PSYCH308A - Data Analysis 4 (DA4)

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Contents

```r
# Load packages. Set messages and warnings to FALSE so I don't have to see the
# masking messages in the output.
library(psych)
library(jmv)       # for descriptive
library(ggplot2)
library(dplyr)
library(magrittr)
library(tidyr)     # for pivot_longer
library(stringr)   # for sub_str
```

Question 01 (Q01):

1. Interpret a p-value of .042. (This question is **not** asking for the decision this p-value results in, rather what does this value mean?)

Answer to Q01:

A p-value of .042 implies that the finding of some statistical test (z-test, t-test, etc.) that the probability of obtaining the test statistic found or something more extreme was .042 (a.k.a. 4.2%) assuming the null hypothesis was true

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Question 02 (Q02):

2. ***In no more than two sentences,*** what is the relationship between sample size, effect size, and power?

Answer to Q02:

Power is positively correlated with both sample size and effect size in a manner that convolutes the two (sample and effect). That is to say, the power of a finding will increase if either sample size increases or effect size increases, and if one (e.g. sample size) is necessarily small, a higher power can be achieved by increasing the other (e.g. effect size).

Question 03 (Q03):

3. A researcher records the number of words recalled by students presented with a list of words for 1 minute. In one group, students were presented with the list of words in color; in a second group, the same words were presented in black and white. An equal number of students were in each group. The researcher reports the following: *Participants recalled significantly more words when the words were presented in color (M = 12.4 words) versus black and white (M = 10.9 words), t(48) = 2.01, p = .035, d = 0.18.* Based on the previous statement, what is the sample size in each group?

Answer to Q03:

Given the wording of the prompt, I'm assuming this test was conducted as an independent sample t-test ("In one group … in a second group" instead of phrasing like, "…the group of students looked at colored words and then later looked at black and white words…").

The degrees of freedom for the t-test ran is given as 48 (*t(48)*).
As this is an indepdendent t-test, two parameters had to be estimated, the mean of the population from which group 1 was drawn, and the mean of the population from which group 2 was drawn. Therefore, we have the relationship

$$
\begin{aligned}
df &= [\textit{Things we know } (n_{total})] - [\textit{Estimated Parameters } (n_{P,est})] \\
df &= n_{total} - n_{P,est} \\
48 &= n_{total} - 2 \\
48 + 2 &= n_{total} \\
50 &= n_{total}
\end{aligned}
$$

Therefore, there were a total of 50 students in the study, with 25 in each group given that the prompt states the same number of students were in each group.

Research Prompt for Q04 through Q09:

You are teaching your first Intro to Psychology course! After the midterm, you are disappointed with your students' overall test scores. You decide to implement two different required study techniques. There are 100 students in the class; 50 of them will be required to meet in groups to study right before the final (Group A) and the other 50 will be required to create flashcards to aid in memorization (Group B). You are interested in two primary research questions:

Research Question 1 (RQ1): Q04 - Q06:

Did student test scores improve significantly from the midterm to the final?
Data: *308A.RQ1 Data.DA4.csv*

Question 04 (Q04):

4. Visualize your data for this research question. Include your visualization here.

Answer to Q04:

Loading Data for Q04: The first step to visualizing the data is to load it. See code below:

```r
# In order to visualize the data we must first load it. To do so we lool
# in the present working directory for CSV files, and take the one that
# has RQ1 in its filename. Append it to the current working directory
# to create the fullpath for loading
here <- getwd()
rq1_name <- list.files(here, pattern = ".*RQ1.*csv")

# Use the file.path function to create a platform appropriate fullpath / filename
# to the Research Question 1 data.
rq1_file <- file.path(here, rq1_name)

# Read the CSV data in as rq1_dat
rq1_dat <- read.csv(rq1_file, header = TRUE)

# Lower-case all column names for convenience
colnames(rq1_dat) <- tolower(colnames(rq1_dat))
```

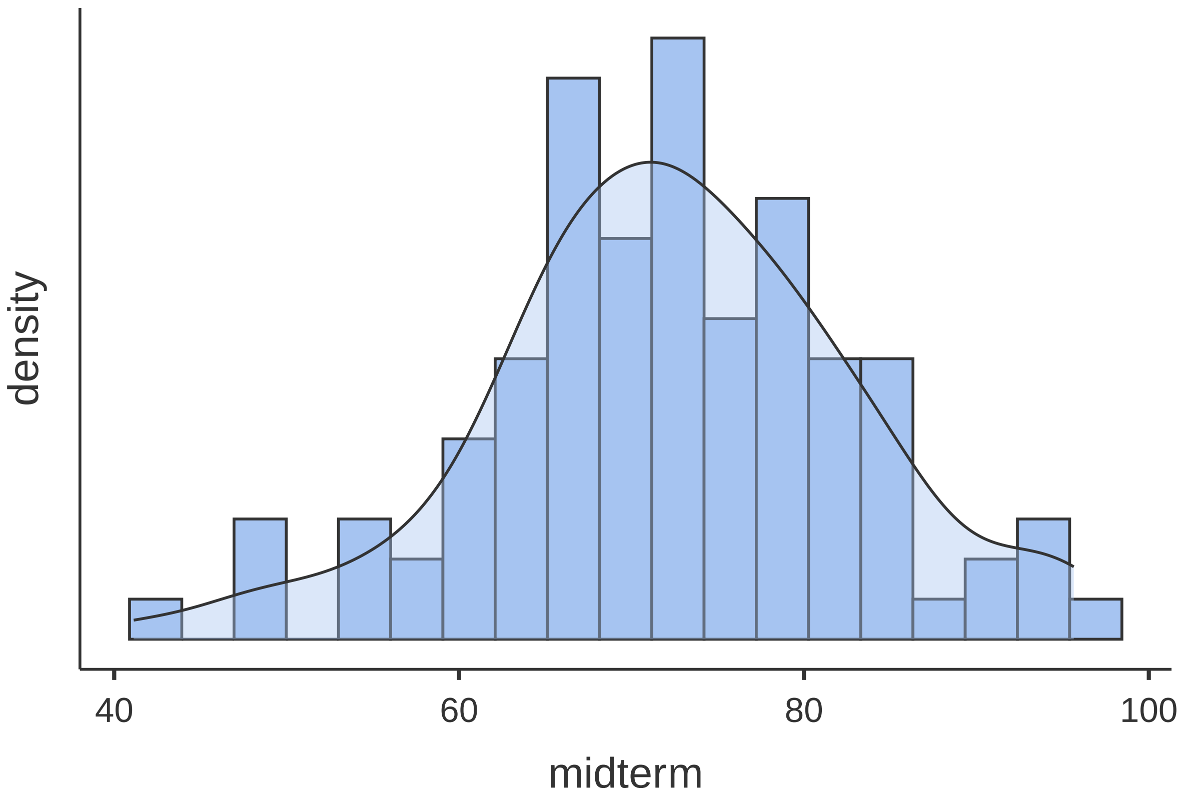
Data Prep Q04 Ultimately we're going to answer Research Question 1 as a dependent T-test since we're evaluating change in student test scores over time (regardless) of study method. So we're going to prepare the data further with some math. See code below:

