

One-Way Within-Subjects ANOVA Demo

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One-way Within-Subjects ANOVA | Research Context Prompt

A local stress researcher is interested in the relationship between psychosocial stress levels and processing speed. After conducting a brief literature review they have hypothesized that regulating feelings of stress impairs concurrent performance of processing speed.

The researcher conducted a study where psychosocial stress was manipulated into three conditions: low stress, mild stress, and strong stress. Money was tight and recruitment was difficult, so they implemented a within-subjects, repeated measures design. Data was collected from 20 participants that consented to participate. The dependent measure in this task was processing speed ability measured in 10-second intervals (i.e., 1.3 = 13 seconds!!)

One-way Within-Subjects ANOVA | Data

```
library(psych)
library(tidyverse)
library(jmv)
library(ggpubr)
library(apaTables)
library(ez)
library(rstatix)

dat_stress <- read.csv("RM.ANOVA.Demo.csv")
dim(dat_stress)
```

```
## [1] 20  4
```

```
head(dat_stress)
```

```
##   ID Calm Mild Strong
## 1  1  3.4  5.0   5.9
## 2  2  3.9  4.0   5.4
## 3  3  4.1  4.4   4.7
## 4  4  3.7  4.3   5.9
## 5  5  4.0  5.0   5.1
## 6  6  4.6  4.1   6.4
```

One-way Within-Subjects ANOVA | Descriptive Stats

```
# Descriptive Stats
describe(dat_stress[,2:4])
```

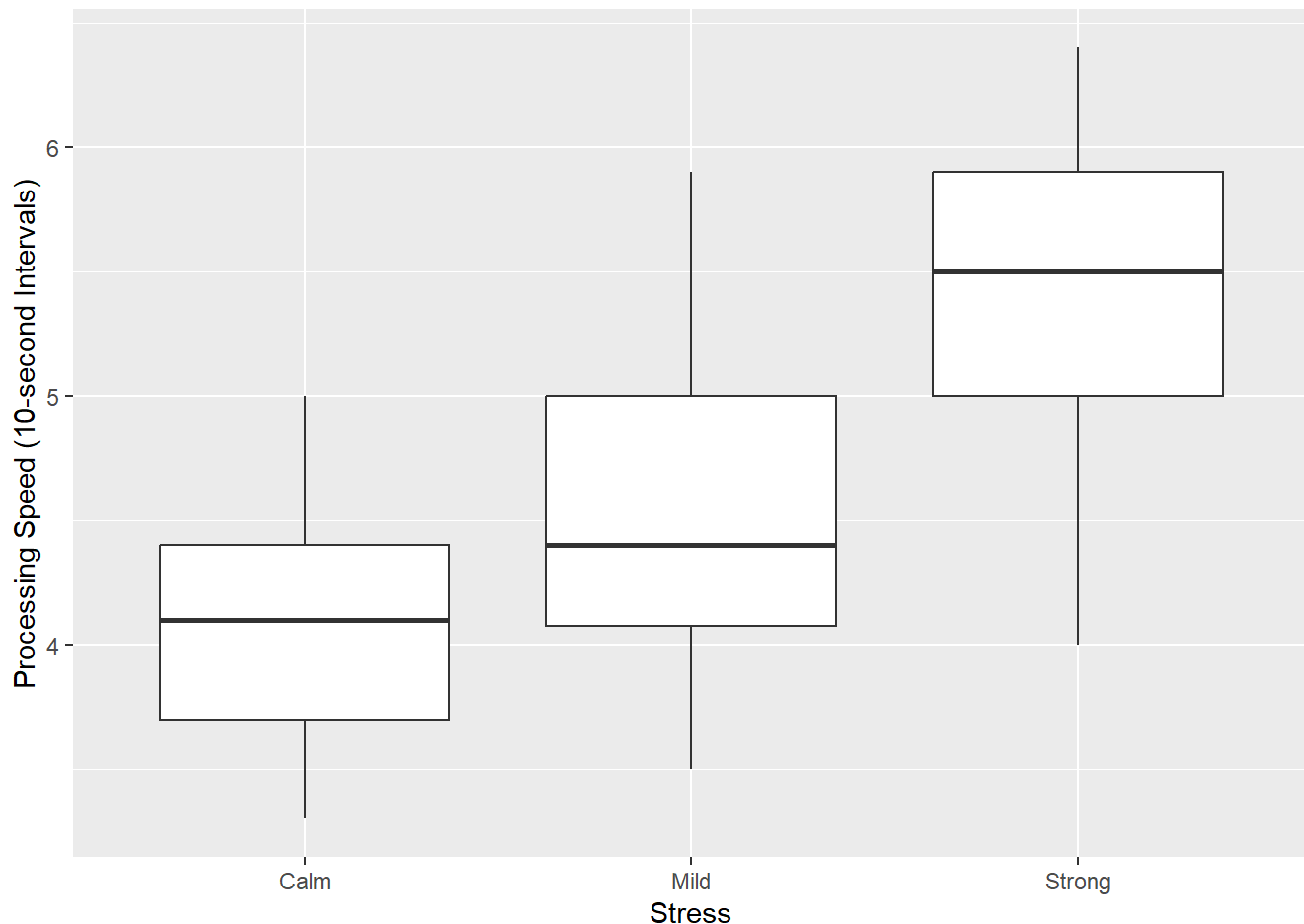
##	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
## Calm	1	20	4.06	0.45	4.1	4.04	0.59	3.3	5.0	1.7	0.20	-0.88	0.10
## Mild	2	20	4.57	0.76	4.4	4.53	0.82	3.5	5.9	2.4	0.53	-1.06	0.17
## Strong	3	20	5.43	0.67	5.5	5.47	0.59	4.0	6.4	2.4	-0.50	-0.87	0.15

