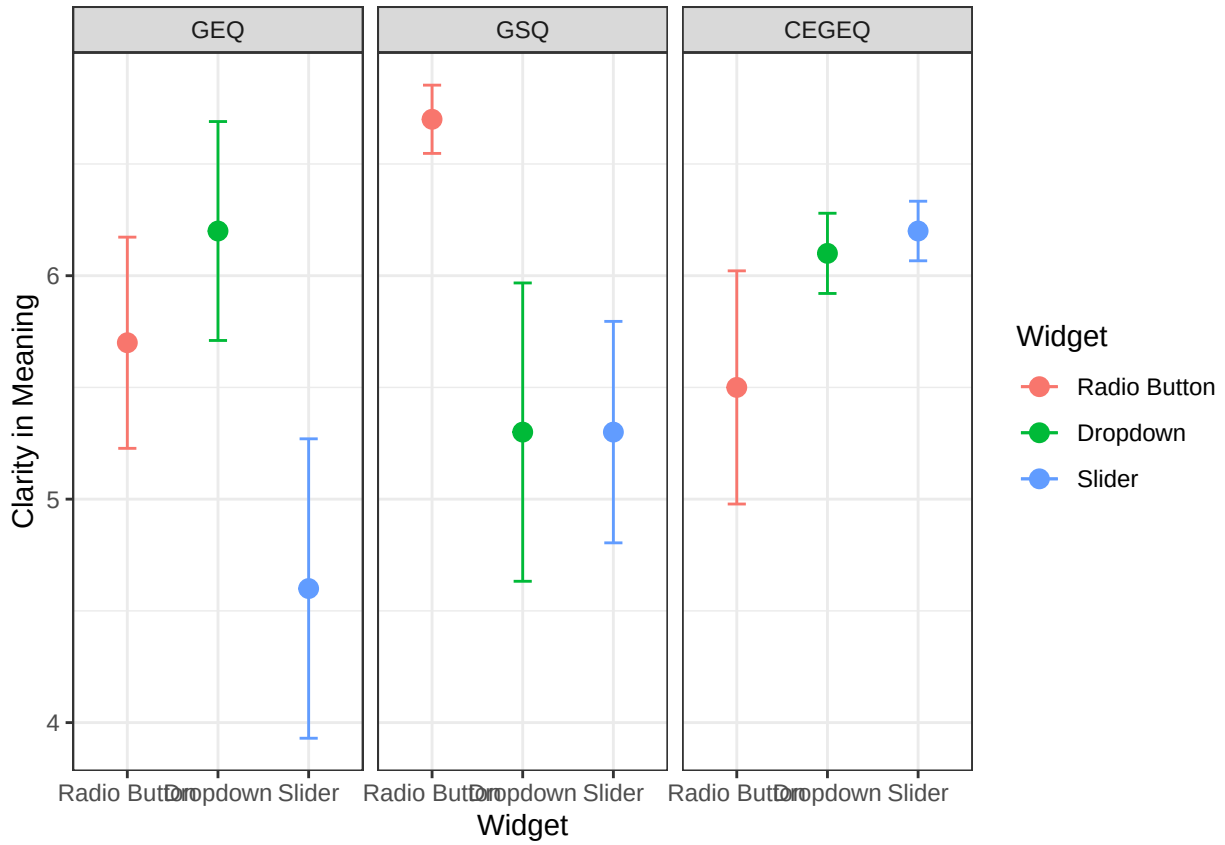
```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClarityInMeaning ~ Widget + (1 | ID)
##    Data: UXdata
##
## REML criterion at convergence: 321.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.0826 -0.1028  0.2174  0.4602  1.5121
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.7782   0.8821
##  Residual             1.5368   1.2397
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      5.9667     0.2778 70.9631  21.479   <2e-16 ***
## WidgetDropdown  -0.1000     0.3201 58.0000  -0.312   0.7558
## WidgetSlider    -0.6000     0.3201 58.0000  -1.875   0.0659 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtDr
## WidgtDrpdwn -0.576
## WidgetSlidr -0.576  0.500
```

```
summary(CMModel2)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClarityInMeaning ~ Widget + (1 | ID)
##    Data: UXdata2
##
## REML criterion at convergence: 321.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.0826 -0.1028  0.2174  0.4602  1.5121
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.7782   0.8821
##  Residual             1.5368   1.2397
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                    Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          5.8667     0.2778 70.9631  21.119   <2e-16 ***
## WidgetSlider        -0.5000     0.3201 58.0000  -1.562    0.124
## WidgetRadio Button   0.1000     0.3201 58.0000   0.312    0.756
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtSl
## WidgetSlidr -0.576
## WidgtRdBttn -0.576  0.500
```

```
ggplot(UXdata, aes(x = Widget, y = ClarityInMeaning, color=Widget)) +
  facet_wrap(~Qtype)+
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  stat_summary(aes(y=fitted(FSModel)), fun=mean, geom="line") +
  labs(x="Widget", y="Clarity in Meaning",
       color="Widget") +
  theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```




```
ESNull <- lmer(EaseOfSelection ~  (1|ID)  + (1|Widget) , data = UXdata, REML = F)
#summary(ESNull)
print("Intercept is Radio Button")
```

```
## [1] "Intercept is Radio Button"
```

```
ESModel <- lmer(EaseOfSelection ~  Widget  + (1|ID) , data = UXdata, REML = F)

ESModelb <- lmer(EaseOfSelection ~  Widget  + (1|ID) + (1|Qtype) , data = UXdata, REML = F)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
print("ANOVA comparing the inclusion of Qtype (model b)")
```

```
## [1] "ANOVA comparing the inclusion of Qtype (model b)"
```

```
anova(ESModelb, ESModel)
```

```
## Data: UXdata
## Models:
## ESModel: EaseOfSelection ~ Widget + (1 | ID)
## ESModelb: EaseOfSelection ~ Widget + (1 | ID) + (1 | Qtype)
##          npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## ESModel     5 335.17 347.67 -162.58   325.17
## ESModelb    6 337.17 352.17 -162.58   325.17     0  1          1
```

```r
print("Intercept is Dropdown")
```

```
## [1] "Intercept is Dropdown"
```

```r
ESModel2 <- lmer(EaseOfSelection ~  Widget + (1|ID) , data = UXdata2, REML = F)
```

```r
print("ANOVA comparing the null model")
```

```
## [1] "ANOVA comparing the null model"
```

```r
anova(ESNull, ESModel)
```

```
## Data: UXdata
## Models:
## ESNull: EaseOfSelection ~ (1 | ID) + (1 | Widget)
## ESModel: EaseOfSelection ~ Widget + (1 | ID)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## ESNull     4 339.39 349.39 -165.70   331.39
## ESModel    5 335.17 347.67 -162.58   325.17 6.2263  1    0.01259 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
summary(ESModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: EaseOfSelection ~ Widget + (1 | ID)
##    Data: UXdata
##
##      AIC      BIC   logLik deviance df.resid
##    335.2    347.7   -162.6    325.2       85
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9032 -0.1344  0.2142  0.5286  1.2570
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.4563   0.6755
##  Residual             1.7974   1.3407
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      6.3333     0.2741 83.1805  23.107  < 2e-16 ***
## WidgetDropdown  -1.1000     0.3462 60.0000  -3.178  0.00235 **
## WidgetSlider    -0.5333     0.3462 60.0000  -1.541  0.12865
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtDr
## WidgtDrpdwn -0.631
## WidgetSlidr -0.631  0.500
```

