|  |  |
| --- | --- |
| Grading Template: Repeated Measures ANOVA |  |
| Conducting the statistic | 3/3 |
| Team explanation of the process, output, interpretation | 3/3 |
| APA Style Results Section of each of the Repeated Measures examples | 6/6 |
| APA Style | 2/2 |
| Total | 14/14 |

OneWay Anova

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#####EXERCISE 1

#Research Question

Do teachers experience more stress when coping with problems associated with students, parents, or administrators?

DV = Teacher’s Stress Scores

IV1 = Type of Stressors: Students, Parents, Administrators

*N* = 15

#### Packages

#install.packages("compute.es")  
#install.packages("ggplot2")  
#install.packages("multcomp")  
#install.packages("nlme")  
#install.packages("pastecs")  
#install.packages("reshape")  
  
library (compute.es)  
library (ggplot2)  
library (multcomp)

## Loading required package: mvtnorm

## Loading required package: survival

## Loading required package: TH.data

## Loading required package: MASS

##   
## Attaching package: 'TH.data'

## The following object is masked from 'package:MASS':  
##   
## geyser

library(nlme)  
library (pastecs)  
library (reshape)

#### The upload (CSV File)

stressData <- read.csv("L29Ex1\_TeacherStress.csv", header=TRUE)  
View(stressData)

## Warning in system2("/usr/bin/otool", c("-L", shQuote(DSO)), stdout = TRUE):  
## running command ''/usr/bin/otool' -L '/Library/Frameworks/R.framework/  
## Resources/modules/R\_de.so'' had status 1

###re-shape the Data in R to get a Long Version

Long\_stressData <-melt(stressData, id = "ID", measured = c("student", "parent", "admin"))

###Name New Columns

names(Long\_stressData)<-c("ID", "Role", "Stress")

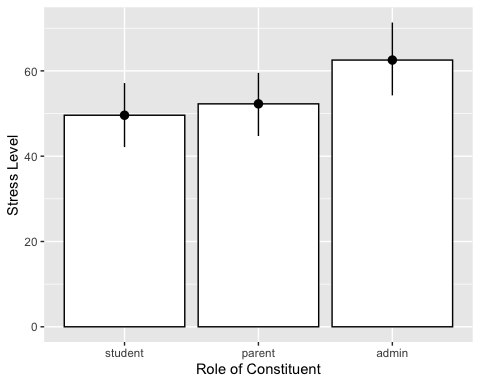
###Name Levels in Role Variable

Long\_stressData$role<-factor(Long\_stressData$Role, labels = c("Student", "Parent", "Administrator"))

###Explore Data ##Bar Charts

Long\_stressData<-Long\_stressData[order(Long\_stressData$ID),]

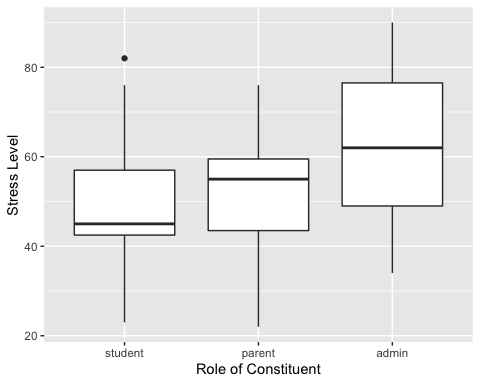
StressBar <- ggplot(Long\_stressData, aes(Role, Stress))  
StressBar + stat\_summary(fun.y = mean, geom = "bar", fill = "White", colour = "Black") + stat\_summary(fun.data = mean\_cl\_boot, geom = "pointrange") + labs(x = "Role of Constituent", y = "Stress Level")



#### Boxplots

Provide us with a better visual of the distribtuion of the data.