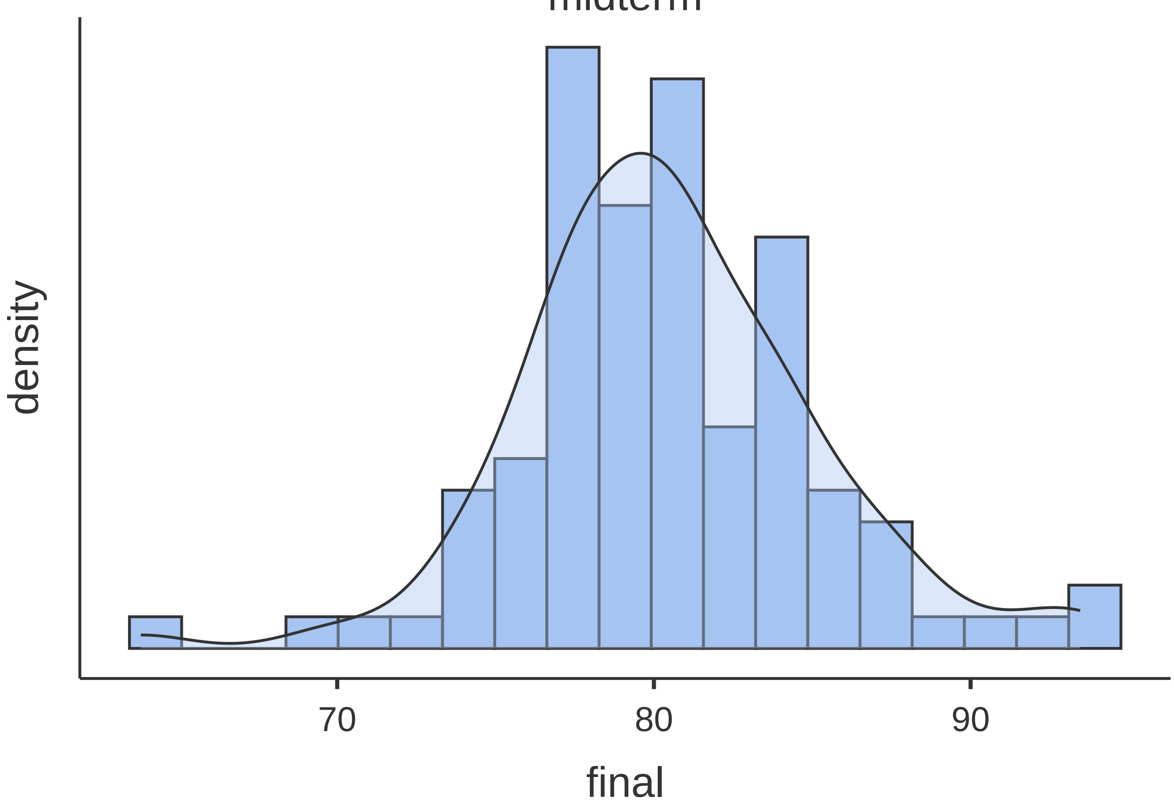
```r
# Since we want to know if scores improved between the midterm and final we'll
# look at midterm scores, final scores, and the delta between the two.
# To do this, we need to add one more column to our math, the difference
# between the two. We need to maintain chirality (direction) as it will
# be informative if scores rise or decrease so we will do final - midterm
# without taking the absolute value. If scores decreased, we should see a
# positive mean of the diff. If they decreased we'll see a negative mean
# of the diff.
rq1_dat$fin_mid_diff <- rq1_dat$final - rq1_dat$midterm
```

