Psy/Educ 6600: Unit 5 Homework

Chapter 16: Mixed Design ANOVA

Your Name

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PREPARATION

Packages

Make sure the packages are **installed** *(Package tab)*

```
library(magrittr)      # Forward pipes in R
library(tidyverse)     # Loads several very helpful 'tidy' packages
library(readxl)        # Read in Excel datasets
library(furniture)     # Nice tables (by our own Tyson Barrett)
library(psych)         # Helpful tid-bits
library(afex)          # Analysis of Factorial Experiments
library(emmeans)       # Estimated marginal means (Least-squares means)
```

SECTION B

Datasets

```
tasks_wide <- data.frame(id = 1:5,
                         clerical_background   = c(10,  7, 13, 18,  6),
                         clerical_popular      = c(12,  9, 15, 12,  8),
                         clerical_metal        = c( 8,  4,  9,  6,  3),
                         mechanical_background = c(15, 19,  8, 10, 16),
                         mechanical_popular    = c(18, 22, 12, 10, 19),
                         mechanical_metal      = c(20, 23, 15, 14, 19))

anograms_wide <- data.frame(id = 1:3,
                            none_5    = c( 9, 10, 12),
                            none_6    = c( 6,  7,  9),
                            none_7    = c( 4,  4,  7),
                            none_8    = c( 2,  3,  5),
                            alone_5   = c(19, 19, 22),
                            alone_6   = c(16, 15, 20),
                            alone_7   = c(15, 11, 17),
                            alone_8   = c(12, 11, 14),
                            withEgo_5 = c(30, 31, 34),
                            withEgo_6 = c(25, 30, 32),
                            withEgo_7 = c(22, 27, 28),
                            withEgo_8 = c(21, 23, 24))

brain_wide <- data.frame(id = 1:6,
                         left_digit   = c( 6,  8,  7,  8,  6,  7),
                         left_letter  = c( 5,  7,  7,  5,  4,  6),
                         left_mixed   = c( 6,  5,  4,  8,  7,  5),
                         right_digit  = c( 9,  8,  9,  7,  7,  9),
                         right_letter = c( 8,  8,  7,  8,  6,  8),
                         right_mixed  = c( 6,  7,  8,  8,  7,  9),
                         none_digit   = c( 8, 10,  9,  9,  8, 10),
                         none_letter  = c( 8,  9, 10,  7,  8, 10),
                         none_mixed   = c( 7,  9,  8,  9,  8,  9))
```

`tasks_wide` - Repeated Measures and Assigned Group Design: Differential Effect of Music on Production, by Task Type

TEXTBOOK QUESTION: *In Exercise 15B1, subjects performed a clerical task under three noise conditions. Now suppose a new group of subjects is added to study the effects of the same three conditions on the performance of a simpler, more mechanical task. The data from Exercise 15B1 follow, along with the data for the mechanical task.*

Restructure from wide to long format:

```
            id        type_task      noise completed
1   1_clerical   Clerical Tasks Background        10
2   1_clerical   Clerical Tasks    Popular        12
3   1_clerical   Clerical Tasks      Metal         8
4 1_mechanical Mechanical Tasks Background        15
5         <NA>             <NA>       <NA>       ...
6   5_clerical   Clerical Tasks      Metal         3
7 5_mechanical Mechanical Tasks Background        16
8 5_mechanical Mechanical Tasks    Popular        19
9 5_mechanical Mechanical Tasks      Metal        19
```

Summary Statistics

Table 1: Descriptives: Performance by Task Type and Noise

		Type of Task	
	Total n = 10	Clerical Tasks n = 5	Mechanical Tasks n = 5
Background			
	12.2 (4.7)	10.8 (4.9)	13.6 (4.5)
Popular			
	13.7 (4.6)	11.2 (2.8)	16.2 (5.0)
Metal			
	12.1 (7.1)	6.0 (2.5)	18.2 (3.7)