StressBoxplot <- ggplot(Long\_stressData, aes(Role, Stress))  
StressBoxplot + geom\_boxplot() + labs(x = "Role of Constituent", y = "Stress Level")



#descriptives

by(Long\_stressData$Stress, Long\_stressData$Role, function(X) round(stat.desc (X, norm=TRUE, basic = TRUE),3))

## Long\_stressData$Role: student  
## nbr.val nbr.null nbr.na min max   
## 15.000 0.000 0.000 23.000 82.000   
## range sum median mean SE.mean   
## 59.000 744.000 45.000 49.600 4.051   
## CI.mean.0.95 var std.dev coef.var skewness   
## 8.688 246.114 15.688 0.316 0.519   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 0.448 -0.479 -0.214 0.933 0.300   
## --------------------------------------------------------   
## Long\_stressData$Role: parent  
## nbr.val nbr.null nbr.na min max   
## 15.000 0.000 0.000 22.000 76.000   
## range sum median mean SE.mean   
## 54.000 784.000 55.000 52.267 3.832   
## CI.mean.0.95 var std.dev coef.var skewness   
## 8.218 220.210 14.839 0.284 -0.110   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## -0.095 -0.750 -0.335 0.962 0.722   
## --------------------------------------------------------   
## Long\_stressData$Role: admin  
## nbr.val nbr.null nbr.na min max   
## 15.000 0.000 0.000 34.000 90.000   
## range sum median mean SE.mean   
## 56.000 938.000 62.000 62.533 4.658   
## CI.mean.0.95 var std.dev coef.var skewness   
## 9.990 325.410 18.039 0.288 0.201   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 0.173 -1.391 -0.621 0.939 0.373

#a priori contrasts

##Logic for contrasts: look at data, see what might make most sense. Teachers care most about catering to students so maybe isolate the student and group the others… then separate the others in the 2nd contrast.

STUDENTvsELSE<-c(-2, 1, 1)  
PRTvsADMIN<-c(0, -1, 1)  
contrasts(Long\_stressData$Role)<-cbind(STUDENTvsELSE, PRTvsADMIN)

#Primary Analysis

tStress\_Model<-lme(Stress ~ Role, random = ~1|ID/Role, data = Long\_stressData, method = "ML")  
baseline<-lme(Stress ~ 1, random = ~1|ID/Role, data = Long\_stressData, method = "ML")  
anova(baseline, tStress\_Model)

## Model df AIC BIC logLik Test L.Ratio p-value  
## baseline 1 4 380.8693 388.0959 -186.4346   
## tStress\_Model 2 6 374.1272 384.9672 -181.0636 1 vs 2 10.74208 0.0046

##Run Summaries

summary(tStress\_Model)

## Linear mixed-effects model fit by maximum likelihood  
## Data: Long\_stressData   
## AIC BIC logLik  
## 374.1272 384.9672 -181.0636  
##   
## Random effects:  
## Formula: ~1 | ID  
## (Intercept)  
## StdDev: 11.74797  
##   
## Formula: ~1 | Role %in% ID  
## (Intercept) Residual  
## StdDev: 9.478517 4.296502  
##   
## Fixed effects: Stress ~ Role   
## Value Std.Error DF t-value p-value  
## (Intercept) 54.80000 3.526588 28 15.539098 0.0000  
## RoleSTUDENTvsELSE 2.60000 1.135479 28 2.289783 0.0298  
## RolePRTvsADMIN 5.13333 1.966707 28 2.610116 0.0144  
## Correlation:   
## (Intr) RSTUDE  
## RoleSTUDENTvsELSE 0   
## RolePRTvsADMIN 0 0   
##   
## Standardized Within-Group Residuals:  
## Min Q1 Med Q3 Max   
## -0.786105556 -0.236794065 0.007710872 0.213345507 0.957180062   
##   
## Number of Observations: 45  
## Number of Groups:   
## ID Role %in% ID   
## 15 45

summary(baseline)

## Linear mixed-effects model fit by maximum likelihood  
## Data: Long\_stressData   
## AIC BIC logLik  
## 380.8693 388.0959 -186.4346  
##   
## Random effects:  
## Formula: ~1 | ID  
## (Intercept)  
## StdDev: 11.06665  
##   
## Formula: ~1 | Role %in% ID  
## (Intercept) Residual  
## StdDev: 11.45996 4.858269  
##   
## Fixed effects: Stress ~ 1   
## Value Std.Error DF t-value p-value  
## (Intercept) 54.8 3.445502 30 15.90479 0  
##   
## Standardized Within-Group Residuals:  
## Min Q1 Med Q3 Max   
## -0.78011901 -0.21267945 -0.02754815 0.20036639 0.85045118   
##   
## Number of Observations: 45  
## Number of Groups:   
## ID Role %in% ID   
## 15 45

*Students versus combined effects of parents and administrators* - there is a statistically significant difference in stress caused from working with the students compared to working with the parents and administrators, *b* = 2.60, *t*(28) = 2.29, *p* = .030.