```
summary(ESModel2)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: EaseOfSelection ~ Widget + (1 | ID)
##    Data: UXdata2
##
##      AIC      BIC   logLik deviance df.resid
##    335.2    347.7   -162.6    325.2       85
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9032 -0.1344  0.2142  0.5286  1.2570
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.4563   0.6755
##  Residual             1.7974   1.3407
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)           5.2333     0.2741 83.1805  19.094  < 2e-16 ***
## WidgetSlider          0.5667     0.3462 60.0000   1.637  0.10686
## WidgetRadio Button    1.1000     0.3462 60.0000   3.178  0.00235 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtSl
## WidgetSlidr -0.631
## WidgtRdBttn -0.631  0.500
```

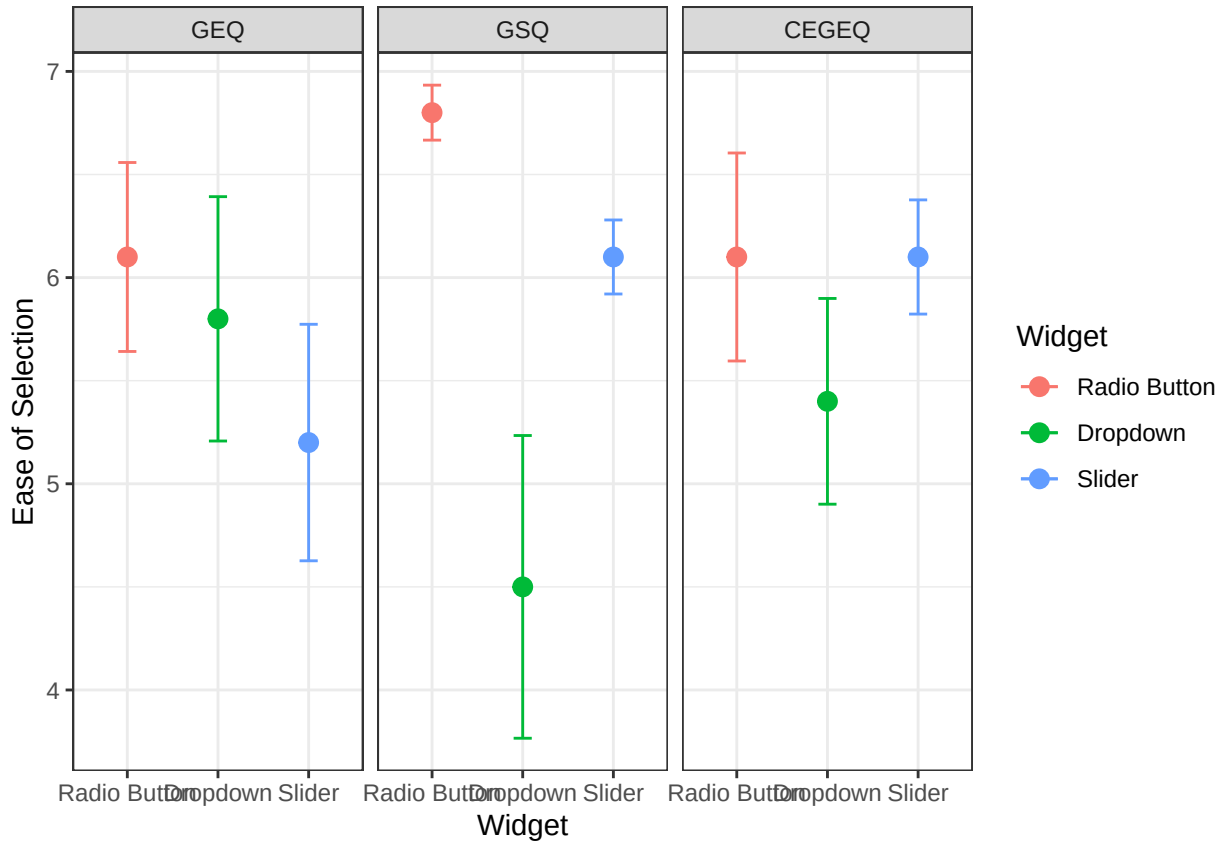
```
ESresults <- report(ESModel, CI = 95)
print(ESresults)
```

```
## We fitted a linear mixed model (estimated using ML and nloptwrap optimizer) to
## predict EaseOfSelection with Widget (formula: EaseOfSelection ~ Widget). The
## model included ID as random effect (formula: ~1 | ID). The model's total
## explanatory power is substantial (conditional R2 = 0.27) and the part related
## to the fixed effects alone (marginal R2) is of 0.08. The model's intercept,
## corresponding to Widget = Radio Button, is at 6.33 (95% CI [5.79, 6.88], t(85)
## = 23.11, p < .001). Within this model:
##
##   - The effect of Widget [Dropdown] is statistically significant and negative
```

```
## (beta = -1.10, 95% CI [-1.79, -0.41], t(85) = -3.18, p = 0.002; Std. beta =
## -0.70, 95% CI [-1.13, -0.26])
##   - The effect of Widget [Slider] is statistically non-significant and negative
## (beta = -0.53, 95% CI [-1.22, 0.15], t(85) = -1.54, p = 0.127; Std. beta =
## -0.34, 95% CI [-0.78, 0.10])
##
## Standardized parameters were obtained by fitting the model on a standardized
## version of the dataset. 95% Confidence Intervals (CIs) and p-values were
## computed using a Wald t-distribution approximation.
```

```
ggplot(UXdata, aes(x = Widget, y = EaseOfSelection, color=Widget)) +
 facet_wrap(~Qtype)+
 stat_summary(fun=mean, geom="point", size=3) +
 stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
 stat_summary(aes(y=fitted(FSModel)), fun=mean, geom="line") +
 labs(x="Widget", y="Ease of Selection",
      color="Widget") +
 theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```



```r
UnNull <- lmer(Understanding ~ 1 +(1|ID), data = UXdata)
#summary(UnNull)
print("Intercept is Radio Button")
```

```
## [1] "Intercept is Radio Button"
```

```r
UnModel <- lmer(Understanding ~1 + Widget + (1|ID), data = UXdata)
UnModelb <- lmer(Understanding ~1 + Widget + (1|ID) + (1|Qtype), data = UXdata)


print("ANOVA comparing the inclusion of Qtype")
```

```
## [1] "ANOVA comparing the inclusion of Qtype"
```

```r
anova(UnModelb, UnModel)
```

```
## refitting model(s) with ML (instead of REML)

## Data: UXdata
## Models:
## UnModel: Understanding ~ 1 + Widget + (1 | ID)
## UnModelb: Understanding ~ 1 + Widget + (1 | ID) + (1 | Qtype)
##          npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## UnModel     5 327.21 339.71 -158.60   317.21
## UnModelb    6 327.93 342.93 -157.97   315.93 1.2803  1     0.2578
```

```r
print("Intercept is Dropdown")
```

```
## [1] "Intercept is Dropdown"
```

```r
UnModel2 <- lmer(Understanding ~1 + Widget + (1|ID), data = UXdata2)

print("ANOVA comparing the null model")
```

```
## [1] "ANOVA comparing the null model"
```

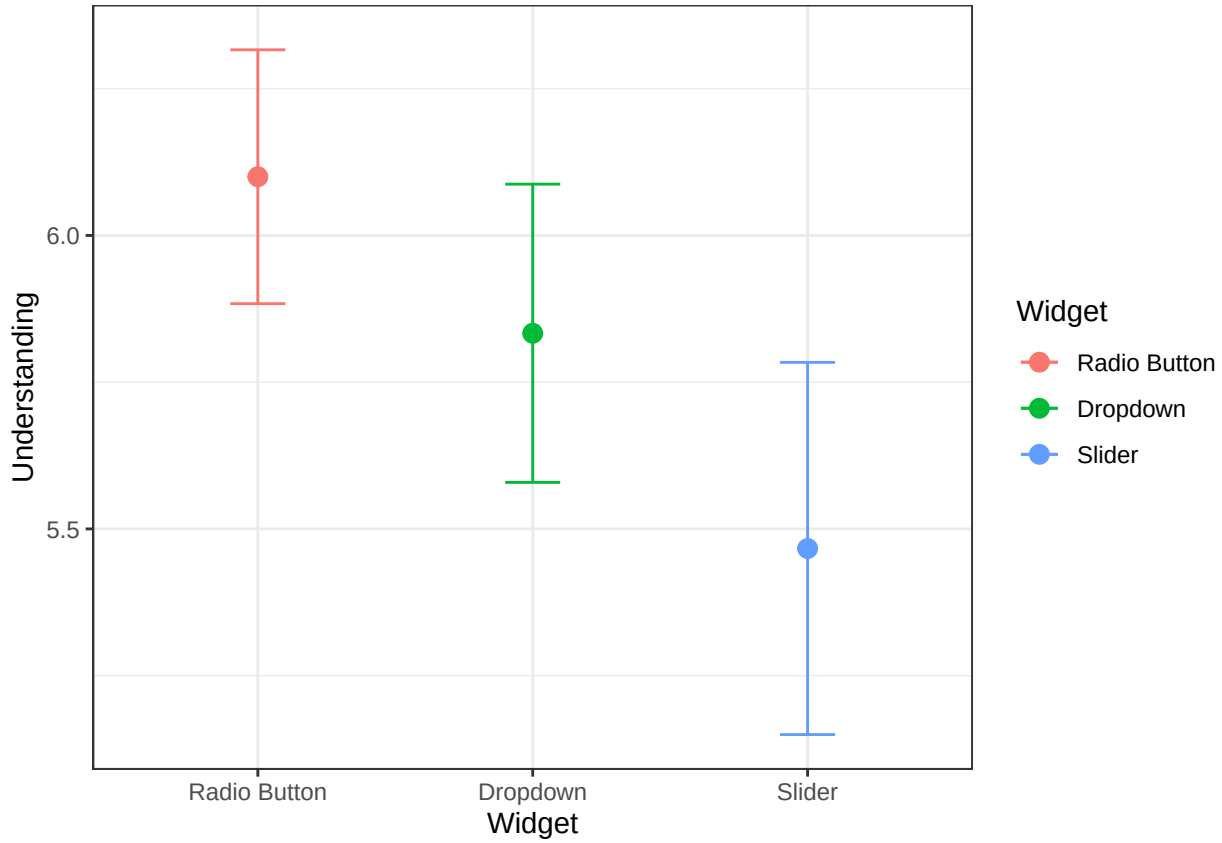
```r
anova(UnNull, UnModel)
```

```
## refitting model(s) with ML (instead of REML)

## Data: UXdata
## Models:
## UnNull: Understanding ~ 1 + (1 | ID)
## UnModel: Understanding ~ 1 + Widget + (1 | ID)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## UnNull     3 326.72 334.22 -160.36   320.72
## UnModel    5 327.21 339.71 -158.60   317.21 3.5134  2     0.1726
```

```
#summary(UnModel)
#summary(UnModel2)
```

```
ggplot(UXdata, aes(x = Widget, y = Understanding, color=Widget)) +
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  stat_summary(aes(y=fitted(FSModel)), fun=mean, geom="line") +
  labs(x="Widget", y="Understanding",
       color="Widget") +
  theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```