Exploratory Visulaizations

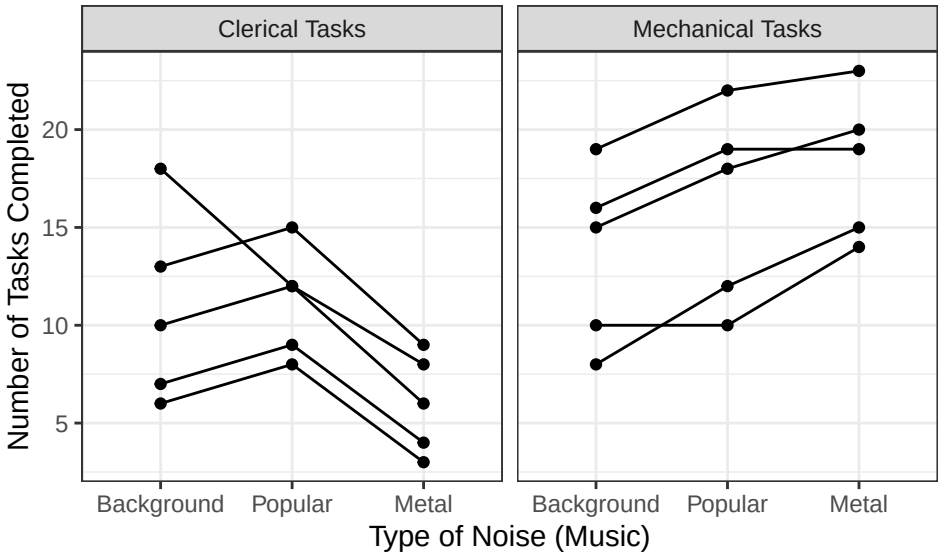

Figure 1: Person Profile Plot: Performance by Task Type and Noise

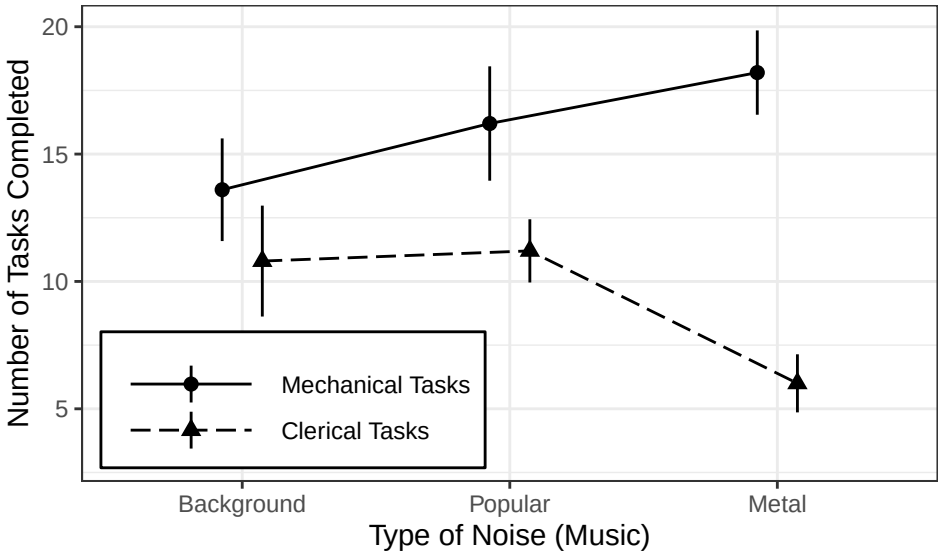

Figure 2: Group Means Plot: Performance by Task Type and Noise

Question B-4a Mixed Design ANOVA: display all Sums-of-Squares components

TEXTBOOK QUESTION: *(a) Perform a mixed-design ANOVA, and display the results in a summary table.*