One-way Within-Subjects ANOVA | Boxplot

```
dat_stressL<- dat_stress %>%
  gather(key="Stress",
    value="Score",
    Calm,
    Mild,
    Strong)

dat_stressL$Stress<-factor(dat_stressL$Stress,labels = c("Calm","Mild","Strong"))

ggplot(data = dat_stressL,
  mapping = aes(y = Score, x = Stress)) +
  geom_boxplot() +
  labs(y = "Processing Speed (10-second Intervals)")
```



One-way Within-Subjects ANOVA | Omnibus Normality Check

```

anovaRM(data=dat_stress,
  rm = list(
    list(label = 'Stress', levels = list('Calm', 'Mild', 'Strong'))),
  rmCells = list(
    list(measure = 'Calm', cell = 'Calm'),
    list(measure = 'Mild', cell = 'Mild'),
    list(measure = 'Strong', cell = 'Strong')),
  rmTerms= list('Stress'),
  qq = TRUE,
  spherTests = TRUE)

```

```

##
## REPEATED MEASURES ANOVA
##
## Within Subjects Effects
##


|          | Sum of Squares | df | Mean Square | F        | p         |
|----------|----------------|----|-------------|----------|-----------|
| Stress   | 19.30300       | 2  | 9.6515000   | 22.22276 | 0.0000004 |
| Residual | 16.50367       | 38 | 0.4343070   |          |           |


##
## Note. Type 3 Sums of Squares
##
##
## Between Subjects Effects
##

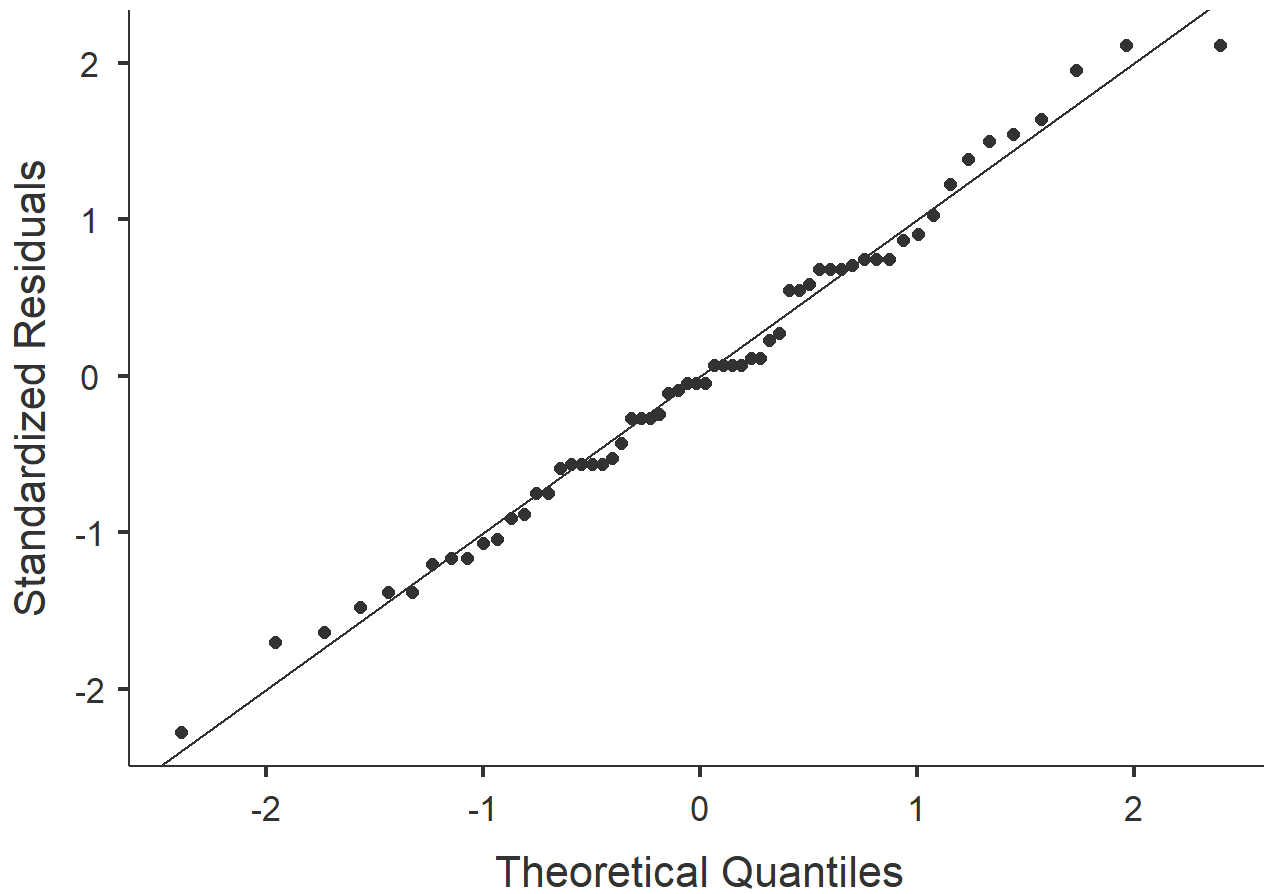

|          | Sum of Squares | df | Mean Square | F | p |
|----------|----------------|----|-------------|---|---|
| Residual | 6.849833       | 19 | 0.3605175   |   |   |


##
## Note. Type 3 Sums of Squares
##
##
## ASSUMPTIONS
##
## Tests of Sphericity
##


|        | Mauchly's W | p         | Greenhouse-Geisser $\epsilon$ | Huynh-Feldt $\epsilon$ |
|--------|-------------|-----------|-------------------------------|------------------------|
| Stress | 0.9655453   | 0.7293799 | 0.9666929                     | 1.000000               |

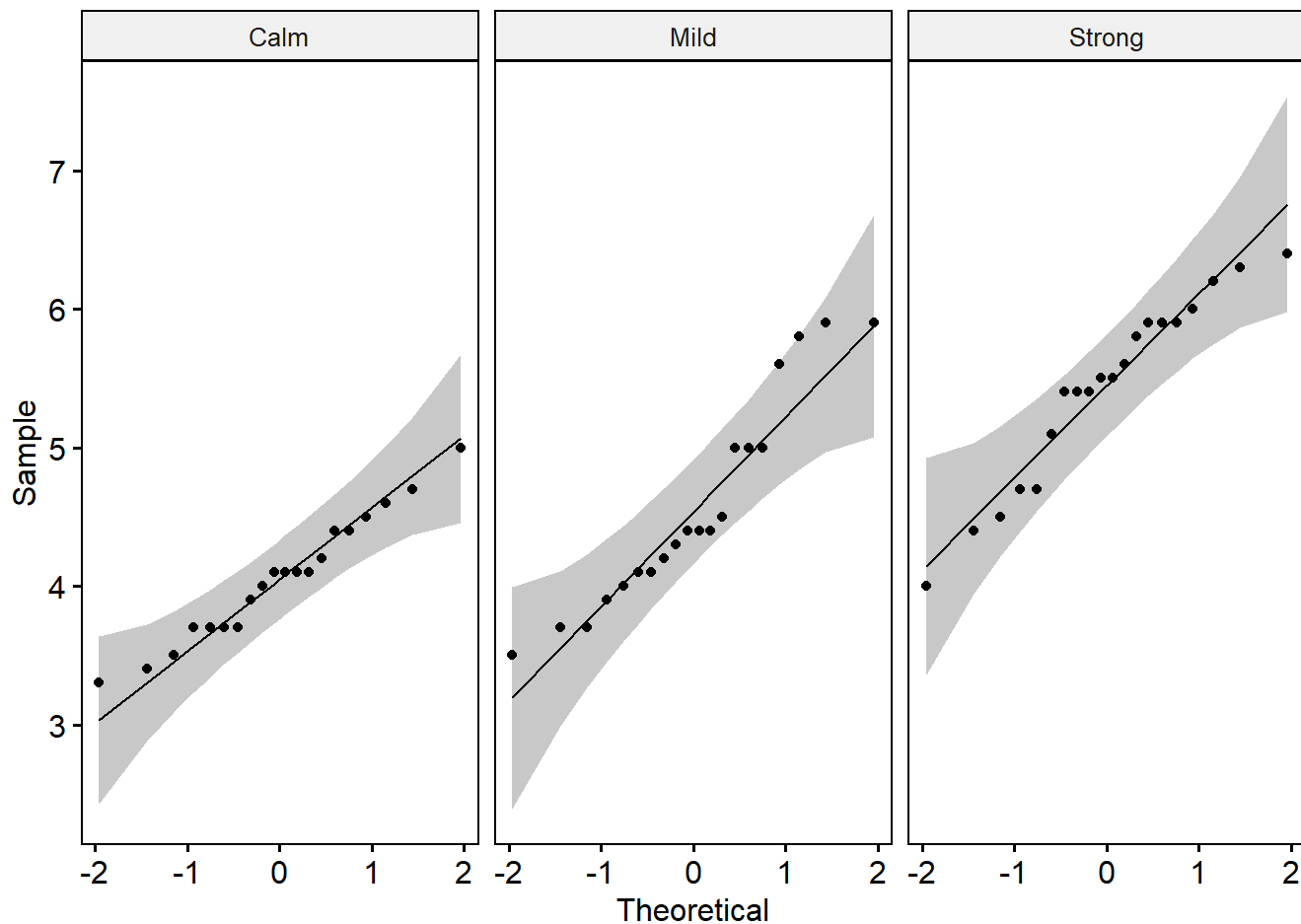

##