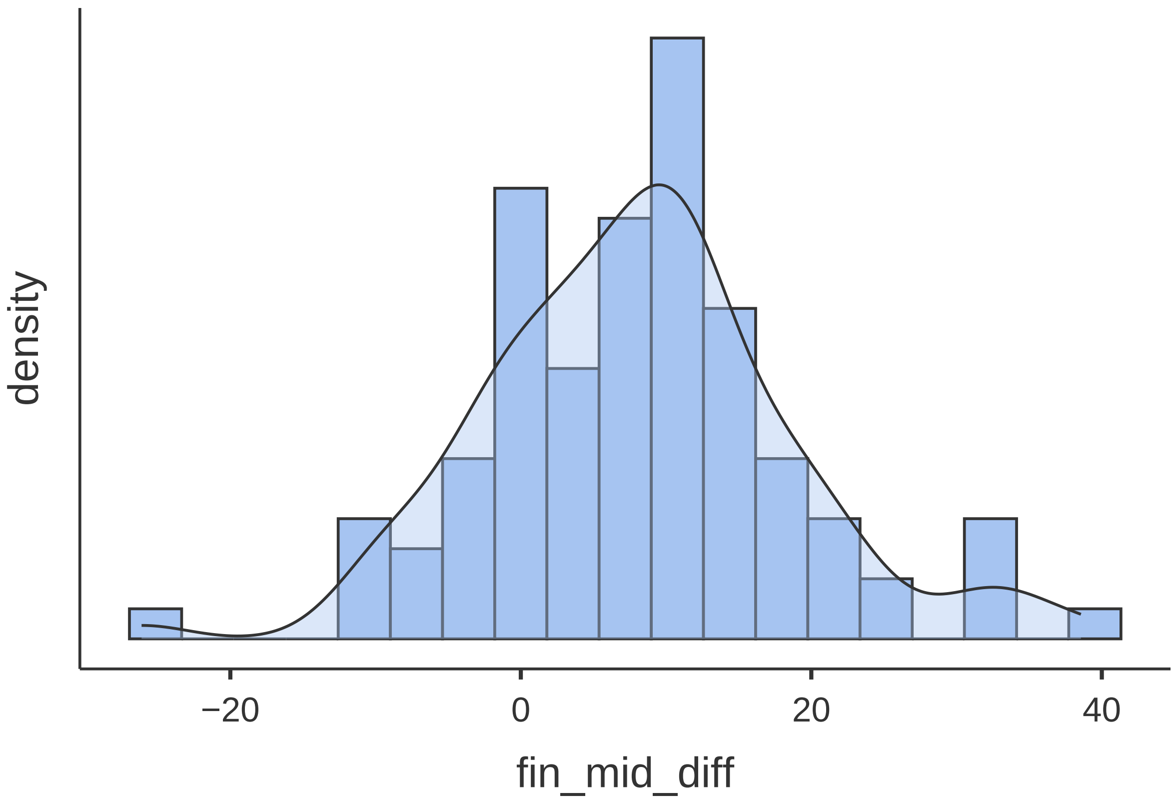
Visualize Prepared Data Q04 - Descriptives and Bar Chart See the histograms below for visualization of the data pertinent to this
research question. Bar graphs of the midterm scores, the final scores, and
the diff of final - midterm are also shown for better understanding

```r
# We're going to create a descriptives object so we can checkout the histogram
# and descriptive stats of the midterm scores, the final scores, and the
# diff of both.
rq1_desc <- jmv::descriptives( rq1_dat[2:4],
                               hist = TRUE,
                               dens = TRUE,
                               sd = TRUE,
                               variance = TRUE,
                               se = TRUE,
                               skew = TRUE,
                               kurt = TRUE
                             )

# Render the rq1 descriptives object as output.
rq1_desc
```

```
##
##  DESCRIPTIVES
##
##  Descriptives
##
##                          midterm       final         fin_mid_diff
##
##    N                           100           100             100
##    Missing                       0             0               0
##    Mean                   72.39620      80.45750        8.061300
##    Std. error mean        1.060126     0.4742058        1.064727
##    Median                 72.16500      80.22500        8.545000
##    Standard deviation     10.60126      4.742058        10.64727
##    Variance               112.3867      22.48712        113.3644
##    Minimum                41.13000      63.80000       -26.11000
##    Maximum                95.65000      93.46000        38.56000
##    Skewness             -0.1713860    0.08208768       0.1736520
##    Std. error skewness   0.2413798     0.2413798       0.2413798
##    Kurtosis              0.4235590      1.572569       0.9956757
##    Std. error kurtosis   0.4783311     0.4783311       0.4783311
##
```