DIRECTIONS: Perform a Repeated Measures ANOVA for number of tasks completed under the four noise conditions to see if there is an effect and if the effect is different dependtion on the type of task. Request no correction for violations of sphericity (`correction = "none"`) and both effect sizes (`es = c("ges", "pes")`. Make sure to save your model (`fit_tasks`), so that you can add `$aov` at the end of the name to extract all the Sums-of-Squares.

```
# Mixed ANOVA: display all Sums-of-Squares components
```

Question B-4b Mixed Design ANOVA: effect sizes

TEXTBOOK QUESTION: *(b) Calculate generalized eta squared for the main effect of the type-of-task factor. Does this look like a large effect size? Explain.*

DIRECTIONS: Run the name of the model `fit_tasks` alone to extract the adjusted degrees of freedom and F-test. The sums-of-squares for the corrected test are the same as for the uncorrected you just did.

```
# Mixed ANOVA: name the model was saved as
```

Means Plot (model based)

DIRECTIONS: Construct a means plot of the model using `emmeans::emmip(~ RM_var)` to help interpret the direction of any significant differences.

```
# RM ANOVA: means plot
```

`anograms_wide` -Repeated Measures and Assigned Group Design: Effect of Music and Task Type on Production

TEXTBOOK QUESTION: *Dr. Jones is investigating various conditions that affect mental effort- which, in this experiment, involves solving anagrams. Subjects were randomly assigned to one of three experimental conditions. Subjects in the first group were told that they would not be getting feedback on their performance. Subjects in the second and third groups were told they would get feedback, but only subjects in the third group were told (erroneously) that anagram solving was highly correlated with intelligence and creativity (Dr. Jones hoped this information would produce ego involvement). The list of anagrams given to each subject contained a random mix of problems at four levels of difficulty determined by the number of letters presented (five, six, seven, or eight). The number of anagrams correctly solved by each subject in each condition and at each level of difficulty is given in the following table:*

Restructure from wide to long format:

```
         id          feedback difficulty correct
1    1_none       No Feedback   Length 5       9
2    1_none       No Feedback   Length 6       6
3    1_none       No Feedback   Length 7       4
4    1_none       No Feedback   Length 8       2
5      <NA>              <NA>       <NA>     ...
6 3_withEgo Feedback and Ego   Length 5      34
7 3_withEgo Feedback and Ego   Length 6      32
8 3_withEgo Feedback and Ego   Length 7      28
9 3_withEgo Feedback and Ego   Length 8      24
```

Summary Statistics

Table 2: Descriptives: Performance by Feedback and Difficulty

		Randomized Condition		
	Total n = 9	No Feedback n = 3	Only Feedback n = 3	Feedback and Ego n = 3
Length 5				
	20.7 (9.4)	10.3 (1.5)	20.0 (1.7)	31.7 (2.1)
Length 6				
	17.8 (9.7)	7.3 (1.5)	17.0 (2.6)	29.0 (3.6)
Length 7				
	15.0 (9.3)	5.0 (1.7)	14.3 (3.1)	25.7 (3.2)
Length 8				
	12.8 (8.5)	3.3 (1.5)	12.3 (1.5)	22.7 (1.5)