```
QCNull <- lmer(QuickCompletion ~  1 +(1|ID), data = UXdata, REML = F)
#summary(QCNull)


print("Intercept is Dropdown")
```

```
## [1] "Intercept is Dropdown"
```

```r
QCModel <- lmer(QuickCompletion ~ 1 + Widget + (1|ID), data = UXdata,REML = F)

QCModelb <- lmer(QuickCompletion ~ 1 + Widget + (1|ID) + (1|Qtype), data = UXdata, REML = F)
```

```
## boundary (singular) fit: see help('isSingular')
```

```r
print("ANOVA comparing inclusiong of Qtype (model b)")
```

```
## [1] "ANOVA comparing inclusiong of Qtype (model b)"
```

```r
anova(QCModelb, QCModel)
```

```
## Data: UXdata
## Models:
## QCModel: QuickCompletion ~ 1 + Widget + (1 | ID)
## QCModelb: QuickCompletion ~ 1 + Widget + (1 | ID) + (1 | Qtype)
##          npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## QCModel     5 328.25 340.75 -159.13   318.25
## QCModelb    6 330.25 345.25 -159.13   318.25     0  1          1
```

```r
print("Intercept is Radio Button")
```

```
## [1] "Intercept is Radio Button"
```

```r
QCModel2 <- lmer(QuickCompletion ~ 1 + Widget + (1|ID), data = UXdata2, REML = F)


print("ANOVA comparing null model")
```

```
## [1] "ANOVA comparing null model"
```

```r
anova(QCNull, QCModel)
```

```
## Data: UXdata
## Models:
## QCNull: QuickCompletion ~ 1 + (1 | ID)
## QCModel: QuickCompletion ~ 1 + Widget + (1 | ID)
##         npar    AIC    BIC  logLik deviance  Chisq Df Pr(>Chisq)
## QCNull     3 335.47 342.97 -164.74   329.47
## QCModel    5 328.25 340.75 -159.13   318.25 11.216  2   0.003669 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
summary(QCModel)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: QuickCompletion ~ 1 + Widget + (1 | ID)
```

```
##    Data: UXdata
##
##      AIC      BIC   logLik deviance df.resid
##    328.3    340.8   -159.1    318.3       85
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.0829 -0.2468  0.1063  0.6094  1.2838
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 1.001    1.000
##  Residual             1.364    1.168
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                Estimate Std. Error       df t value Pr(>|t|)
## (Intercept)     5.96667    0.28076 66.26605  21.252   <2e-16 ***
## WidgetDropdown -0.90000    0.30156 60.00000  -2.984   0.0041 **
## WidgetSlider    0.03333    0.30156 60.00000   0.111   0.9124
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtDr
## WidgtDrpdwn -0.537
## WidgetSlidr -0.537  0.500
```

```
summary(QCModel2)
```

```
## Linear mixed model fit by maximum likelihood . t-tests use Satterthwaite's
##   method [lmerModLmerTest]
## Formula: QuickCompletion ~ 1 + Widget + (1 | ID)
##    Data: UXdata2
##
##      AIC      BIC   logLik deviance df.resid
##    328.3    340.8   -159.1    318.3       85
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.0829 -0.2468  0.1063  0.6094  1.2838
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 1.001    1.000
##  Residual             1.364    1.168
## Number of obs: 90, groups:  ID, 30
##
## Fixed effects:
##                    Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          5.0667     0.2808 66.2661  18.046  < 2e-16 ***
## WidgetSlider         0.9333     0.3016 60.0000   3.095  0.00299 **
## WidgetRadio Button   0.9000     0.3016 60.0000   2.984  0.00410 **
## ---
```

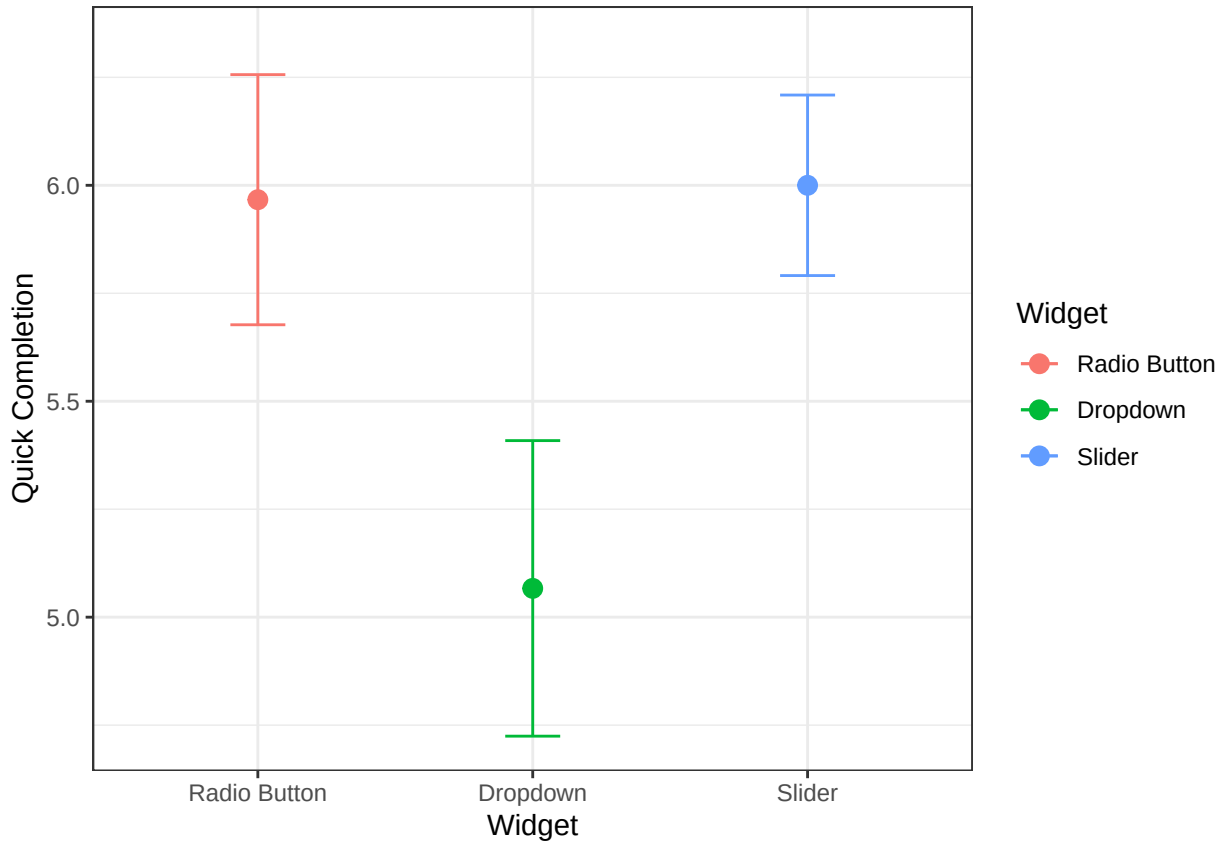
```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtSl
## WidgetSlidr -0.537
## WidgtRdBttn -0.537  0.500
```

```
QCResults <- report(QCModel2, CI = 95)

print(QCResults)
```

```
## We fitted a linear mixed model (estimated using ML and nloptwrap optimizer) to
## predict QuickCompletion with Widget (formula: QuickCompletion ~ 1 + Widget).
## The model included ID as random effect (formula: ~1 | ID). The model's total
## explanatory power is substantial (conditional R2 = 0.47) and the part related
## to the fixed effects alone (marginal R2) is of 0.07. The model's intercept,
## corresponding to Widget = Dropdown, is at 5.07 (95% CI [4.51, 5.62], t(85) =
## 18.05, p < .001). Within this model:
##
##   - The effect of Widget [Slider] is statistically significant and positive (beta
## = 0.93, 95% CI [0.33, 1.53], t(85) = 3.10, p = 0.003; Std. beta = 0.58, 95% CI
## [0.21, 0.95])
##   - The effect of Widget [Radio Button] is statistically significant and positive
## (beta = 0.90, 95% CI [0.30, 1.50], t(85) = 2.98, p = 0.004; Std. beta = 0.56,
## 95% CI [0.19, 0.93])
##
## Standardized parameters were obtained by fitting the model on a standardized
## version of the dataset. 95% Confidence Intervals (CIs) and p-values were
## computed using a Wald t-distribution approximation.
```

```
ggplot(UXdata, aes(x = Widget, y = QuickCompletion, color=Widget)) +
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
  stat_summary(aes(y=fitted(FSModel)), fun=mean, geom="line") +
  labs(x="Widget", y="Quick Completion",
       color="Widget") +
  theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```