```



One-way Within-Subjects ANOVA | Normality Assumption Check

```
ggqqplot(dat_stressL,  
  'Score',  
  facet.by = "Stress")
```



One-way Within-Subjects ANOVA | Conducting the ANOVA

```
options(digits = 3)
anovaRM(data=dat_stress,
  rm = list(
    list(label = 'Stress', levels = list('Calm', 'Mild', 'Strong'))),
  rmCells = list(
    list(measure = 'Calm', cell = 'Calm'),
    list(measure = 'Mild', cell = 'Mild'),
    list(measure = 'Strong', cell = 'Strong')),
  rmTerms= list('Stress'),
  effectSize = 'eta',
  postHoc='Stress',
  postHocCorr = list("bonf"),
  emMeans=list(
    list('Stress')),
  emmTables=TRUE,
  qq = TRUE,
  spherTests = TRUE,
  spherCorr = list('none', 'GG'))
```

```

##
## REPEATED MEASURES ANOVA
##
## Within Subjects Effects
##
##
## Sphericity Correction Sum of Squares df Mean Square F p
##  $\eta^2$ 
##
## Stress None 19.3 2 9.651 22.2 < .
001 0.453
## Greenhouse-Geisser 19.3 1.93 9.984 22.2 < .
001 0.453
##
## Residual None 16.5 38 0.434
## Greenhouse-Geisser 16.5 36.73 0.449
##
## Note. Type 3 Sums of Squares
##
##
## Between Subjects Effects
##
## Sum of Squares df Mean Square F p  $\eta^2$ 
##
## Residual 6.85 19 0.361
##
## Note. Type 3 Sums of Squares
##
##