Exploratory Visualizations

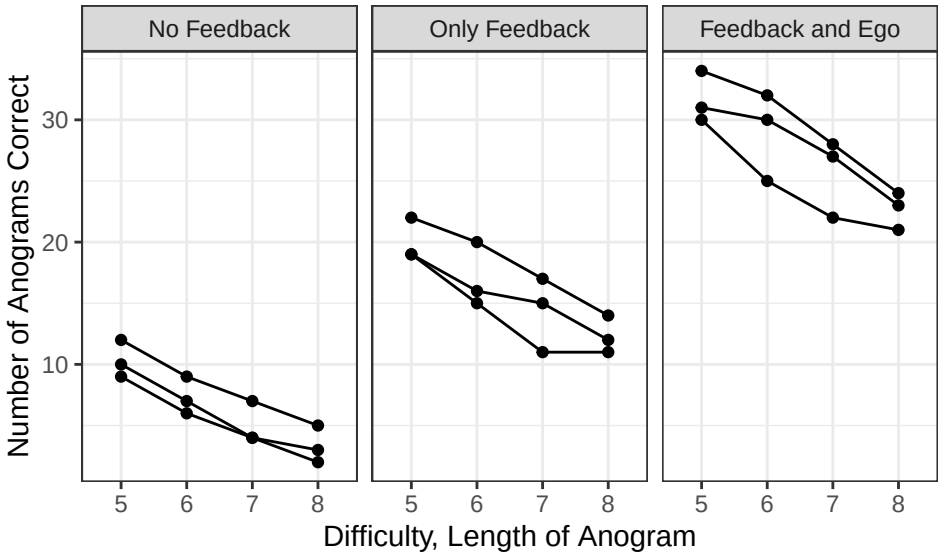

Figure 3: Person Profile Plot: Performance by Feedback and Difficulty

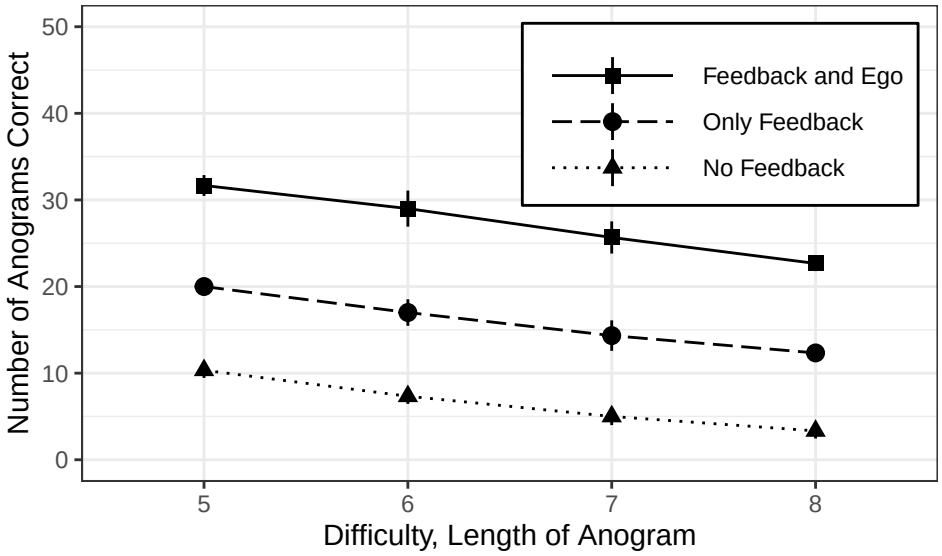

Figure 4: Group Means Plot: Performance by Feedback and Difficulty

Question B-5b Mixed Design ANOVA: display all Sums-of-Squares components

TEXTBOOK QUESTION: *(b) Perform a mixed analysis of variance, and display the results in a summary table. Would any of your conclusions change if you do not assume sphericity? Explain.*

DIRECTIONS: Perform a Repeated Measures ANOVA for number of tasks completed under the four noise conditions to see if there is an effect and if the effect is different dependtion on the type of task. Make sure to save your model (`fit_ano`), so that you can add `$aov` at the end of the name to extract all the Sums-of-Squares.

```
# Mixed ANOVA: display all Sums-of-Squares components
```

DIRECTIONS: Use the `summary()` function on the model name `fit_ano` to display the sphericity test and corrections to answer the last portion of this question.

```
# Mixed ANOVA: sphericity tests and corrections
```

Question B-5c Mixed Design ANOVA: Main Effect's post-hoc with appropriate correction

TEXTBOOK QUESTION: *(c) Perform post hoc pairwise comparisons for both main effects, using the appropriate error term from part b in each case. Explain why these follow-up tests are appropriate given your results in part b.*