*Parents versus administrators* - working with administrators is statistically significantly more stressful than working with parents, *b* = 5.13, *t* (28) = 2.61, *p* = .014.

Type one error considerations: traditional BonFerroni would require dividing .05/2 for the two contrasts. This would mean that the P value would need to be < .025 to be that statistically significant. However: 1.) we could argue that our hypothesis is onetailed, multiply the p value x2 and claim it to be .0149 (and then do the same with parents vs. Admin). OR 2.) Argue the logic of the LSD model if there are 3 or fewer pairwise comparisons, we can retain the alpha level for the omnibus (.05) - Either way. we could argue that these differences are statistically significant.

#effect sizes for the contrasts

rcontrast<-function(t, df)  
{r<-sqrt(t^2/(t^2 + df))  
 print(paste("r = ", r))  
 }  
  
#rcontrast(t-value, df)  
rcontrast(2.289783, 28)

## [1] "r = 0.397139905651822"

rcontrast(2.610116, 28)

## [1] "r = 0.442375351363714"

#RESULTS

A one-way within-subjects ANOVA was conducted to evaluate whether teachers feel more stress when coping with students, parents, or administrators. The within subjects factor was the role of constituent: student parent or administrator. Means and standard deviations for stress scores are presented in Table 1 and a bar chart of the stress means are found in Figure 1.

The analysis was conducted via a mutilevel model in the R package “nlme.” Compared to an empty (or baseline) model with no predictors, the role of the constituent had a significant effect on teacher stress level:

Orthogonal contrasts suggest that stress levels were significantly lower when working with students than the combined effects of working with teachers or administrators: *b* = 2.60, *t* (28) = 2.29, *p* = .030, *r* = .397. Similarly, stress levels were statistically significantly lower when working with parents compared to administrators: *b* = 5.13, *t* (28) = 2.61, *p* = .015, *r* = .442.

Table 1

*Means and Standard Deviations for teachers’ stress levels and types of stressors.*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Means and Standard Deviations | | |
| Test | *M* | *SD* | |
| Students | 49.60 | | 15.69 |
| Parents | 52.27 | | 14.84 |
| Administration | 62.53 | | 18.04 |

A screenshot of a social media post

Description automatically generated

Figure 1. Types of reinforcement consumption and reinforcement schedules versus test scores.

#####EXERCISE 2

#Research Question

Does the child’s self-esteem change across ages 5, 7, 9, 11, and 13?

DV = Self-esteem descriptor IV1 = Age of Child (5 levels): 5, 7, 9, 11, and 13

*N* = 25 *n* = 5 age points

#### Packages

library (compute.es)  
library (ggplot2)  
library (multcomp)  
library(nlme)  
library (pastecs)  
library (reshape)

#### The upload (CSV File)

esteemData <- read.csv("L29Ex2\_selfesteem.csv", header=TRUE)  
View(esteemData)

## Warning in system2("/usr/bin/otool", c("-L", shQuote(DSO)), stdout = TRUE):  
## running command ''/usr/bin/otool' -L '/Library/Frameworks/R.framework/  
## Resources/modules/R\_de.so'' had status 1

###re-shape the Data in R to get a Long Version

Long\_esteemData <-melt(esteemData, id = "ID", measured = c("sed1", "sed2", "sed3", "sed4", "sed5"))

###Name New Columns

names(Long\_esteemData)<-c("ID", "Age", "SED")

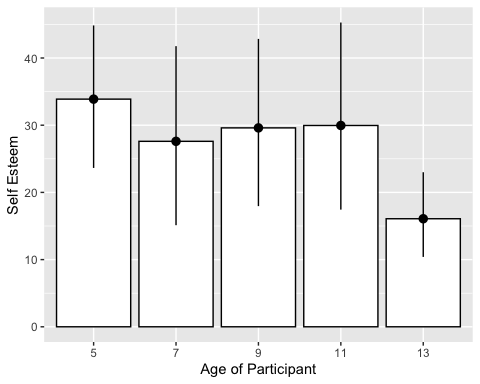
###Name Levels in Role Variable

Long\_esteemData$Age<-factor(Long\_esteemData$Age, labels = c("5", "7", "9", "11", "13"))