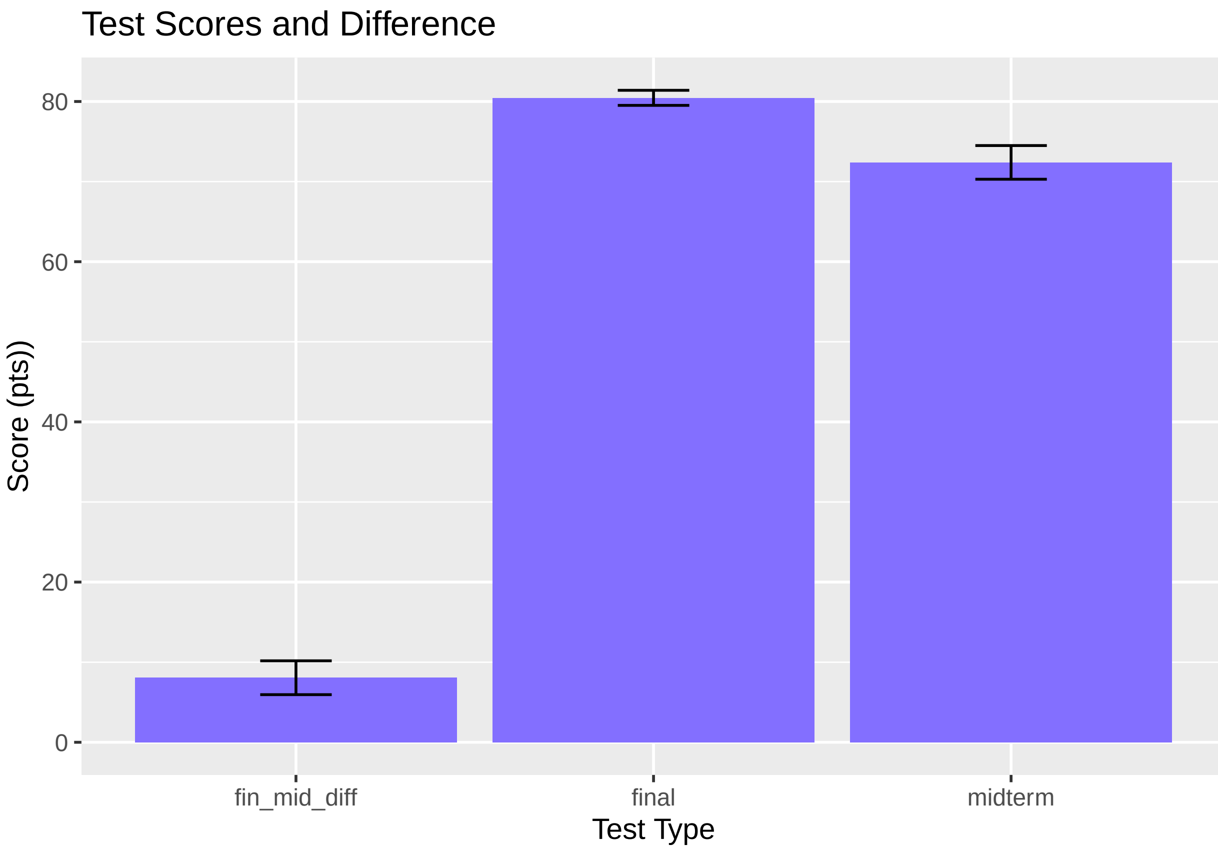

density
40
60
80
100
midterm


density
70
80
90
final




```
# Now we're going to create a bar chart of the midterm scores, final scores,
# and diffs .. though the diffs data willbe oddly scaled (much smaller) than the
# raw scores

# In order to plot the scores as bar charts, we need to permute the data so all
# scores are in one vector and there's n indy axis vector of the same size that
# defines whether the score is a midterm score, final score, or difference.
# We use pivot_longer to concatenate the three dcore vectors to each other
# (interleaved), with the column names saved in the new "name" vector.
rq1_long <- rq1_dat[2:4] %>%
            pivot_longer(cols = c(midterm, final, fin_mid_diff) )

# We're going to lay all three datasets out on a single bar graph
# even though that may jackup the scaling to be bad for the diff.
bar_rq1 <- ggplot( rq1_long, aes(name, value) )



# Annotate the ggplot object to make a bar graph of test scodes.
bar_rq1 + stat_summary( fun = mean,
                        geom = "bar",
                        position = "dodge",
                        fill="slateblue1"
                      ) +
          stat_summary( fun.data = mean_cl_normal,
                        geom = "errorbar",
                        position = position_dodge(width = 0.90),
                        width = 0.2
```

```r
                  ) +
        labs(x = "Test Type", y = "Score (pts))") +
        ggtitle('Test Scores and Difference')
```



Discussion of Visualization for RQ1 It is notable that the error bar on the final scores is so much tighter than
that of the midterm scores. This is reflected in the final scores histogram which looks less "spread out" (smaller variance) than the same of the midterm scores. The larger spread in the differences of scores is also accounted for by the larger spread in the midterms as the tighter final scores minus the more spread out midterm scores will result in more spread out differences.

Question 05 (Q05):

5. Did student test scores improve significantly from the midterm to the final? Using RStudio to analyze, conduct a hypothesis test to evaluate this question. Organize your answer according to the 4 steps of hypothesis testing.

Answer to Q05:

Question 05 T-Test Code: The code below runs the t-test by feeding the final and midterm scores, not the
manually written diff above, to the t-test algorithm for paired samples. The

organization of the results of this t-test, according to the 4 steps of NHST are
in the next section.

```r
# We use the ttestPS to conduct a paired samples t-test from the jamovi (jmv)
# package. We want to include the effect size, confidence intervals, the
# means of our inputs, the standard errors, and the descriptive statistics in
# out output.
# NOTE: we supply "final" scores as i1 instead of i2 because that seems to
#       give the same directionality in mean difference in what we found
#       in our descriptive stats above.
rq1_test_results <- jmv::ttestPS( data = rq1_dat,
                                  pairs = list(list(i1='final', i2='midterm')),
                                  effectSize = TRUE,
                                  ci = TRUE,
                                  meanDiff = TRUE,
                                  desc = TRUE
                                 )
# Dump the test results to output
rq1_test_results
```

```
##
##  PAIRED SAMPLES T-TEST
##
##  Paired Samples T-Test
##
##                                        statistic    df          p              Mean difference    SE di
##
##    final    midterm    Student's t     7.571237    99.00000    < .0000001           8.061300
##
##    Note. H   <sub>Measure 1 - Measure 2</sub>   0
##
##
##  Descriptives
##
##                N      Mean        Median      SD           SE
##
##    final      100    80.45750    80.22500     4.742058    0.4742058
##    midterm    100    72.39620    72.16500    10.601257    1.0601257
##
```

```r
# save the test results in a dataframe object for use later
rq1_test_df <- rq1_test_results$ttest$asDF
```

Question 05 Discussion To perform the significance test we use the SCEC acronym to remember our steps:
Specify, Criteria, Estimate, Conclude:

1. **Specify** the Hypotheses:

    a. *Null Hypothesis:* Student test scores did **not** significantly change between the midterm and the final.
    b. *Alternative Hypothesis*: Student test scores dd change significantly between the midterm and the final.