DIRECTIONS: Use the prior model `fit_ano` to run post hoc test for the levels of each main effect, separately SINCE THE INTERACTION IS NOT SIGNIFICANT (including a means plot). Choose an appropriate method to control type I errors when making multiple comparisons.

```
# Mixed ANOVA: post hoc pairwise tests <-- feedback
```

```
# RM ANOVA: means plot <--feedback
```

```
# Mixed ANOVA: post hoc pairwise tests <-- difficulty
```

```
# RM ANOVA: means plot <-- difficulty
```

`brain_wide` - Repeated Measures and Observed Groups Design: Differential Effect of Stimuli on Recall, by Brain Damage

TEXTBOOK QUESTION: *Exercise 15B6 described a neuropsychologist studying subjects with brain damage to the left cerebral hemisphere. Such a study would probably include a group of subjects with damage to the right hemisphere and a group of control subjects without brain damage. The data from Exercise 15B6 (the number of digit or letter strings each subject recalled) follow, along with data for the two comparison groups just mentioned.*

Restructure from wide to long format:

```
       id  damage stimuli longest_correct
1  1_left    Left  Digits              6
2  1_left    Left Letters              5
3  1_left    Left   Mixed              6
4 1_right   Right  Digits              9
5    <NA>    <NA>    <NA>            ...
6 6_right   Right   Mixed              9
7  6_none Neither  Digits             10
8  6_none Neither Letters             10
9  6_none Neither   Mixed              9
```

Summary Statistics

Table 3: Descriptives: Recall by Hemisphere and Stimuli

		Hemisphere of Brain Damage		
	Total	Left	Right	Neither
	n = 18	n = 6	n = 6	n = 6
Digits				
	8.1 (1.2)	7.0 (0.9)	8.2 (1.0)	9.0 (0.9)
Letters				
	7.3 (1.6)	5.7 (1.2)	7.5 (0.8)	8.7 (1.2)
Mixed				
	7.2 (1.5)	5.8 (1.5)	7.5 (1.0)	8.3 (0.8)