###Explore Data ##Bar Charts

Long\_esteemData<-Long\_esteemData[order(Long\_esteemData$ID),]

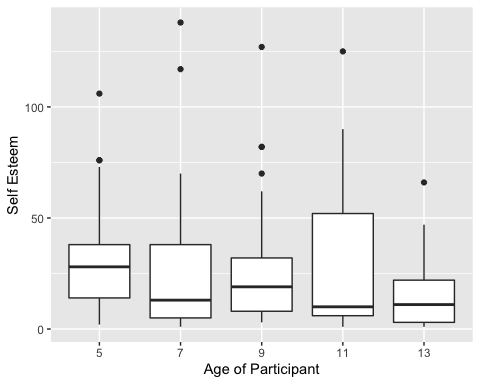
EsteemBar <- ggplot(Long\_esteemData, aes(Age, SED))  
EsteemBar + stat\_summary(fun.y = mean, geom = "bar", fill = "White", colour = "Black") + stat\_summary(fun.data = mean\_cl\_boot, geom = "pointrange") + labs(x = "Age of Participant", y = "Self Esteem")



#### Boxplots

Provide us with a better visual of the distribtuion of the data.

bushBoxplot <- ggplot(Long\_esteemData, aes(Age, SED))  
bushBoxplot + geom\_boxplot() + labs(x = "Age of Participant", y = "Self Esteem")



####Descriptives

by(Long\_esteemData$SED, Long\_esteemData$Age, function(X) round(stat.desc (X, norm=TRUE, basic = TRUE),3))

## Long\_esteemData$Age: 5  
## nbr.val nbr.null nbr.na min max   
## 25.000 0.000 0.000 2.000 106.000   
## range sum median mean SE.mean   
## 104.000 847.000 28.000 **33.880** 5.583   
## CI.mean.0.95 var std.dev coef.var skewness   
## 11.524 779.360 **27.917** 0.824 0.871   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 0.939 -0.182 -0.101 0.894 0.013   
## --------------------------------------------------------   
## Long\_esteemData$Age: 7  
## nbr.val nbr.null nbr.na min max   
## 25.000 0.000 0.000 1.000 138.000   
## range sum median mean SE.mean   
## 137.000 690.000 13.000 27.600 7.070   
## CI.mean.0.95 var std.dev coef.var skewness   
## 14.593 1249.750 35.352 1.281 1.821   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 1.963 2.628 1.457 0.731 0.000   
## --------------------------------------------------------   
## Long\_esteemData$Age: 9  
## nbr.val nbr.null nbr.na min max   
## 25.000 0.000 0.000 3.000 127.000   
## range sum median mean SE.mean   
## 124.000 740.000 19.000 29.600 6.298   
## CI.mean.0.95 var std.dev coef.var skewness   
## 12.999 991.750 31.492 1.064 1.520   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 1.639 1.548 0.859 0.778 0.000   
## --------------------------------------------------------   
## Long\_esteemData$Age: 11  
## nbr.val nbr.null nbr.na min max   
## 25.000 0.000 0.000 1.000 125.000   
## range sum median mean SE.mean   
## 124.000 749.000 10.000 29.960 6.973   
## CI.mean.0.95 var std.dev coef.var skewness   
## 14.391 1215.457 34.863 1.164 1.208   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 1.303 0.273 0.151 0.785 0.000   
## --------------------------------------------------------   
## Long\_esteemData$Age: 13  
## nbr.val nbr.null nbr.na min max   
## 25.000 0.000 0.000 1.000 66.000   
## range sum median mean SE.mean   
## 65.000 402.000 11.000 16.080 3.390   
## CI.mean.0.95 var std.dev coef.var skewness   
## 6.997 287.327 16.951 1.054 1.352   
## skew.2SE kurtosis kurt.2SE normtest.W normtest.p   
## 1.458 1.035 0.574 0.816 0.000