##########################Time data##################

```
Timedata <- read.csv("C:/Users/thoma/Downloads/Study 2 - Collective Results.xlsx - Time Consumed.csv")

#Data Wrangling
Timedata$ID <- factor(Timedata$ID)

Timedata$QType <- factor(Timedata$QType, levels = (c("GEQ", "GSQ", "CEGEQ")))

Timedata$Widget <- factor(Timedata$Widget, levels = (c("Radio Button", "Dropdown", "Slider")))

Timedata$Condition <- paste(Timedata$Widget, Timedata$QType, sep = "_")

Timedata <- Timedata%>%
  subset(Timedata$ID != "P6")

Timedata2 <- Timedata
Timedata2$Widget <- factor(Timedata2$Widget, levels = (c("Slider", "Radio Button", "Dropdown")))
```

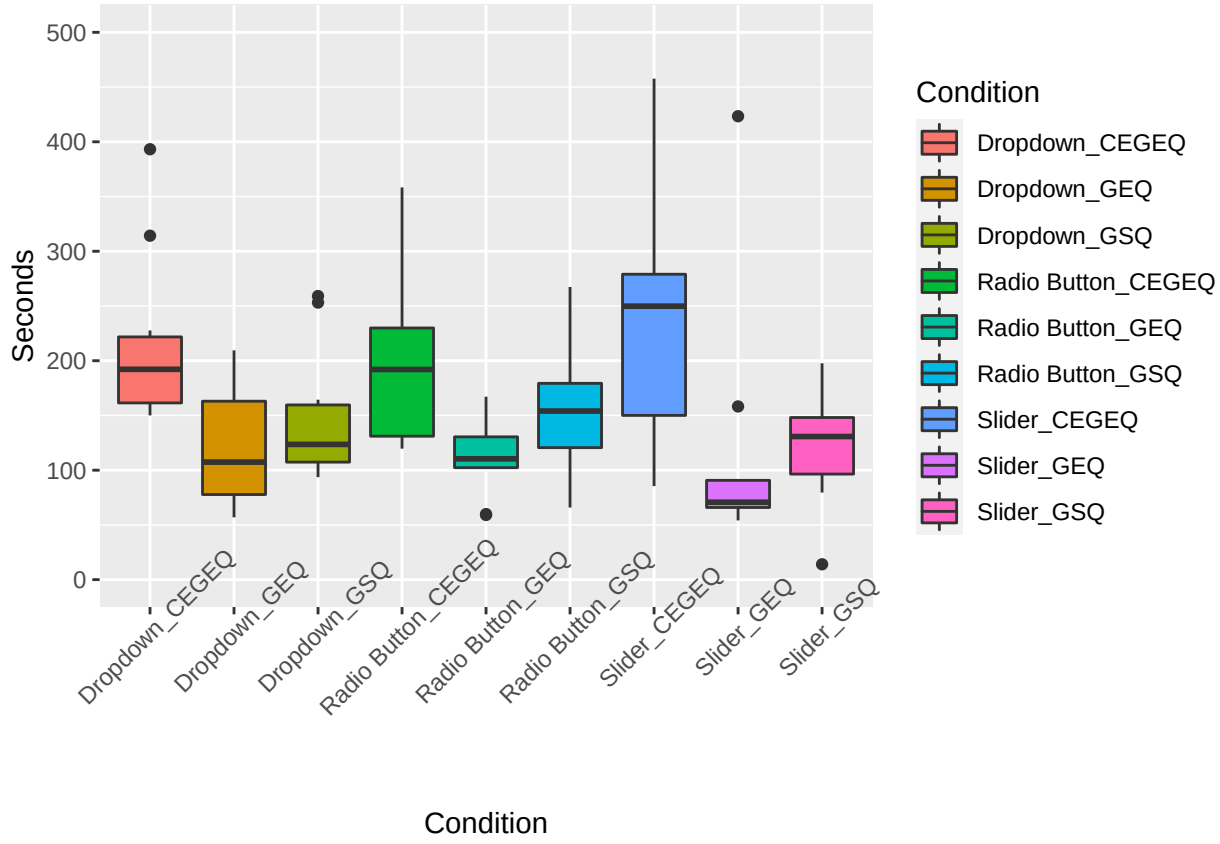
```
TimedataSummary <- Timedata %>%
  group_by(Condition) %>%
  summarise(n = n(),
            meanTime = mean(Seconds),
            sd = sd(Seconds)
            )
```

```
TimedataSummary
```

```
## # A tibble: 9 x 4
##   Condition              n meanTime    sd
##   <chr>              <int>    <dbl> <dbl>
## 1 Dropdown_CEGEQ        10     216.  78.9
## 2 Dropdown_GEQ           9     122.  55.6
## 3 Dropdown_GSQ          10     148.  61.3
## 4 Radio Button_CEGEQ    10     255. 173.
## 5 Radio Button_GEQ      10     110.  33.4
## 6 Radio Button_GSQ       9     153.  58.5
## 7 Slider_CEGEQ           9     234. 111.
## 8 Slider_GEQ            10     115. 112.
## 9 Slider_GSQ            10     122.  52.6
```

```
ggplot(data = Timedata, aes(x = Condition, y = Seconds, fill = Condition))+
 geom_boxplot()+
 theme(axis.text.x = element_text(angle = 45))+
 ylim(0,500)
```

```
## Warning: Removed 1 rows containing non-finite values (stat_boxplot).
```



```
NullTimeModel<- lmer(Seconds ~ (1|ID), data = Timedata)

QTimeModel <- lmer(Seconds ~  QType + (1|ID) + (1|Widget), data = Timedata)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
WTimeModel <- lmer(Seconds ~ Widget + (1|ID) + (1|QType), data = Timedata2)
```

```
summary(QTimeModel)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Seconds ~ QType + (1 | ID) + (1 | Widget)
##    Data: Timedata
##
## REML criterion at convergence: 983.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.9115 -0.4090 -0.0421  0.2436  3.6417
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 4021     63.41
##  Widget   (Intercept)    0      0.00
##  Residual             3966     62.98
## Number of obs: 87, groups:  ID, 29; Widget, 3
##
## Fixed effects:
##             Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)   115.75      16.60  55.74   6.975 3.89e-09 ***
## QTypeGSQ       24.68      16.54  56.00   1.492    0.141
## QTypeCEGEQ    119.15      16.54  56.00   7.204 1.59e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##            (Intr) QTyGSQ
## QTypeGSQ   -0.498
## QTypeCEGEQ -0.498  0.500
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see help('isSingular')
```

```
summary(WTimeModel)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Seconds ~ Widget + (1 | ID) + (1 | QType)
```

```
##    Data: Timedata2
##
## REML criterion at convergence: 991.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.8054 -0.3576 -0.0187  0.2564  3.5340
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 3994     63.20
##  QType    (Intercept) 3795     61.61
##  Residual             4047     63.61
## Number of obs: 87, groups:  ID, 29; QType, 3
##
## Fixed effects:
##                     Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)          157.010     39.275   2.762   3.998   0.0327 *
## WidgetRadio Button    15.420     16.715  54.005   0.923   0.3604
## WidgetDropdown         4.645     16.715  54.005   0.278   0.7821
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtRB
## WidgtRdBttn -0.213
## WidgtDrpdwn -0.213  0.500
```

```
TimeModel <- lmer(Seconds ~  QType + Widget + (1|ID) , data = Timedata)
summary(TimeModel)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Seconds ~ QType + Widget + (1 | ID)
##    Data: Timedata
##
## REML criterion at convergence: 968
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.7939 -0.3728 -0.0090  0.2690  3.4949
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 3994     63.20
##  Residual             4047     63.61
## Number of obs: 87, groups:  ID, 29
##
## Fixed effects:
##                Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)      124.39      19.16  73.61   6.490 8.79e-09 ***
## QTypeGSQ          25.06      16.72  54.00   1.499    0.140
## QTypeCEGEQ       118.99      16.72  54.00   7.119 2.64e-09 ***
## WidgetDropdown   -10.81      16.72  54.00  -0.646    0.521
```