Exploratory Visualizations

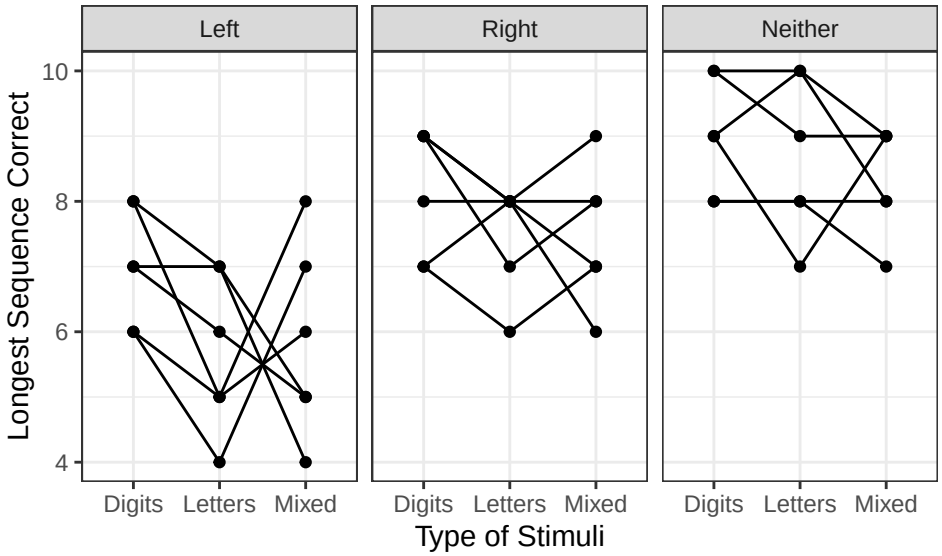

Figure 5: Person Profile Plot: Recall by Hemisphere and Stimul

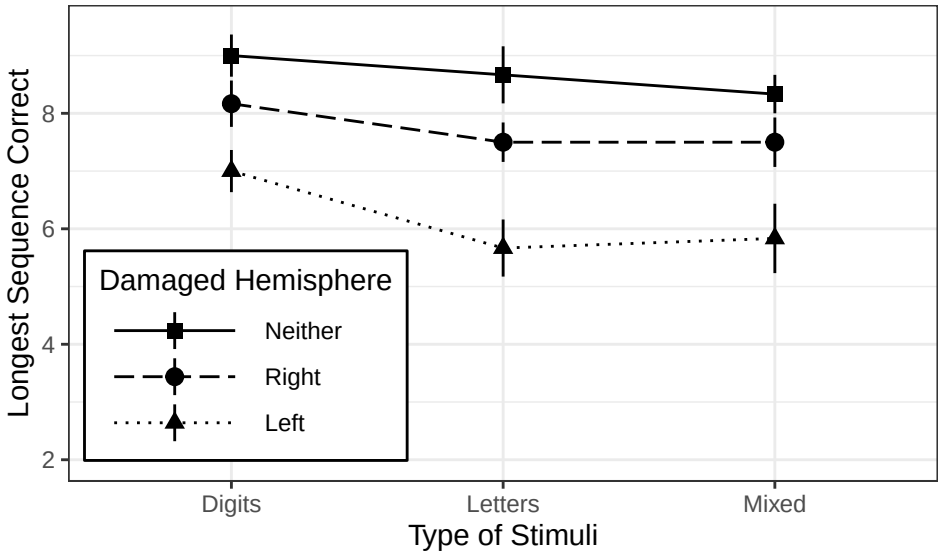

Figure 6: Group Means Plot: Recall by Hemisphere and Stimul

Question B-8a-b Mixed Design ANOVA: with sphericity test and corrections

TEXTBOOK QUESTION: *(a) Perform a mixed-design ANOVA and test the three F ratios at the .05 level. What can you conclude about the effects of brain damage on short-term recall for these types of stimuli? (b) Draw a graph of these data, subject by subject. Do the assumptions of the mixed-design ANOVA seem reasonable in this case? Explain.*

DIRECTIONS: Perform a Repeated Measures ANOVA for longest correct recall under the various stimuli to see if there is an effect and if the effect is different dependtion on brain damage. Make sure to save your model (`fit_brain`), so that you can use the `summary()` function on the name to test for sphericity and make appropriate corrections.

```
# Mixed ANOVA:  with sphericity tests and corrections
```

Question B-8c Mixed Design ANOVA: Main Effect's post-hoc with appropriate correction

TEXTBOOK QUESTION: *(c) Perform post hoc pairwise comparisons for both main effects. Do not assume sphericity for the RM factor.*

DIRECTIONS: Use the prior model `fit_brain` to run post hoc test for the levels of each main effect, separately SINCE THE INTERACTION IS NOT SIGNIFICANT (including a means plot). Choose an appropriate method to control type I errors when making multiple comparisons. (you do not need to worry about sphericity)

```
# Mixed ANOVA: post hoc pairwise tests <-- damage
```

```
# RM ANOVA: means plot <-- damage
```

```
# Mixed ANOVA: post hoc pairwise tests <-- stimuli
```

```
# RM ANOVA: means plot <-- stimuli
```

SECTION C

Import Data, Define Factors, and Compute New Variables

Import Data, Define Factors, and Compute New Variables

- Make sure the **dataset** is saved in the same *folder* as this file
- Make sure the that *folder* is the **working directory**