#A Priori Contrasts 5 vs older 7 vs older 9 vs older 11 vs 13

FIVEvsOLDER<-c(-4, 1, 1, 1, 1)  
SEVENvsOLDER<-c(0, -3, 1, 1, 1)  
NINEvsOLDER<-c(0, 0, -2, 1, 1)  
ELEVENvsTHIRTEEN<-c(0, 0, 0, -1, 1)  
contrasts(Long\_esteemData$Age)<-cbind(FIVEvsOLDER,SEVENvsOLDER, NINEvsOLDER, ELEVENvsTHIRTEEN)

SE\_Model<-lme(SED ~ Age, random = ~1|ID/Age, data = Long\_esteemData, method = "ML")  
baseline<-lme(SED ~ 1, random = ~1|ID/Age, data = Long\_esteemData, method = "ML")  
anova(baseline, SE\_Model)

## Model df AIC BIC logLik Test L.Ratio p-value  
## baseline 1 4 1127.454 1138.767 -559.7270   
## SE\_Model 2 8 1117.323 1139.950 -550.6617 1 vs 2 18.1306 0.0012

summary(SE\_Model)

## Linear mixed-effects model fit by maximum likelihood  
## Data: Long\_esteemData   
## AIC BIC logLik  
## 1117.323 1139.95 -550.6617  
##   
## Random effects:  
## Formula: ~1 | ID  
## (Intercept)  
## StdDev: 25.30206  
##   
## Formula: ~1 | Age %in% ID  
## (Intercept) Residual  
## StdDev: 13.48968 6.809819  
##   
## Fixed effects: SED ~ Age   
## Value Std.Error DF t-value p-value  
## (Intercept) 27.424000 5.345806 96 5.130003 0.0000  
## AgeFIVEvsOLDER -1.614000 0.689724 96 -2.340067 0.0214  
## AgeSEVENvsOLDER -0.596667 0.890430 96 -0.670088 0.5044  
## AgeNINEvsOLDER -2.193333 1.259258 96 -1.741767 0.0848  
## AgeELEVENvsTHIRTEEN -6.940000 2.181098 96 -3.181883 0.0020  
## Correlation:   
## (Intr) AFIVEO ASEVEN ANINEO  
## AgeFIVEvsOLDER 0   
## AgeSEVENvsOLDER 0 0   
## AgeNINEvsOLDER 0 0 0   
## AgeELEVENvsTHIRTEEN 0 0 0 0   
##   
## Standardized Within-Group Residuals:  
## Min Q1 Med Q3 Max   
## -1.15384007 -0.20327885 -0.06896333 0.17448754 1.26231251   
##   
## Number of Observations: 125  
## Number of Groups:   
## ID Age %in% ID   
## 25 125

summary(baseline)

## Linear mixed-effects model fit by maximum likelihood  
## Data: Long\_esteemData   
## AIC BIC logLik  
## 1127.454 1138.767 -559.727  
##   
## Random effects:  
## Formula: ~1 | ID  
## (Intercept)  
## StdDev: 25.12203  
##   
## Formula: ~1 | Age %in% ID  
## (Intercept) Residual  
## StdDev: 14.85631 7.281895  
##   
## Fixed effects: SED ~ 1   
## Value Std.Error DF t-value p-value  
## (Intercept) 27.424 5.258877 100 5.214802 0  
##   
## Standardized Within-Group Residuals:  
## Min Q1 Med Q3 Max   
## -1.30474741 -0.15956776 -0.05398593 0.11199567 1.20013645   
##   
## Number of Observations: 125  
## Number of Groups:   
## ID Age %in% ID   
## 25 125

#Effect Sizes

rcontrast<-function(t, df)  
{r<-sqrt(t^2/(t^2 + df))  
 print(paste("r = ", r))  
 }  
  
rcontrast(-2.340067, 96)

## [1] "r = 0.232298714891031"

rcontrast(-0.670088, 96)

## [1] "r = 0.0682311884174072"

rcontrast(-1.741767, 96)

## [1] "r = 0.175024336868375"

rcontrast(-3.181883, 96)

## [1] "r = 0.308870637501227"

#post Hocs.

postHocs<-glht(SE\_Model, linfct = mcp(Age = "Tukey"))  
summary(postHocs)