$$H_0: \mu_{diff} = 0$$
$$H_1: \mu_{diff} \neq 0$$

2. **Criteria:** We will check for significance using a two-tailed t-test with *alpha* set to .05. Our degrees of freedom will be equal to the number of samples we can take differences between, n_{diff} (a.k.a. the number of things we know), minus the number of things we're estimating, in this case the mean difference in scores from the population, of which there is 1.
   So: $df\ =\ n_{diff}\ -\ 1$
   $df\ =\ 100\ -1$
   $df\ =\ 99$
   ... which gives us a t_{crit} of 1.984

   $\alpha\ =\ .05$
   $df\ =\ 99$
   $t_{crit}\ =\ 1.984$

3. **Estimate:** Given the test conducted in the R-code above, we found the following t-test results. Please note that all values printed below are generated in text, on the fly, using the embedded r/tex-code shown after the printout:

   $\bar{x}_{diff}\ =\ 8.0613$
   $ESE_{diff}\ =\ 1.064727$
   $t_{calc}\ =\ 7.5712366$
   p $<$ .000001
   $d\ =\ 0.7571237$
   $\eta^2\ =\ 0.3666984$

   Verbatim Code:

```
$\bar{x}_{diff}\ =\ $ `\r rq1_test_df$'md[stud]'`
$ESE_{diff}\ =\ $ `\r rq1_test_df$'sed[stud]'`
$t_{calc}\ =\ $ `\r rq1_test_df$'stat[stud]'`
`\r if( rq1_test_df$'p[stud]' >= 0.000001 ){ paste("p =", str_sub(sprintf("%.3f", rq1_test_df$'p[st
$d\ =\ $ `\r rq1_test_df$'es[stud]'`
$\eta^2\ =\ $ `\r rq1_test_df$'stat[stud]'^2 / (rq1_test_df$'stat[stud]'^2 + rq1_test_df$'df[stud]'
```

4. **Conclude:** Given that $t_{calc} > t_{crit}$ we reject H_0. The test scores did change significantly between the midterm and the final. Given that $\bar{x}_{diff}$ is positive when the midterm scores are subtracted from the final scores, this indicates that the test scores significantly improved between the midterm and the final.

Question 06 (Q06):

6. Report your findings in APA format. (Hint: make sure to answer the research question!)

Answer to Q06: We conducted a dependent t-test to examine whether test scores improved between the midterm and final tests for a class of 100 students given required study techniques. We found that final test scores, after implementing the study techniques, were significantly improved (final, $\bar{x}\ =\ 80.46,\ SD\ =\ 4.74$) compared to midterm test scores before the study techniques were implemented (midterm, $\bar{x}\ =\ 72.40,\ SD\ =\ 10.60$), t(99) = 7.57, p $<$ .001, $\eta^2 = .37$. This was a large effect; the introduction of study techniques accounted for 37% of variance in the test score differences.

Research Question 2 (RQ2): Q07 - Q09:

Does the study technique used predict scores on the final exam?
Data: *308A.RQ2 Data.DA4.csv*

Question 07 (Q07):

7. Visualize your data for this research question. Include your visualization here.

Answer to Q07:

Loading Data for Q07: The first step to visualizing the data is to load it. See code below:

```
# In order to visualize the data we must first load it. To do so we look
# in the present working directory for CSV files, and take the one that
# has RQ2 in its filename. Append it to the current working directory
# to create the fullpath for loading
here <- getwd()
rq2_name <- list.files(here, pattern = ".*RQ2.*csv")

# Use the file.path function to create a platform appropriate fullpath / filename
# to the Research Question 2 data.
rq2_file <- file.path(here, rq2_name)

# Read the CSV data in as rq1_dat
rq2_dat <- read.csv(rq2_file, header = TRUE)

# Lower-case all column names for convenience
colnames(rq2_dat) <- tolower(colnames(rq2_dat))
```

Data Prep Q07 Ultimately we're going to answer Research Question 2 as an independent t-test since we're evaluating differences in test scores between the study technique employed by Group A and that by Group B. Since we're not looking at matched samples between groups (i.e. the same students are not in both groups) there is no math to do here. We just need to make sure the group category is set to the correct datatype (factor). We also rename the categories as "A" and "B" are not particularly descriptive. See code below:

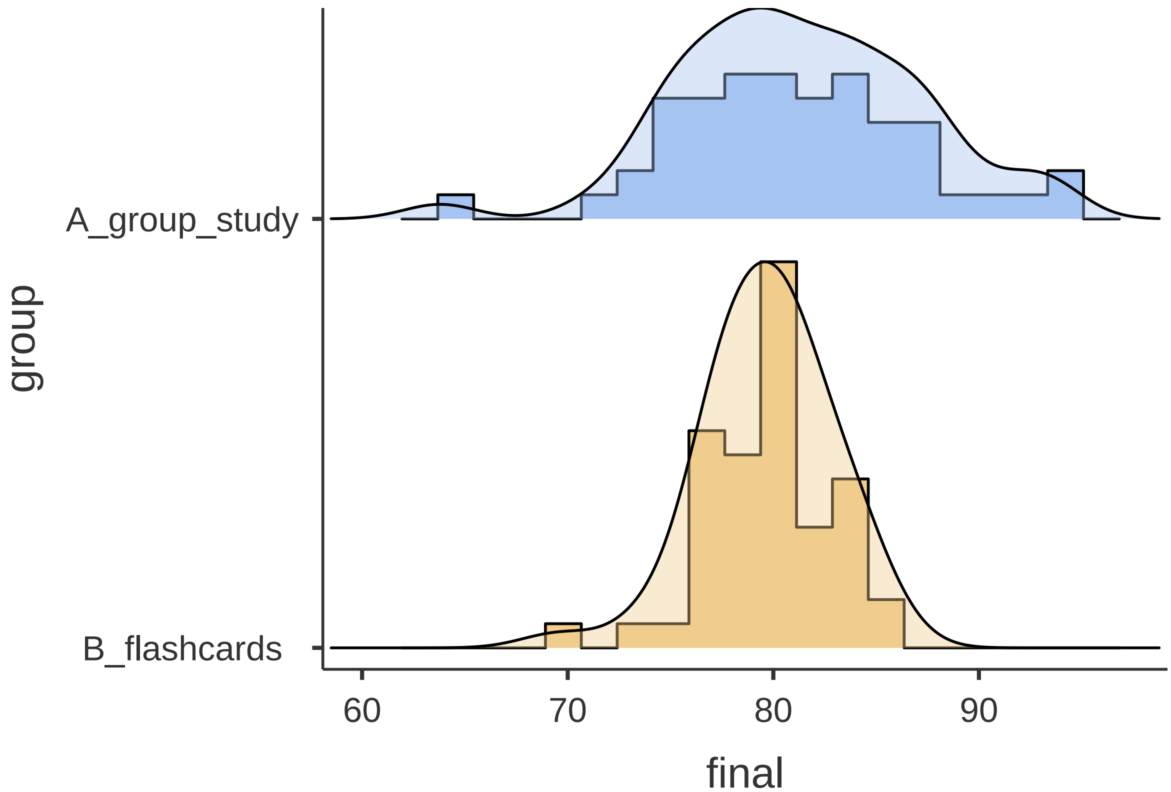
```
# Recast the variables in the "group" vector to be factors instead of freeform
# character strings
rq2_dat$group <- as.factor(rq2_dat$group)

# Rename group "A" to A_group_study and group "B" to "B_flashcards"
levels(rq2_dat$group) <- sub("A", "A_group_study", levels(rq2_dat$group))
levels(rq2_dat$group) <- sub("B", "B_flashcards", levels(rq2_dat$group))
```

Visualize Prepared Data Q07 - Descriptives and Bar Chart See the histograms below for visualization of the data pertinent to this research question (RQ2). Bar graphs of the final scores for Group A and Group B are also shown for better understanding.

```
# We're going to create a descriptives object so we can checkout the histogram
# and descriptive stats of the final scores split by Group. Since we have the
```

```r
# descriptives available for all final scores combined from RQ1 above, we
# won't recreate that here.
rq2_desc <- jmv::descriptives( rq2_dat,
                               vars = c('final'),
                               splitBy = c('group'),
                               hist = TRUE,
                               dens = TRUE,
                               sd = TRUE,
                               variance = TRUE,
                               se = TRUE,
                               skew = TRUE,
                               kurt = TRUE
                              )

# Render the rq2 descriptives object as output.
rq2_desc
```

```
##
##  DESCRIPTIVES
##
##  Descriptives
##
##                           group           final
##
##    N                      A_group_study          50
##                           B_flashcards           50
##    Missing                A_group_study           0
##                           B_flashcards            0
##    Mean                   A_group_study     81.25500
##                           B_flashcards      79.66000
##    Std. error mean        A_group_study    0.8349668
##                           B_flashcards     0.4307366
##    Median                 A_group_study     80.94000
##                           B_flashcards      79.78500
##    Standard deviation     A_group_study     5.904107
##                           B_flashcards      3.045768
##    Variance               A_group_study     34.85848
##                           B_flashcards      9.276702
##    Minimum                A_group_study     63.80000
##                           B_flashcards      69.54000
##    Maximum                A_group_study     93.46000
##                           B_flashcards      85.75000
##    Skewness               A_group_study   -0.1407758
##                           B_flashcards    -0.5920366
##    Std. error skewness    A_group_study    0.3366007
##                           B_flashcards     0.3366007
##    Kurtosis               A_group_study    0.5314386
##                           B_flashcards      1.417350
##    Std. error kurtosis    A_group_study    0.6619084
##                           B_flashcards     0.6619084
##
```




```
# Now we're going to create a bar chart of the final scores sorted by group.
# No pivoting is needed here as data is already properly formatted.

# First we create the bar chart ggplot object via associating the group with
# the scores as an aesthetic object (aes)
bar_rq2 <- ggplot( rq2_dat, aes(group, final) )

# Now we annotate the bar chart appropriately. Bars will be colored orchid.
# error bars will be added.
bar_rq2 + stat_summary( fun = mean,
                        geom = "bar",
                        position = "dodge",
                        fill="orchid1"
                       ) +
          stat_summary( fun.data = mean_cl_normal,
                        geom = "errorbar",
                        position = position_dodge(width = 0.90),
                        width = 0.2
                       ) +
          labs(x = "Study Method of Group", y = "Score (pts))") +
          ggtitle('Final Test Scores by Study Method')
```

Discussion of Visualization for RQ2 The study technique employed by Group B, using flashcards for memorization,
produced less spread in test scores for that group, however, the mean final test scores were remarkably similar to those of Group A. Despite this, the study technique employed by Group A, studying in groups right before the final exam had more spread out test scores (higher variance / standard deviation). I'll be surprised if the difference in means between these two groups is significant.

Question 08 (Q08):

8. Does the study technique used predict scores on the final exam? Using RStudio to analyze, conduct a hypothesis test to evaluate this question. Organize your answer according to the 4 steps of hypothesis testing.