  NOTE: I added the second line to convert all the variables names to lower case. I still kept the `F` as a capital letter at the end of the five factor variables.

```
ihno_clean <- read_excel("Ihno_dataset.xls") %>%
  dplyr::rename_all(tolower) %>%
  dplyr::mutate(genderF = gender %>%
                  factor(levels = c(1, 2),
                         labels = c("Female",
                                    "Male"))) %>%
  dplyr::mutate(majorF = major %>%
                  factor(levels = c(1, 2, 3, 4,5),
                         labels = c("Psychology",
                                    "Premed",
                                    "Biology",
                                    "Sociology",
                                    "Economics"))) %>%
  dplyr::mutate(reasonF = reason %>%
                  factor(levels = c(1, 2, 3),
                         labels = c("Program requirement",
                                    "Personal interest",
                                    "Advisor recommendation"))) %>%
  dplyr::mutate(exp_condF = exp_cond %>%
                  factor(levels = c(1, 2, 3, 4),
                         labels = c("Easy",
                                    "Moderate",
                                    "Difficult",
                                    "Impossible"))) %>%
  dplyr::mutate(coffeeF = coffee %>%
                  factor(levels = c(0, 1),
                         labels = c("Not a regular coffee drinker",
                                    "Regularly drinks coffee")))
```

`ihno_clean` - Repeated Measures and Observed Group Design: Differential Effect of a Pop Quiz (time = Baseline, pre-quiz, post-quiz) on Anxiety (anxiety), by Major (majorF)

Question C-1a Mixed Design ANOVA: with main effect post hocs

TEXTBOOK QUESTION: *(a) Perform a mixed-design ANOVA with the three anxiety measures as the RM levels, and major as the between-subjects factor. Request a plot of the cell means, ~~and post hoc tests for both the RM factor (LSD) and for major (Tukey)~~. Report the results of the ANOVA in APA style.*

Restructure from wide to long format:

```
ihno_anx_long <- ihno_clean %>%
  tidyr::pivot_longer(cols = c(anx_base, anx_pre, anx_post),
                      names_to = "time",
                      names_prefix = "anx_",
                      names_ptypes = list(time = factor()),
                      values_to = "anxiety")
```

```
ihno_anx_long %>%
  dplyr::select(sub_num, majorF, time, anxiety) %>%
  psych::headTail()
```

```
  sub_num     majorF time anxiety
1       1 Psychology base      17
2       1 Psychology  pre      22
3       1 Psychology post      20
4       2 Psychology base      17
5     ...       <NA> <NA>     ...
6      99  Economics post      18
7     100  Economics base      17
8     100  Economics  pre      11
9     100  Economics post      14
```

DIRECTIONS: Using the `ihno_anx_long` dataset restructured above, perform a Repeated Measures ANOVA for at the three time points to see if the experiment had an effect on anxiety and if the effect is different dependtion on major. Make sure to save your model (`fit_anx_major`), so that you can use the `summary()` function on the name to test for sphericity and make appropriate corrections. Do specify that you would like to display BOTH effect size measures with `es = c("ges", "pes")`, but do NOT include `correction = "none"`.

```
# Mixed ANOVA:  with sphericity tests and corrections
```

DIRECTIONS: To display the effect size meausre, run the name (`fit_anx_major`) of the model alone.

```
# Mixed ANOVA: effect sizes
```

DIRECTIONS: SINCE THE INTERACTIONIS SIGNIFICANT, instead of focusing on the main effects alone, plot the interaction with the `emmeans::emmip(group_var ~ RM_var)` function.

```
# Mixed ANOVA: means plot <-- interaction
```

`ihno_clean` - Repeated Measures and Observed Group Design: Differential Effect of a Pop Quiz (time = Baseline, pre-quiz, post-quiz) on Heart Rate (heart_rate), by Gender (genderF)

Question C-2a Mixed Design ANOVA: with main effect post hocs

TEXTBOOK QUESTION: *(a) Perform a mixed-design ANOVA with the three heart-rate measures as the RM levels and gender as the between-subjects factor. Request a plot of the cell means and post hoc tests for the RM factor (LSD). Report the results of the ANOVA in APA style.*

Restructure from wide to long format:

```
ihno_hr_long <- ihno_clean %>%
  tidyr::pivot_longer(cols = c(hr_base, hr_pre, hr_post),
                      names_to = "time",
                      names_prefix = "hr_",
                      names_ptypes = list(time = factor()),
                      values_to = "heart_rate")
```

```
ihno_hr_long %>%
  dplyr::select(sub_num, genderF, time, heart_rate) %>%
  psych::headTail()
```

```
  sub_num genderF time heart_rate
1       1  Female base         71
2       1  Female  pre         68
3       1  Female post         65
4       2  Female base         73
5     ...    <NA> <NA>        ...
6      99    Male post         73
7     100    Male base         70
8     100    Male  pre         70
9     100    Male post         64
```