##   
## Simultaneous Tests for General Linear Hypotheses  
##   
## Multiple Comparisons of Means: Tukey Contrasts  
##   
##   
## Fit: lme.formula(fixed = SED ~ Age, data = Long\_esteemData, random = ~1 |   
## ID/Age, method = "ML")  
##   
## Linear Hypotheses:  
## Estimate Std. Error z value Pr(>|z|)   
## 7 - 5 == 0 -6.280 4.274 -1.469 0.5825   
## 9 - 5 == 0 -4.280 4.274 -1.001 0.8549   
## 11 - 5 == 0 -3.920 4.274 -0.917 0.8904   
## 13 - 5 == 0 -17.800 4.274 -4.165 <0.001 \*\*\*  
## 9 - 7 == 0 2.000 4.274 0.468 0.9902   
## 11 - 7 == 0 2.360 4.274 0.552 0.9817   
## 13 - 7 == 0 -11.520 4.274 -2.695 0.0547 .   
## 11 - 9 == 0 0.360 4.274 0.084 1.0000   
## 13 - 9 == 0 -13.520 4.274 -3.163 0.0133 \*   
## 13 - 11 == 0 -13.880 4.274 -3.247 0.0103 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
## (Adjusted p values reported -- single-step method)

confint(postHocs)

##   
## Simultaneous Confidence Intervals  
##   
## Multiple Comparisons of Means: Tukey Contrasts  
##   
##   
## Fit: lme.formula(fixed = SED ~ Age, data = Long\_esteemData, random = ~1 |   
## ID/Age, method = "ML")  
##   
## Quantile = 2.7285  
## 95% family-wise confidence level  
##   
##   
## Linear Hypotheses:  
## Estimate lwr upr   
## 7 - 5 == 0 -6.2800 -17.9418 5.3818  
## 9 - 5 == 0 -4.2800 -15.9418 7.3818  
## 11 - 5 == 0 -3.9200 -15.5818 7.7418  
## 13 - 5 == 0 -17.8000 -29.4618 -6.1382  
## 9 - 7 == 0 2.0000 -9.6618 13.6618  
## 11 - 7 == 0 2.3600 -9.3018 14.0218  
## 13 - 7 == 0 -11.5200 -23.1818 0.1418  
## 11 - 9 == 0 0.3600 -11.3018 12.0218  
## 13 - 9 == 0 -13.5200 -25.1818 -1.8582  
## 13 - 11 == 0 -13.8800 -25.5418 -2.2182

#Results:

A one-way within subjects ANOVA was conducted to evaluate how children’s self-esteem changes across ages 5, 7, 9, 11, and 13. The within subjects factor was the age of the child. Means and standard deviations for self-esteem scores are presented in Table 1 and a bar chart of the stress means are found in Figure 1.

The analysis was conducted via a multilevel model in the R package “nlme.” Compared to an empty (or baseline) model with no predictors, the age of the child had a significant effect on self-esteem:

Type one error was managed with a traditional Bonferroni, dividing the family-wise alpha (.05) by 4. Thus, for a statistically significant contrast the *p* value needed to be less than .0125. Orthogonal contrasts suggested that there were non-significant differences between self-esteem for five-year olds compared to older children: *b* = -1.614, *t* (96) = -2.340, *p* = .021, *r* = .232; non-significant differences between 7-year olds and older children: *b* = -0.597, *t* (96) = -.670, *p* = .504, *r* = .068; and non-significant differences between 9-year olds and older children: *b* = -2.193, *t* (96) = -1.742, *p* = .085, *r* = .175. There were however significant differences between age 11 and 13-year olds: *b* = -6.940, *t* (96) = -3.181, *p* = .0020, *r* = .31.

Table 1

*Means and Standard Deviations for self-esteem scores at different ages (5, 7, 9, 11, and 13).*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Means and Standard Deviations | | |
| Test | *M* | *SD* | |
| Age 5 | 33.88 | | 27.92 |
| Age 7 | 27.6 | | 35.35 |
| Age 9 | 29.6 | | 31.5 |
| Age 11 | 29.96 | | 34.86 |
| Age 13 | 16.08 | | 16.91 |

A close up of a logo

Description automatically generated

Figure 1. Types of reinforcement consumption and reinforcement schedules versus test scores.