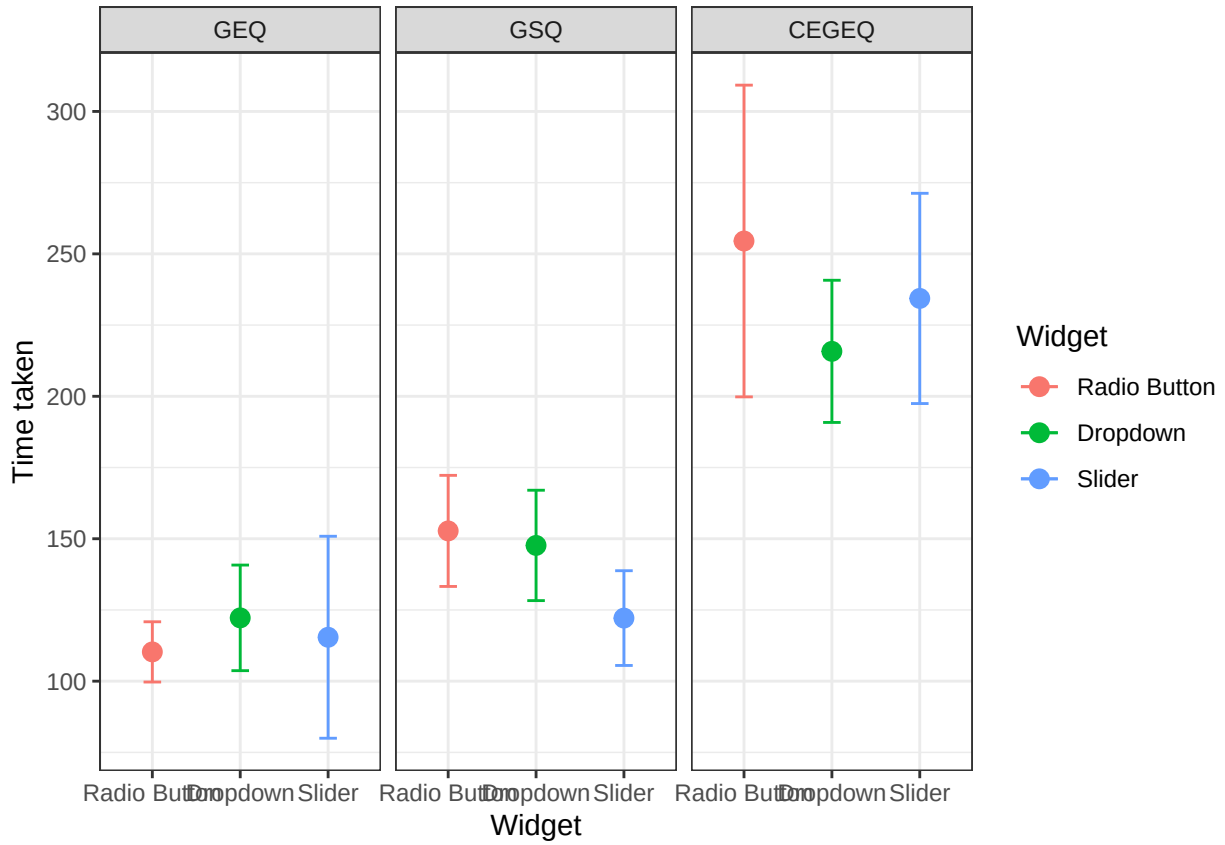
```
## WidgetSlider     -15.30      16.72  54.00  -0.916    0.364
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) QTyGSQ QTCEGE WdgtDr
## QTypeGSQ    -0.421
## QTypeCEGEQ  -0.436  0.500
## WidgtDrpdwn -0.421 -0.034 -0.017
## WidgetSlidr -0.436 -0.017  0.017  0.500
```

```
anova(NullTimeModel, TimeModel)
```

```
## refitting model(s) with ML (instead of REML)

## Data: Timedata
## Models:
## NullTimeModel: Seconds ~ (1 | ID)
## TimeModel: Seconds ~ QType + Widget + (1 | ID)
##               npar    AIC    BIC  logLik deviance Chisq Df Pr(>Chisq)
## NullTimeModel    3 1052.3 1059.7 -523.16   1046.3
## TimeModel        7 1018.2 1035.5 -502.12   1004.2 42.09  4  1.598e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
ggplot(Timedata, aes(x = Widget, y = Seconds, color=Widget)) +
 facet_wrap(~ QType)+
 stat_summary(fun=mean, geom="point", size=3) +
 stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
 stat_summary(aes(y=fitted(QTimeModel)), fun=mean, geom="line") +
 labs(x="Widget", y="Time taken",
      color="Widget") +
 theme_bw()
```

```
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
## geom_path: Each group consists of only one observation. Do you need to adjust
## the group aesthetic?
```




```
GEQTimeData <- Timedata %>%
  subset(QType == "GEQ")

dataGEQTimesummary <- GEQTimeData %>%
  group_by(Widget) %>%
  summarise(GEQ = mean(Seconds))

GSQTimeData <- Timedata %>%
  subset(QType == "GSQ")

dataGSQTimesummary <- GSQTimeData %>%
  group_by(Widget) %>%
  summarise(GSQ = mean(Seconds))


CEGEQTimeData <- Timedata %>%
  subset(QType == "CEGEQ")

dataCEGETimeQsummary <- CEGEQTimeData %>%
  group_by(Widget) %>%
  summarise(CEGEQ = mean(Seconds))
```

```
#Anova looking at interaction between Q type & Widget, + Tukey pairwise comparisons
FullTimeANOVA <- aov(Seconds ~ QType * Widget, data = Timedata,)

summary(FullTimeANOVA)
```

```
##              Df Sum Sq Mean Sq F value   Pr(>F)
## QType         2 229380  114690  13.606 8.53e-06 ***
## Widget        2   3584    1792   0.213    0.809
## QType:Widget  4   9831    2458   0.292    0.883
## Residuals    78 657473    8429
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
TukeyHSD(FullTimeANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Seconds ~ QType * Widget, data = Timedata)
##
## $QType
##                diff       lwr       upr     p adj
## GSQ-GEQ    24.68276 -32.92371  82.28922 0.5642199
## CEGEQ-GEQ 119.14759  61.54112 176.75405 0.0000128
## CEGEQ-GSQ  94.46483  36.85836 152.07129 0.0005528
##
## $Widget
##                              diff       lwr      upr     p adj
## Dropdown-Radio Button -10.792509 -68.39897 46.81396 0.8955966
## Slider-Radio Button   -15.286730 -72.89319 42.31973 0.8018685
## Slider-Dropdown        -4.494221 -62.10069 53.11224 0.9810324
##
## $`QType:Widget`
##                                           diff        lwr        upr     p adj
## GSQ:Radio Button-GEQ:Radio Button     42.472667  -92.11678 177.062109 0.9841608
## CEGEQ:Radio Button-GEQ:Radio Button  144.240000   13.24026 275.239744 0.0200674
## GEQ:Dropdown-GEQ:Radio Button         11.946000 -122.64344 146.535443 0.9999986
## GSQ:Dropdown-GEQ:Radio Button         37.380000  -93.61974 168.379744 0.9917565
## CEGEQ:Dropdown-GEQ:Radio Button      105.504000  -25.49574 236.503744 0.2164933
## GEQ:Slider-GEQ:Radio Button            5.142000 -125.85774 136.141744 1.0000000
## GSQ:Slider-GEQ:Radio Button           11.868000 -119.13174 142.867744 0.9999984
## CEGEQ:Slider-GEQ:Radio Button        124.086000  -10.50344 258.675443 0.0946139
## CEGEQ:Radio Button-GSQ:Radio Button  101.767333  -32.82211 236.356776 0.2921244
## GEQ:Dropdown-GSQ:Radio Button        -30.526667 -168.61252 107.559188 0.9985844
## GSQ:Dropdown-GSQ:Radio Button         -5.092667 -139.68211 129.496776 1.0000000
## CEGEQ:Dropdown-GSQ:Radio Button       63.031333  -71.55811 197.620776 0.8548963
## GEQ:Slider-GSQ:Radio Button          -37.330667 -171.92011  97.258776 0.9931744
## GSQ:Slider-GSQ:Radio Button          -30.604667 -165.19411 103.984776 0.9982695
## CEGEQ:Slider-GSQ:Radio Button         81.613333  -56.47252 219.699188 0.6253909
## GEQ:Dropdown-CEGEQ:Radio Button     -132.294000 -266.88344   2.295443 0.0577822
## GSQ:Dropdown-CEGEQ:Radio Button     -106.860000 -237.85974  24.139744 0.2024787
## CEGEQ:Dropdown-CEGEQ:Radio Button    -38.736000 -169.73574  92.263744 0.9895800
## GEQ:Slider-CEGEQ:Radio Button       -139.098000 -270.09774  -8.098256 0.0289200
## GSQ:Slider-CEGEQ:Radio Button       -132.372000 -263.37174  -1.372256 0.0456850
## CEGEQ:Slider-CEGEQ:Radio Button      -20.154000 -154.74344 114.435443 0.9999207
## GSQ:Dropdown-GEQ:Dropdown             25.434000 -109.15544 160.023443 0.9995470
```

```
## CEGEQ:Dropdown-GEQ:Dropdown           93.558000  -41.03144 228.147443 0.4047991
## GEQ:Slider-GEQ:Dropdown               -6.804000 -141.39344 127.785443 1.0000000
## GSQ:Slider-GEQ:Dropdown               -0.078000 -134.66744 134.511443 1.0000000
## CEGEQ:Slider-GEQ:Dropdown            112.140000  -25.94585 250.225854 0.2073097
## CEGEQ:Dropdown-GSQ:Dropdown           68.124000  -62.87574 199.123744 0.7687955
## GEQ:Slider-GSQ:Dropdown              -32.238000 -163.23774  98.761744 0.9969843
## GSQ:Slider-GSQ:Dropdown              -25.512000 -156.51174 105.487744 0.9994348
## CEGEQ:Slider-GSQ:Dropdown             86.706000  -47.88344 221.295443 0.5106705
## GEQ:Slider-CEGEQ:Dropdown           -100.362000 -231.36174  30.637744 0.2755970
## GSQ:Slider-CEGEQ:Dropdown            -93.636000 -224.63574  37.363744 0.3664721
## CEGEQ:Slider-CEGEQ:Dropdown           18.582000 -116.00744 153.171443 0.9999573
## GSQ:Slider-GEQ:Slider                  6.726000 -124.27374 137.725744 1.0000000
## CEGEQ:Slider-GEQ:Slider              118.944000  -15.64544 253.533443 0.1262716
## CEGEQ:Slider-GSQ:Slider              112.218000  -22.37144 246.807443 0.1796003
```

```
#data$Condition


#pairwise.t.test(data$SCORE, data$Condition, p.adjust.method="holm")
```

```
GEQTimeANOVA <- lm(Seconds ~  Widget, data = GEQTimeData,)

summary(GEQTimeANOVA)
```

```
##
## Call:
## lm(formula = Seconds ~ Widget, data = GEQTimeData)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -65.28 -45.94 -14.82  25.51 307.94
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)     110.274     23.852   4.623 9.09e-05 ***
## WidgetDropdown   11.946     34.656   0.345    0.733
## WidgetSlider      5.142     33.732   0.152    0.880
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 75.43 on 26 degrees of freedom
## Multiple R-squared:  0.004561,   Adjusted R-squared:  -0.07201
## F-statistic: 0.05956 on 2 and 26 DF,  p-value: 0.9423
```

```
TukeyHSD(aov(GEQTimeANOVA))
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = GEQTimeANOVA)
##
## $Widget
```

```
##                           diff       lwr      upr     p adj
## Dropdown-Radio Button 11.946 -74.17044 98.06244 0.9367613
## Slider-Radio Button    5.142 -78.67759 88.96159 0.9872771
## Slider-Dropdown       -6.804 -92.92044 79.31244 0.9789918
```

```
GSQTimeANOVA <- aov(Seconds ~  Widget, data = GSQTimeData,)

summary(GSQTimeANOVA)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Widget       2   5232    2616   0.791  0.464
## Residuals   26  86035    3309
```

```
TukeyHSD(GSQTimeANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Seconds ~ Widget, data = GSQTimeData)
##
## $Widget
##                             diff       lwr      upr     p adj
## Dropdown-Radio Button  -5.092667 -70.76974 60.58441 0.9797569
## Slider-Radio Button   -30.604667 -96.28174 35.07241 0.4882222
## Slider-Dropdown       -25.512000 -89.43737 38.41337 0.5885427
```

```
CEGEQTimeANOVA <- aov(Seconds ~  Widget, data = CEGEQTimeData,)

summary(CEGEQTimeANOVA)
```