Answer to Q08:

Question 08 T-Test Code: The code below runs the t-test by feeding the final test scores to the t-test algorithm for independent samples. The organization of the results of this t-test, according to the 4 steps of NHST are in the next section.

```
# We use the ttestIS to conduct an independent t-test from the jamovi (jmv)
# package. We want to include the effect size, confidence intervals, the
# means of our inputs, the standard errors, and the descriptive statistics in
# out output.
rq2_test_results <- jmv::ttestIS( data = rq2_dat,
```

```r
                                    vars = 'final',
                                    group = 'group',
                                    effectSize = TRUE,
                                    ci = TRUE,
                                    meanDiff = TRUE,
                                    desc = TRUE
                                   )
# Dump the test results to output
rq2_test_results
```

```
##
##  INDEPENDENT SAMPLES T-TEST
##
##  Independent Samples T-Test
##
##                             Statistic     df          p            Mean difference    SE difference
##
##    final    Student's t    1.697670     98.00000    0.0927436           1.595000        0.9395231
##
##    Note. H   <sub>A_group_study</sub>   <sub>B_flashcards</sub>
##     Levene's test is significant (p < .05), suggesting a violation of the assumption of equal varian
##
##
##  Group Descriptives
##
##             Group            N     Mean        Median      SD          SE
##
##    final    A_group_study    50    81.25500    80.94000    5.904107    0.8349668
##             B_flashcards     50    79.66000    79.78500    3.045768    0.4307366
##
```

```r
# save the test results in a dataframe object for use later
rq2_test_df <- rq2_test_results$ttest$asDF
```

Question 08 Discussion To perform the significance test we use the SCEC acronym to remember our steps:
Specify, Criteria, Estimate, Conclude:

1. **Specify** the Hypotheses:

   a. *Null Hypothesis:* There is **no** difference between the final test scores of students using the Group A study technique vs. students using the Group B study technique.
   b. *Alternative Hypothesis*: There mean of Group A's final scores is different than the mean of Group B's final scores.

   $H_0 : \mu_A = \mu_B$
   $H_1 : \mu_A \neq \mu_B$

2. **Criteria:** We will check for significance using a two-tailed t-test with *alpha* set to .05. Our degrees of freedom will be equal to the total number of students between both groups, $n_A + n_B$ (a.k.a. the number of things we know), minus the number of things we're estimating, in this case the mean of the final test scores for Group A and the mean of the final test scores for Group B, or two items.
   So: $df = n_{students} - 2$

$df\ =\ 100\ -2$
$df\ =\ 98$
... which gives us a t_{crit} of 1.984

$\alpha\ =\ .05$
$df\ =\ 98$
$t_{crit}\ =\ 1.984$

3. **Estimate:** Given the test conducted in the R-code above, we found the following t-test results. Please note that all values printed below are generated in text, on the fly, using the embedded r/tex-code shown after the printout:

   $\bar{x}_{A}\ -\ \bar{x}_{B}\ =\ 1.595$
   $ESED\ =\ 0.9395231$
   $t_{calc}\ =\ 1.6976698$
   p = .093
   $d\ =\ 0.339534$
   $\eta^2\ =\ 0.0285688$

   Verbatim Code:

```
$\bar{x}_{A}\ -\ \bar{x}_{B}\ =\ $ `\r rq2_test_df$'md[stud]'`
$ESED\ =\ $ `\r rq2_test_df$'sed[stud]'`
$t_{calc}\ =\ $ `\r rq2_test_df$'stat[stud]'`
`\r if( rq2_test_df$'p[stud]' >= 0.000001 ){ paste("p =", str_sub(sprintf("%.3f", rq2_test_df$'p[st
$d\ =\ $ `\r rq2_test_df$'es[stud]'`
$\eta^2\ =\ $ `\r rq2_test_df$'stat[stud]'^2 / (rq2_test_df$'stat[stud]'^2 + rq2_test_df$'df[stud]'
```

4. **Conclude:** Given that $t_{calc}\ <\ t_{crit}$ we fail to reject H_0.
   The mean final test scores **did not** vary significantly between Group A and Group B. We failed to find a significant difference in study technique impact on final test scores.

Question 09 (Q09):

9. ...

   a. Report your findings in APA format. (Hint: make sure to answer the research question!)

      Answer (9.a): We conducted an independent t-test to determine whether studying as a group just prior to a course final (Group A), or studying using flashcards to improve memorization (Group B), was better at improving final test scores amongst 100 students, with 50 students randomly assigned to each group. The students studying as a group ($\bar{x}_{A}\ =\ 81.23$) did *not* perform significantly better or worse than those studying with flashcards ($\bar{x}_{B}\ =\ 79.66$), t(98) = 1.70, p = .093, η^2 = .03. This was a small effect, the difference in study technique accounted for slightly less than 3% of variance the final scores of the students.

   b. The Dean of the university was also interested in your results, as this may help to raise scores in other departments. Unfortunately, she does not understand statistical language. Please interpret your findings for the Dean. Did scores improve? Which technique is better?

Answer (9.b): We required students to try one of two study techniques between the midterm and the final of our psychology course to determine which technique, if any, was better at improving test scores. We found that both techniques, studying in groups just before the final, and using flashcards to improve memorization, significantly improved test scores. The study techniques accounted for 37% of the improvement measured in test scores. However, we also found that neither study technique was notably better than the other. So students could use either or both techniques to improve scores.

Question 10 (Q10):

10. A developmental psychologist is interested in the effect of a positive psychology intervention on the well-being of aging adults. She administers the intervention, collects well-being scores from a sample of 100 participants, and tests whether their well-being differs significantly from the national average. Using G*Power, she determines the power for her test is .80.

    a. Interpret this value

    b. What suggestion would you give her if she wants a higher probability of detecting a true effect?

Answer to Q10:

10.a Answer:

It's difficult to determine exactly what to make if the power value given by the researcher as the manner in which G*Power was used to calculate power is unclear. However, the G*Power manual does give at least one effect size index table in section 3.1 which indicates values above .50 should be be considered large. This is consistent with Cohen's d, which is what G*Power validated against according to the User Manual. Therefore, we can, with some assumption, conclude that the developmental psychology did find a large effect of the intervention on the well-being of aging adults. We can't say much more without knowing how, mathematically, the .80 was calculated.