DIRECTIONS: Using the `ihno_hr_long` dataset just reformatted, perform a Repeated Measures ANOVA for at the three time points to see if the experiment had an effect on heart rateand if the effect is different dependtion on gender Make sure to save your model (`fit_hr_gender`), so that you can use the `summary()` function on the name to test for sphericity and make appropriate corrections. Do specify that you would like to display BOTH effect size measures with `es = c("ges", "pes")`, but do NOT include `correction = "none"`.

```
# Mixe ANOVA:  with sphericity tests and corrections
```

DIRECTIONS: Use the prior model `fit_hr_gender` to run post hoc test for the levels of each main effect, separately SINCE THE INTERACTION IS **NOT** SIGNIFICANT (including a means plot). Choose an appropriate method to control type I errors when making multiple comparisons. You do not need to worry about sphericity since there are only 2 time points. Also, you do not need to worry about follow-up tests for gender, since it only has 2 levels.

```
# Mixed ANOVA: post hoc pairwise tests <-- time
```

```
# RM ANOVA: means plot <-- time
```

`ihno_clean` - Repeated Measures and Assigned Group Design: Differential Effect of the Experiemnt (quiz_type = Pop Quiz vs. Standard Quiz) on Quiz Score (quiz_score), by Difficulty Level (exp_condF)

Question C-3a Mixed Design ANOVA: is there an interaction?

TEXTBOOK QUESTION: *(a) Perform a mixed-design ANOVA with the two 10-point quizzes (statquiz and exp_sqz) as the RM levels, and exp_cond as the between-subjects factor. Request a plot of the cell means. Report the results of the ANOVA in APA style. If the interaction is significant, explain the pattern you see in the plot of the cell means.*

Restructure from wide to long format:

```
ihno_statquiz_long <- ihno_clean %>%
  tidyr::pivot_longer(cols = c(statquiz, exp_sqz),
                      names_to = "quiz_type",
                      names_ptypes = list(time = factor()),
                      values_to = "quiz_score") %>%
  dplyr::mutate(quiz_type = quiz_type %>%
                  forcats::fct_recode("Regular" = "statquiz",
                                      "Experimental" = "exp_sqz"))
```

```
ihno_statquiz_long %>%
  dplyr::select(sub_num, exp_condF, quiz_type, quiz_score) %>%
  psych::headTail()
```

```
  sub_num  exp_condF    quiz_type quiz_score
1       1       Easy      Regular          6
2       1       Easy Experimental          7
3       2       Easy      Regular          9
4       2       Easy Experimental         11
5     ...       <NA>         <NA>        ...
6      99 Impossible      Regular          8
7      99 Impossible Experimental          8
8     100   Moderate      Regular          7
9     100   Moderate Experimental          7
```

DIRECTIONS: Using the `ihno_statquiz_long` dataset restructured above, perform a Repeated Measures ANOVA for at the two quizes to see if the experiment had an effect on score and if the effect is different dependtion on difficulty level. Make sure to save your model (`fit_quiz_cond`), so that you can use the `summary()` function on the name to view the output. Do specify that you would like to display BOTH effect size measures with `es = c("ges", "pes")`, but do NOT include `correction = "none"`.

> NOTE: When the measure is only repeated twice, sphericity can not be violated, so no such test are performed.

```
# Mixed ANOVA:  with summary
```

DIRECTIONS: SINCE THE INTERACTIONIS SIGNIFICANT, instead of focusing on the main effects alone, plot the interaction with the `emmeans::emmip(group_var ~ RM_var)` function.

```
# RM ANOVA: means plot <-- interaction
```