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## Widget       2   7506    3753    0.23  0.796
## Residuals   26 423521   16289
```

```
TukeyHSD(CEGEQTimeANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = Seconds ~ Widget, data = CEGEQTimeData)
##
## $Widget
##                           diff       lwr      upr     p adj
## Dropdown-Radio Button -38.736 -180.5678 103.0958 0.7778478
## Slider-Radio Button   -20.154 -165.8723 125.5643 0.9371227
## Slider-Dropdown        18.582 -127.1363 164.3003 0.9462691
```

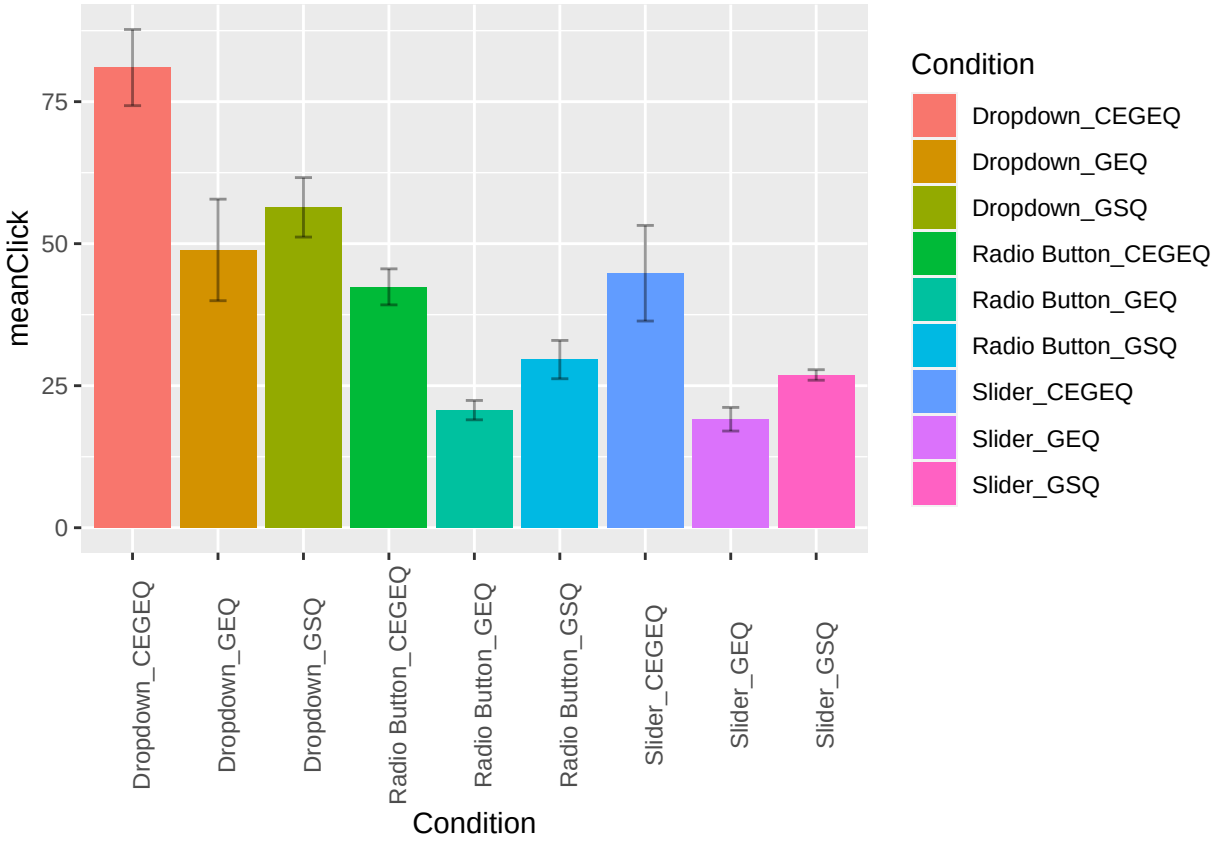
```
ClickData <- read.csv("C:/Users/thoma/Downloads/Study 2 - Collective Results.xlsx - Click Count(1).csv")

#Data Wrangling
```

```r
ClickData$ID <- factor(ClickData$ID)

ClickData$Qtype <- factor(ClickData$Qtype, levels = (c("GEQ", "GSQ", "CEGEQ")))

ClickData$Widget <- factor(ClickData$Widget, levels = (c("Radio Button", "Dropdown", "Slider")))

ClickData$Condition <- paste(ClickData$Widget, ClickData$Qtype, sep = "_")

ClickData2 <- ClickData
ClickData2$Widget <- factor(ClickData2$Widget, levels = (c("Slider", "Radio Button", "Dropdown")))
```

```r
ClickDataSummary <- ClickData %>%
  group_by(Condition) %>%
  summarise(n = n(),
            meanClick = mean(ClickCount, na.rm = T),
            sd = sd(ClickCount, na.rm = T)

            )

ClickDataSummary
```

```
## # A tibble: 9 x 4
##   Condition              n meanClick    sd
##   <chr>              <int>     <dbl> <dbl>
## 1 Dropdown_CEGEQ        10      81   6.70
## 2 Dropdown_GEQ          10      48.9 8.94
## 3 Dropdown_GSQ          10      56.4 5.23
## 4 Radio Button_CEGEQ    10      42.4 3.17
## 5 Radio Button_GEQ      10      20.7 1.70
## 6 Radio Button_GSQ      10      29.6 3.37
## 7 Slider_CEGEQ          10      44.8 8.42
## 8 Slider_GEQ            10      19.1 2.08
## 9 Slider_GSQ            10      26.9 0.928
```

```r
ggplot(data = ClickDataSummary, aes(x = Condition, y = meanClick, fill = Condition))+
  geom_col()+
  geom_errorbar(aes(ymin = meanClick - sd, ymax = meanClick + sd), width = 0.2, alpha = 0.4)+
  theme(axis.text.x = element_text(angle = 90))
```




```
NullClickModel<- lmer(ClickCount ~  (1|ID), data = ClickData)
```

```
## boundary (singular) fit: see help('isSingular')
```

```
QClickModel <- lmer(ClickCount ~  Qtype  + (1|ID) + (1|Widget), data = ClickData)
summary(QClickModel)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClickCount ~ Qtype + (1 | ID) + (1 | Widget)
##    Data: ClickData
##
## REML criterion at convergence: 557.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.6403 -0.5280 -0.0335  0.4165  3.5342
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept)   9.052   3.009
##  Widget   (Intercept) 330.298  18.174
##  Residual              22.740   4.769
## Number of obs: 89, groups:  ID, 30; Widget, 3
##
```