## ASSUMPTIONS
##
## Tests of Sphericity
##
## Mauchly's W p Greenhouse-Geisser  $\epsilon$  Huynh-Feldt  $\epsilon$ 
##
## Stress 0.966 0.729 0.967 1.00
##
##
## POST HOC TESTS
##
## Post Hoc Comparisons - Stress
##
## Stress Stress Mean Difference SE df t p-bonferroni
##
## Calm - Mild -0.515 0.211 19.0 -2.44 0.074
## - Strong -1.375 0.190 19.0 -7.25 < .001
## Mild - Strong -0.860 0.223 19.0 -3.86 0.003
##
##

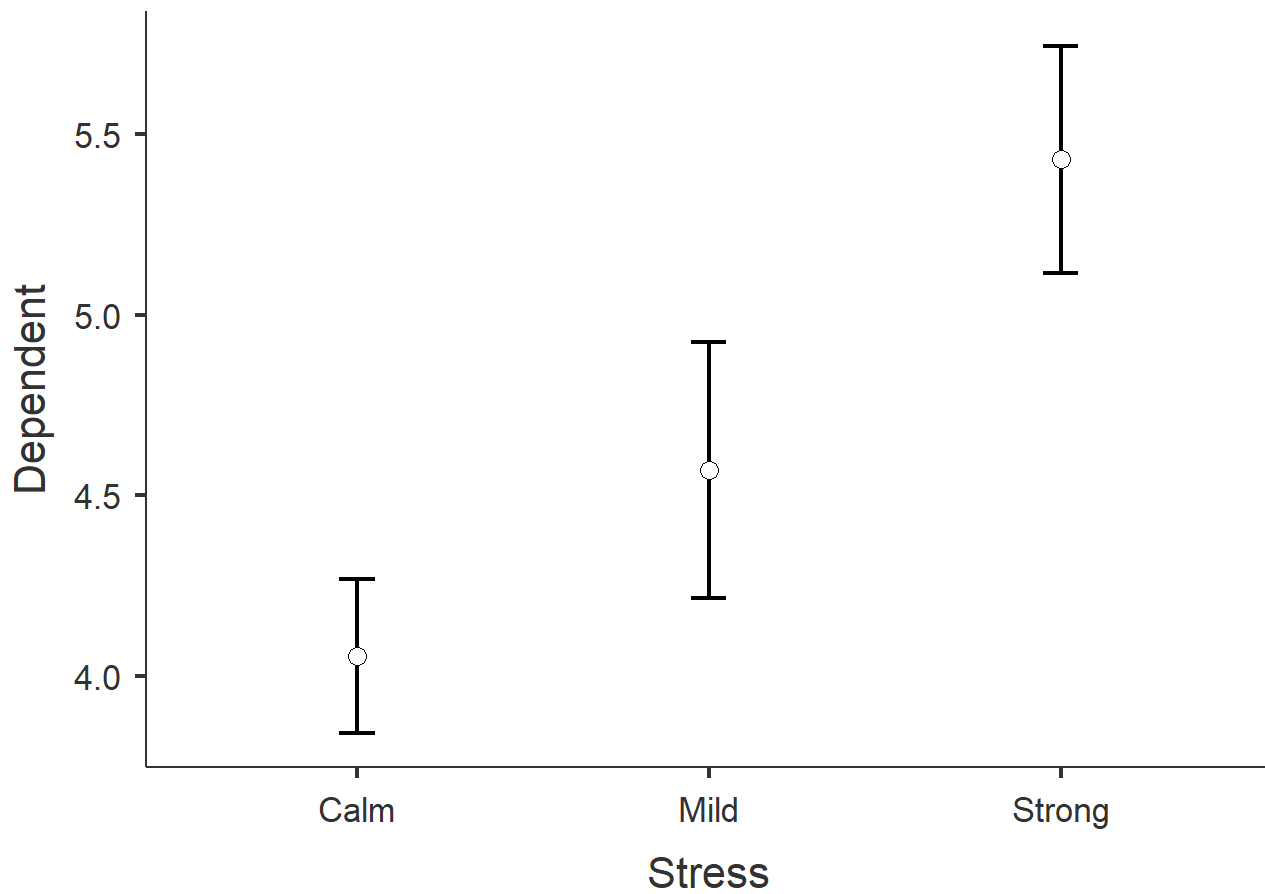
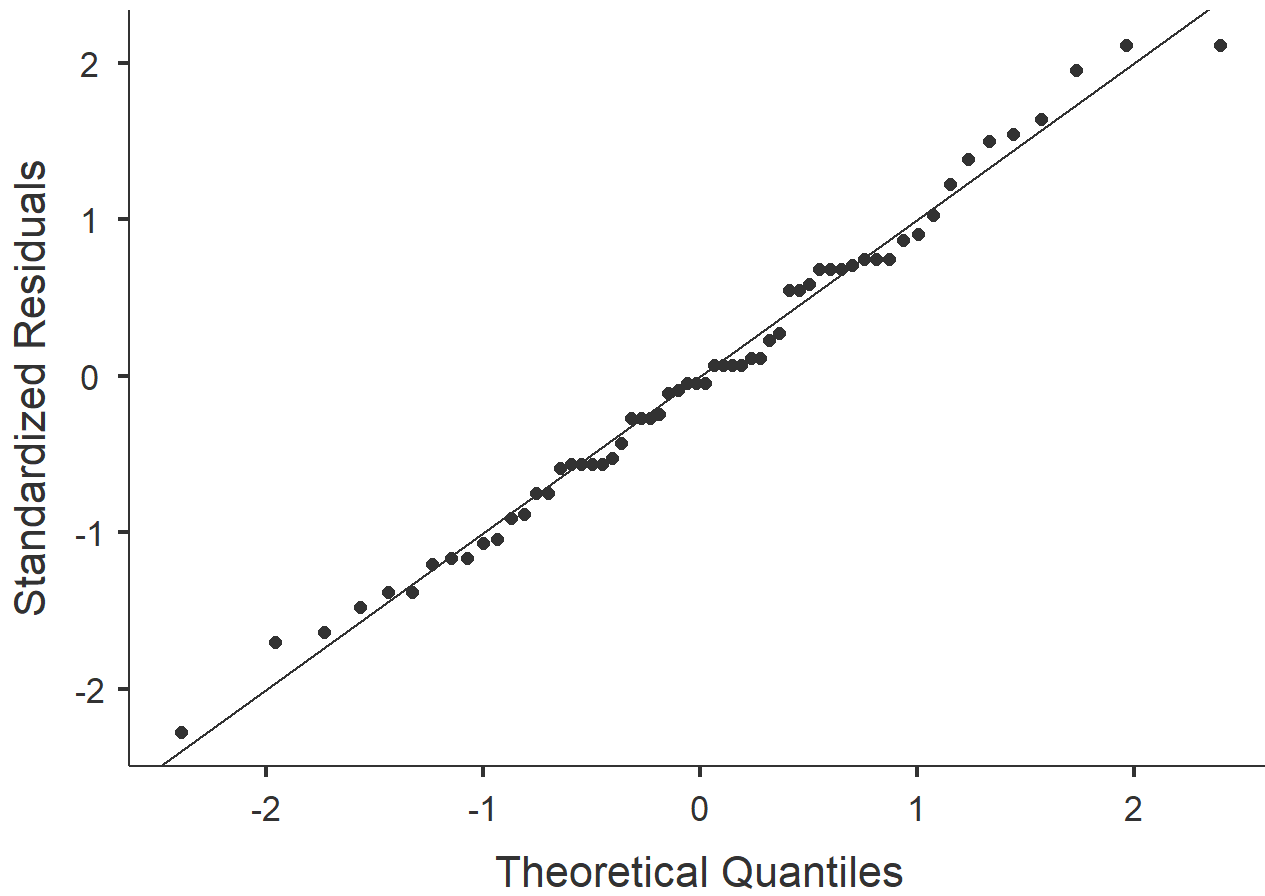
```

```
##  
## ESTIMATED MARGINAL MEANS  
##  
## STRESS  
##  
## Estimated Marginal Means - Stress
```

```
##
```