10.b Answer:

If the researcher wanted a higher probability of detecting a true effect, I would suggest she run another study evaluating the intervention via a dependent-samples t-test method. That is, she should collect data on the well-being of the study participants **before** the intervention, and then collect the same data on the same participants **after** the intervention and subtract the two well-being scores. This would help eliminate other sources that may have impacted study participants well-being.

Question 11 (Q11):

11. What would it mean if your analysis returned the following values? Consider the meaning of t - not the decision associated with it.

a. $t(24) = 0.35$

b. $t(24) = 1.00$

c. $t(24) = 3.2$

Answer to Q11:

T-scores are effectively Z-scores that are drawn from a slightly differently shaped normal curve (standardized to a different denominator) because the population standard deviation is unknown. In the case of hypothesis testing, where we are evaluating the distance of some sample statistic (usually the mean) from the population parameter as normalized to an estimated standard error, we're effectively reporting the distance between our sample mean and the population mean as a multiple of estimated standard error units. So, given that context, here are my answers:

11.a

The sample mean is roughly 1/3rd (or 0.35 times) of an estimated standard error unit away from the population mean. In context this would imply the sample mean is relatively close to the population mean.

11.b

The sample mean is precisely one estimated standard error unit away from the population mean. In context this would imply the sample mean you drew is likely within a relatively tight grouping of all the possible means that could have been drawn for your sample size.

11.c

The sample mean is roughly 3.2 times an estimated standard erroru nit away from the population mean. In context this would imply the sample mean far from the population mean implying that it may be unlikely to have been drawn from the assumed population. —

Question 12 (Q12):

12. Draw and annotate all the properties of the null and alternative curves: power, beta, alpha, type 1 error, type 2 error.

Answer to Q12:

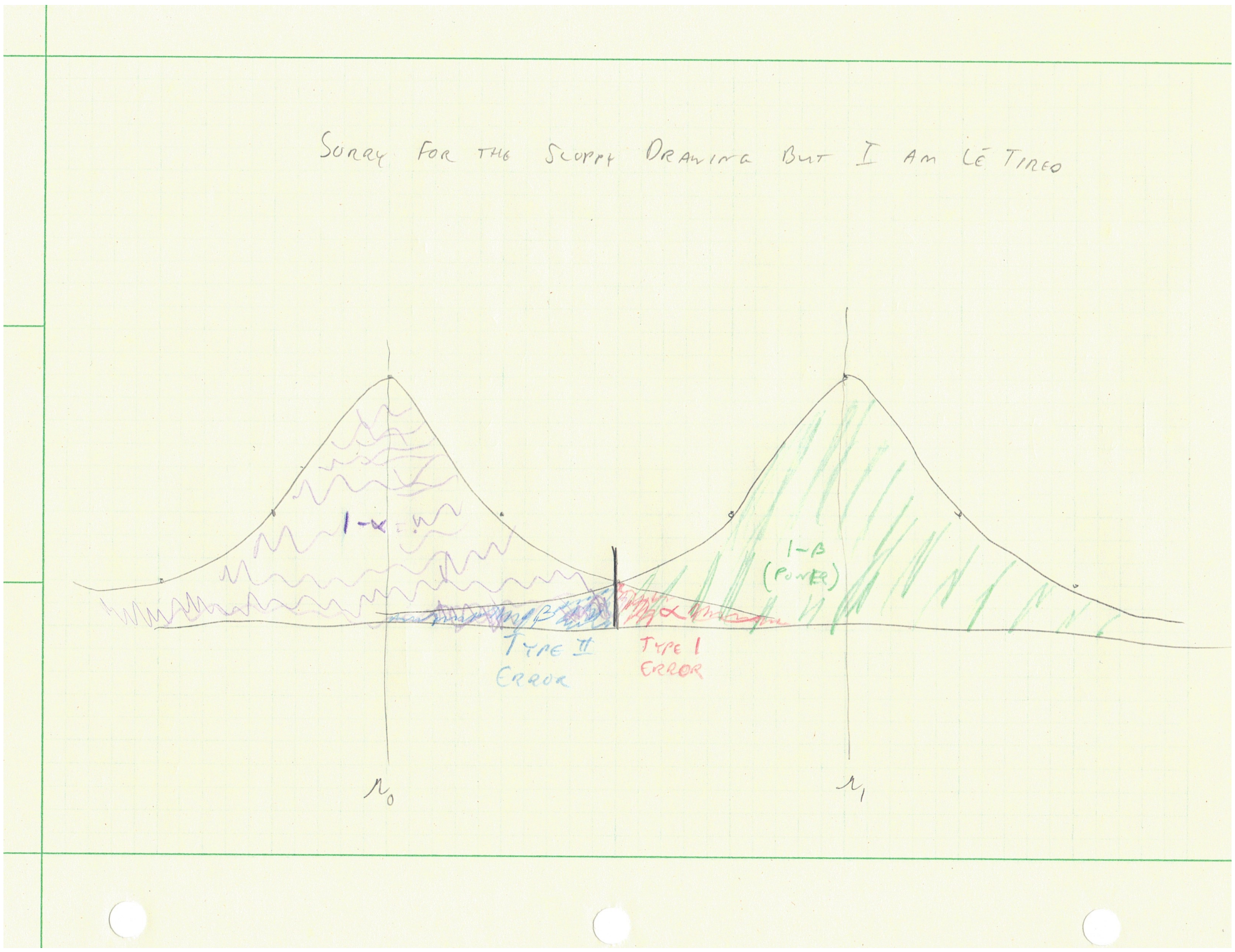


Figure 1: See hand-drawn picture above