```
## Fixed effects:
##             Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)   29.567     10.543  2.029   2.804    0.105
## QtypeGSQ       8.081      1.245 55.769   6.493 2.41e-08 ***
## QtypeCEGEQ    26.500      1.231 55.321  21.523  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##            (Intr) QtyGSQ
## QtypeGSQ   -0.058
## QtypeCEGEQ -0.058  0.495
```

```
WClickModel <- lmer(ClickCount ~  Widget  + (1|ID) + (1|Qtype), data = ClickData)
summary(WClickModel)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClickCount ~ Widget + (1 | ID) + (1 | Qtype)
##    Data: ClickData
##
## REML criterion at convergence: 556.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.6221 -0.5330 -0.0338  0.3965  3.5370
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept)   9.051   3.009
##  Qtype    (Intercept) 183.730  13.555
##  Residual              22.741   4.769
## Number of obs: 89, groups:  ID, 30; Qtype, 3
##
## Fixed effects:
##                Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)     30.9000     7.8932  2.0527   3.915    0.057 .
## WidgetDropdown  31.2000     1.2313 55.3198  25.340   <2e-16 ***
## WidgetSlider    -0.6194     1.2445 55.7671  -0.498    0.621
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtDr
## WidgtDrpdwn -0.078
## WidgetSlidr -0.077  0.495
```

```
ClickModel <- lmer(ClickCount ~ Widget + Qtype + (1|ID), data = ClickData)

ClickModel2 <- lmer(ClickCount ~ Widget + Qtype + (1|ID), data = ClickData2)

summary(ClickModel)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClickCount ~ Widget + Qtype + (1 | ID)
##    Data: ClickData
##
## REML criterion at convergence: 539.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.6350 -0.5232 -0.0308  0.4063  3.5240
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept)  9.051   3.009
##  Residual             22.741   4.769
## Number of obs: 89, groups:  ID, 30
##
## Fixed effects:
##                Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)      19.373      1.252 83.956  15.468  < 2e-16 ***
## WidgetDropdown   31.200      1.231 55.319  25.340  < 2e-16 ***
## WidgetSlider     -0.620      1.244 55.766  -0.498     0.62
## QtypeGSQ          8.080      1.244 55.766   6.492 2.42e-08 ***
## QtypeCEGEQ       26.500      1.231 55.319  21.522  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtDr WdgtSl QtyGSQ
## WidgtDrpdwn -0.492
## WidgetSlidr -0.493  0.495
## QtypeGSQ    -0.493  0.000  0.021
## QtypeCEGEQ  -0.492  0.000  0.000  0.495
```

```
summary(ClickModel2)
```

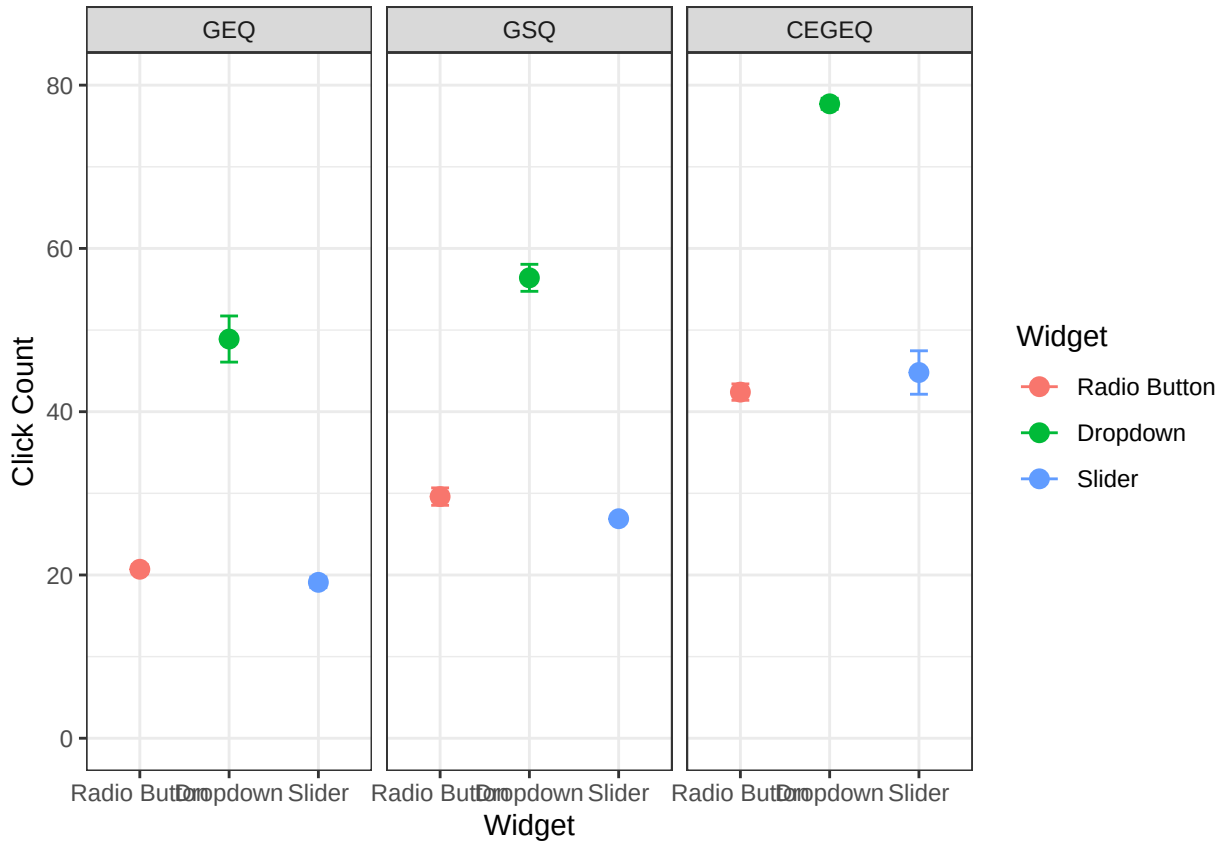
```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ClickCount ~ Widget + Qtype + (1 | ID)
##    Data: ClickData2
##
## REML criterion at convergence: 539.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.6350 -0.5232 -0.0308  0.4063  3.5240
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept)  9.051   3.009
##  Residual             22.741   4.769
## Number of obs: 89, groups:  ID, 30
##
## Fixed effects:
```

```
##                     Estimate Std. Error     df t value Pr(>|t|)
## (Intercept)           18.753      1.257 83.965  14.921  < 2e-16 ***
## WidgetRadio Button     0.620      1.244 55.766   0.498     0.62
## WidgetDropdown        31.820      1.244 55.766  25.568  < 2e-16 ***
## QtypeGSQ               8.080      1.244 55.766   6.492 2.42e-08 ***
## QtypeCEGEQ            26.500      1.231 55.319  21.522  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) WdgtRB WdgtDr QtyGSQ
## WidgtRdBttn -0.499
## WidgtDrpdwn -0.499  0.511
## QtypeGSQ    -0.471 -0.021 -0.021
## QtypeCEGEQ  -0.490  0.000  0.000  0.495
```

```
ClickPlot <-  ggplot(ClickData, aes(x = Widget, y = ClickCount, color=Widget), axis.text.x = element_te
  facet_wrap(~ Qtype)+
  stat_summary(fun=mean, geom="point", size=3) +
  stat_summary(fun.data=mean_se, geom="errorbar", width=0.2) +
 # stat_summary(aes(y=fitted(ClickModel)), fun=mean, geom="line") +
  labs(x="Widget", y="Click Count",        color="Widget") +
  ylim(0,80)+
  theme(axis.text.x = element_text(angle = 40))+
  theme_bw()

ClickPlot
```

```
## Warning: Removed 4 rows containing non-finite values (stat_summary).
```

```
## Warning: Removed 4 rows containing non-finite values (stat_summary).
```




```
GEQClickData <- ClickData %>%
  subset(Qtype == "GEQ")

dataGEQClicksummary <- GEQClickData %>%
  group_by(Widget) %>%
  summarise(GEQ = mean(ClickCount))

GSQClickData <- ClickData %>%
  subset(Qtype == "GSQ")

dataGSQClicksummary <- GSQClickData %>%
  group_by(Widget) %>%
  summarise(GSQ = mean(ClickCount))


CEGEQClickData <- ClickData %>%
  subset(Qtype == "CEGEQ")

dataCEGEClickQsummary <- CEGEQClickData %>%
  group_by(Widget) %>%
  summarise(CEGEQ = mean(ClickCount))
```

```
#Anova looking at interaction between Q type & Widget, + Tukey pairwise comparisons
FullClickANOVA <- aov(ClickCount ~ Qtype * Widget, data = ClickData,)

summary(FullClickANOVA)
```

```
##              Df Sum Sq Mean Sq F value  Pr(>F)
## Qtype         2  10987    5494 193.474 < 2e-16 ***
## Widget        2  19755    9878 347.864 < 2e-16 ***
## Qtype:Widget  4    421     105   3.703 0.00812 **
## Residuals    80   2272      28
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 1 observation deleted due to missingness
```