	Stress	Mean	SE	Lower	Upper
##					
##	Calm	4.06	0.101	3.84	4.27
##	Mild	4.57	0.169	4.22	4.92
##	Strong	5.43	0.150	5.12	5.74

```
##
```



One-way Within-Subjects ANOVA | Conducting the ANOVA

```
res <- anova_test(dat_stressL,
                  dv=Score,
                  wid=ID,
                  within=Stress,
                  effect.size = "ges",
                  type = 3,
                  detailed=TRUE)

get_anova_table(res)
```

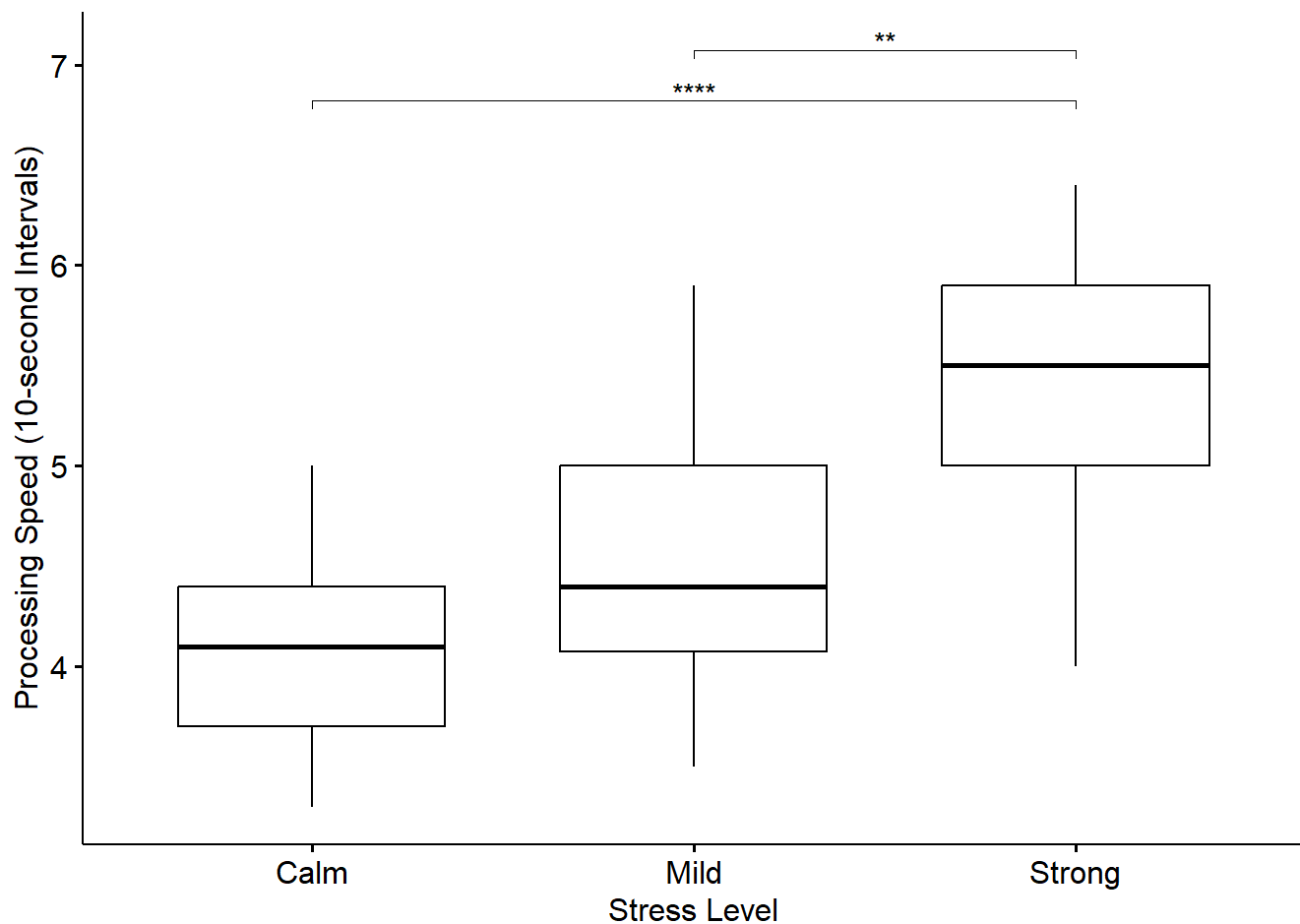
```
## ANOVA Table (type III tests)
##
##          Effect DFn DFd    SSn  SSd      F      p p<.05  ges
## 1 (Intercept)   1  19 1317.0  6.85 3653.0 3.46e-23    * 0.983
## 2      Stress   2  38   19.3 16.50   22.2 4.06e-07    * 0.453
```

One-way Within-Subjects ANOVA | ANOVA Output: Manual Post-Hoc Tests Code

```
pair<-dat_stressL %>%
  pairwise_t_test(Score~Stress,
                  paired=TRUE,
                  p.adjust.method = "bonferroni") %>%
  add_xy_position(x = "Stress")
```

One-way Within-Subjects ANOVA | Professional ANOVA Visualization Code

```
ggboxplot(dat_stressL,
          x = "Stress",
          y = "Score") +
  stat_pvalue_manual(pair,
                    hide.ns = TRUE,
                    tip.length = .01) +
  labs(y = "Processing Speed (10-second Intervals)", x = "Stress Level")
```



One-way Within-Subjects ANOVA | APA Style ANOVA Tables

```
apa.ezANOVA.table(res,
  correction="none",
  table.title = "Repeated Measure ANOVA",
  table.number=3)
```

```
##
##
## Table 3
##
## Repeated Measure ANOVA
##
## Predictor df_num df_den SS_num SS_den F p ges
## (Intercept) 1 19 1316.95 6.85 3652.95 .000 .98
## Stress 2 38 19.30 16.50 22.22 .000 .45
##
## Note. df_num indicates degrees of freedom numerator. df_den indicates degrees of freedom denominator.
## p-values based on assumed sphericity.
## p-values and degrees of freedom in the table incorporate this correction.
## SS_num indicates sum of squares numerator. SS_den indicates sum of squares denominator.
## ges indicates generalized eta-squared.
##
```