```
TukeyHSD(FullClickANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = ClickCount ~ Qtype * Widget, data = ClickData)
##
## $Qtype
##                diff       lwr      upr p adj
## GSQ-GEQ    8.433333  5.119433 11.74723 1e-07
## CEGEQ-GEQ 26.500000 23.214303 29.78570 0e+00
## CEGEQ-GSQ 18.066667 14.752766 21.38057 0e+00
##
## $Widget
##                               diff        lwr        upr     p adj
## Dropdown-Radio Button  31.2000000  27.914303  34.485697 0.0000000
## Slider-Radio Button    -0.6314176  -3.945318   2.682483 0.8923155
## Slider-Dropdown       -31.8314176 -35.145318 -28.517517 0.0000000
##
## $`Qtype:Widget`
##                                           diff          lwr        upr
## GSQ:Radio Button-GEQ:Radio Button     8.900000   1.30211833  16.497882
## CEGEQ:Radio Button-GEQ:Radio Button  21.700000  14.10211833  29.297882
## GEQ:Dropdown-GEQ:Radio Button        28.200000  20.60211833  35.797882
## GSQ:Dropdown-GEQ:Radio Button        35.700000  28.10211833  43.297882
## CEGEQ:Dropdown-GEQ:Radio Button      60.300000  52.70211833  67.897882
## GEQ:Slider-GEQ:Radio Button          -1.600000  -9.19788167   5.997882
## GSQ:Slider-GEQ:Radio Button           6.188889  -1.61719248  13.994970
## CEGEQ:Slider-GEQ:Radio Button        24.100000  16.50211833  31.697882
## CEGEQ:Radio Button-GSQ:Radio Button  12.800000   5.20211833  20.397882
## GEQ:Dropdown-GSQ:Radio Button        19.300000  11.70211833  26.897882
## GSQ:Dropdown-GSQ:Radio Button        26.800000  19.20211833  34.397882
## CEGEQ:Dropdown-GSQ:Radio Button      51.400000  43.80211833  58.997882
## GEQ:Slider-GSQ:Radio Button         -10.500000 -18.09788167  -2.902118
## GSQ:Slider-GSQ:Radio Button          -2.711111 -10.51719248   5.094970
## CEGEQ:Slider-GSQ:Radio Button        15.200000   7.60211833  22.797882
## GEQ:Dropdown-CEGEQ:Radio Button       6.500000  -1.09788167  14.097882
## GSQ:Dropdown-CEGEQ:Radio Button      14.000000   6.40211833  21.597882
## CEGEQ:Dropdown-CEGEQ:Radio Button    38.600000  31.00211833  46.197882
## GEQ:Slider-CEGEQ:Radio Button       -23.300000 -30.89788167 -15.702118
## GSQ:Slider-CEGEQ:Radio Button       -15.511111 -23.31719248  -7.705030
## CEGEQ:Slider-CEGEQ:Radio Button       2.400000  -5.19788167   9.997882
```

```
## GSQ:Dropdown-GEQ:Dropdown             7.500000  -0.09788167  15.097882
## CEGEQ:Dropdown-GEQ:Dropdown          32.100000  24.50211833  39.697882
## GEQ:Slider-GEQ:Dropdown             -29.800000 -37.39788167 -22.202118
## GSQ:Slider-GEQ:Dropdown             -22.011111 -29.81719248 -14.205030
## CEGEQ:Slider-GEQ:Dropdown            -4.100000 -11.69788167   3.497882
## CEGEQ:Dropdown-GSQ:Dropdown          24.600000  17.00211833  32.197882
## GEQ:Slider-GSQ:Dropdown             -37.300000 -44.89788167 -29.702118
## GSQ:Slider-GSQ:Dropdown             -29.511111 -37.31719248 -21.705030
## CEGEQ:Slider-GSQ:Dropdown           -11.600000 -19.19788167  -4.002118
## GEQ:Slider-CEGEQ:Dropdown           -61.900000 -69.49788167 -54.302118
## GSQ:Slider-CEGEQ:Dropdown           -54.111111 -61.91719248 -46.305030
## CEGEQ:Slider-CEGEQ:Dropdown         -36.200000 -43.79788167 -28.602118
## GSQ:Slider-GEQ:Slider                7.788889  -0.01719248  15.594970
## CEGEQ:Slider-GEQ:Slider             25.700000  18.10211833  33.297882
## CEGEQ:Slider-GSQ:Slider             17.911111  10.10502975  25.717192
##                                        p adj
## GSQ:Radio Button-GEQ:Radio Button   0.0100630
## CEGEQ:Radio Button-GEQ:Radio Button 0.0000000
## GEQ:Dropdown-GEQ:Radio Button       0.0000000
## GSQ:Dropdown-GEQ:Radio Button       0.0000000
## CEGEQ:Dropdown-GEQ:Radio Button     0.0000000
## GEQ:Slider-GEQ:Radio Button         0.9990094
## GSQ:Slider-GEQ:Radio Button         0.2347800
## CEGEQ:Slider-GEQ:Radio Button       0.0000000
## CEGEQ:Radio Button-GSQ:Radio Button 0.0000257
## GEQ:Dropdown-GSQ:Radio Button       0.0000000
## GSQ:Dropdown-GSQ:Radio Button       0.0000000
## CEGEQ:Dropdown-GSQ:Radio Button     0.0000000
## GEQ:Slider-GSQ:Radio Button         0.0010352
## GSQ:Slider-GSQ:Radio Button         0.9715024
## CEGEQ:Slider-GSQ:Radio Button       0.0000004
## GEQ:Dropdown-CEGEQ:Radio Button     0.1548961
## GSQ:Dropdown-CEGEQ:Radio Button     0.0000032
## CEGEQ:Dropdown-CEGEQ:Radio Button   0.0000000
## GEQ:Slider-CEGEQ:Radio Button       0.0000000
## GSQ:Slider-CEGEQ:Radio Button       0.0000005
## CEGEQ:Slider-CEGEQ:Radio Button     0.9841646
## GSQ:Dropdown-GEQ:Dropdown           0.0557987
## CEGEQ:Dropdown-GEQ:Dropdown         0.0000000
## GEQ:Slider-GEQ:Dropdown             0.0000000
## GSQ:Slider-GEQ:Dropdown             0.0000000
## CEGEQ:Slider-GEQ:Dropdown           0.7322640
## CEGEQ:Dropdown-GSQ:Dropdown         0.0000000
## GEQ:Slider-GSQ:Dropdown             0.0000000
## GSQ:Slider-GSQ:Dropdown             0.0000000
## CEGEQ:Slider-GSQ:Dropdown           0.0001863
## GEQ:Slider-CEGEQ:Dropdown           0.0000000
## GSQ:Slider-CEGEQ:Dropdown           0.0000000
## CEGEQ:Slider-CEGEQ:Dropdown         0.0000000
## GSQ:Slider-GEQ:Slider               0.0509527
## CEGEQ:Slider-GEQ:Slider             0.0000000
## CEGEQ:Slider-GSQ:Slider             0.0000000
```

```r
#data$Condition


#pairwise.t.test(data$SCORE, data$Condition, p.adjust.method="holm")
```

```r
GEQClickANOVA <- aov(ClickCount ~  Widget, data = GEQClickData,)

summary(GEQClickANOVA)
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## Widget       2   5619    2810   96.78 4.85e-13 ***
## Residuals   27    784      29
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
TukeyHSD(aov(GEQClickANOVA))
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = GEQClickANOVA)
##
## $Widget
##                         diff        lwr        upr     p adj
## Dropdown-Radio Button  28.2  22.225341  34.174659 0.0000000
## Slider-Radio Button    -1.6  -7.574659   4.374659 0.7861008
## Slider-Dropdown       -29.8 -35.774659 -23.825341 0.0000000
```

```r
GSQClickANOVA <- aov(ClickCount ~  Widget, data = GSQClickData,)

summary(GSQClickANOVA)
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## Widget       2   5202  2601.2   190.1 3.02e-16 ***
## Residuals   26    356    13.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 1 observation deleted due to missingness
```

```r
TukeyHSD(GSQClickANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = ClickCount ~ Widget, data = GSQClickData)
##
## $Widget
##                            diff        lwr        upr     p adj
## Dropdown-Radio Button  26.800000  22.689721  30.910279 0.0000000
## Slider-Radio Button    -2.711111  -6.934021   1.511799 0.2655257
## Slider-Dropdown       -29.511111 -33.734021 -25.288201 0.0000000
```

```r
CEGEQClickANOVA <- aov(ClickCount ~  Widget, data = CEGEQClickData,)

summary(CEGEQClickANOVA)
```

```
##             Df Sum Sq Mean Sq F value   Pr(>F)
## Widget       2   9354    4677   111.6 8.89e-14 ***
## Residuals   27   1132      42
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
TukeyHSD(CEGEQClickANOVA)
```

```
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = ClickCount ~ Widget, data = CEGEQClickData)
##
## $Widget
##                         diff        lwr        upr     p adj
## Dropdown-Radio Button  38.6  31.420305  45.779695 0.0000000
## Slider-Radio Button     2.4  -4.779695   9.579695 0.6886971
## Slider-Dropdown       -36.2 -43.379695 -29.020305 0.0000000
```