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**NOTE: Type your answers in the appropriate fields; please make answer fields larger as needed. Note: The text fields have been set to blue; this is to make it easier for the TA’s to see your answers and grade. Submit this assignment on Canvas by 11:59 PM on Friday, November 10, 2023. This assignment will be graded by Simran.**

*Conceptual Problems*

1. Imagine you had a factorial design in which you were testing if work schedule (none vs. part-time vs. full-time) and course load (part-time vs. full-time) were related to student GPA during an academic quarter. If I told you that this was a balanced design, where each unique combination of conditions (e.g., no work and part-time student status, part-time work and full-time student status, etc.) had 20 participants, what are the *df* between for each condition, the *df* for the interaction, the *df* within (error), and the *df* total? [1 Points]

|  |  |
| --- | --- |
| Source | DF |
| DF-work | 2 |
| DF-course | 1 |
| DF-interaction | 2 |
| DF-within | 114 |
| DF-total | 119 |

*Computational Problems*

Please use the ‘Age Religion Health’ data file (the same one used in the lab). Please include all sytanx at the **BOTTOM** of the homework, in the appropriate boxes. For any numbers with decimals, please round to 2 decimal places. For p values, report values > .05 with 2 decimal places, and values < .05 with 3 decimal places. For *p* values that are less than .001, you may report them as < .001. Use Type I sum of squares (this is the default for the anova() or summary() functions; it is NOT the default for the Anova() function).

2. One-Way ANOVA with Orthogonal Contrasts

1. Read in the ‘Age Religion Health’ and perform a one-way ANOVA assessing the effect of marital status (married\_04) on frequency of reading the bible (Bible\_04). Fill in the results of the anlysis in the table below: [1 Points]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | DF | SS | MS | F | P |
| Between | 4 | 167 | 41.74 | 6.83 | <.001 |
| Within | 800 | 4892 | 6.11 |  |  |
| Total | 804 | 5059 |  |  |  |

1. Use orthogonal contrasts to perform a post-hoc test. For the first contrast, compare Widowed to all other groups combined. For the second contrast, you will need to figure out the only other possible comparison possible (list it in the table below). For the third contrast, compared Married to Never Married. For the fourth contrast, compare Divorced to Separated, and perform the comparison. Fill in the results in the table below. Note: Make sure to enter these contrast in the order listed here, or you will not get the right answers. Make sure to use Type I Sum of Squares. [1.5 Point]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Comparison | DF | SS | MS | F | P |
| Contrast 1 | Widowed to (Married, Never Married, Divorced, and Separated) | 1 | 137 | 137.47 | 22.50 | <.001 |
| Contrast 2 | (Married, Never Married) to (Divorced, Separated) | 1 | 0 | 0 | 0 | .997 |
| Contrast 3 | Married to Never Married | 1 | 2.6 | 2.57 | 0.42 | .517 |
| Contrast 4 | Divorced to Separated | 1 | 26.9 | 26.92 | 4.40 | .036 |
| Within | - | 800 | 4891.8 | 6.12 |  |  |
| Total | - | 804 | 5058.74 |  |  |  |

1. Create bar graphs showing the mean and standard error bars for each contrast performed. Arrange the graphs in a 2x2 panel (hint: use ggarrange from the ggpubr package). Title each graph as “Contrast 1”, “Contrast 2”, “Contrast 3”, or “Contrast 4”. Make sure the graphs have the same Y axis range and scale, and make sure that the groups are labeled properly on the X axis. [1 Points]

A group of squares with text

Description automatically generated with medium confidence

1. Interpret the results of the analysis (i.e., Part A and Part C). You should have at least one sentence for the overall ANOVA, and several sentences for the orthogonal contrasts. Please include p values for each statement. [1 Point]

Hint: To start, what can be concluded based on the overall ANOVA analysis? Then describe the results of the contrasts. Start by listing which group(s) read the bible significantly more or less than the other group(s). Then state the specific groups that did not significantly differ from each other. It may be helpful to describe each contrast that was performed. *Please see the example in the lab script for what is expected.*

The overall ANOVA indicated statistically significant differences between marital status groups in the frequency of bible reading. Compared to the average scores of those married, never married, divorced, and separated, widows show a higher frequency of reading the bible. Additionally, people who are separated read the bible more frequently on average than those who are divorced. No significant differences were found between the average of divorced and separated people and those who were married or never married. Divorced and separated people also did not differ significantly in their scores.

3. Two-Way ANOVA:

1. Conduct a two-way factorial ANOVA assessing whether marriage status (married\_04) and sex (in that order) predict differences in subjects’ weight (Weight\_04). Fill in the table below with the results of the analysis: [1.5 Point]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | DF | SS | MS | F | P |
| Marriage Status | 4 | 25231 | 6308 | 5.21 | <.001 |
| Sex | 1 | 98083 | 98083 | 81.01 | <.001 |
| Interaction | 4 | 17025 | 4256 | 3.52 | .007 |
| Within | 797 | 964968 | 1211 |  |  |
| Total | 806 | 1105307 |  |  |  |

1. Make two bar graphs with standard error bars to graph the means of each sex by marriage status grouping. For the first bar graph, put Sex on the x axis and have different colored bars for marriage status. For the second bar graph, put marriage status on the x axis, and have different colored bars for sex. Make sure to label all graphs appropriately.

[.5 Points]

A comparison of different colored bars

Description automatically generated

1. Perform a simple effects analysis and test whether there are sex differences in weight across all levels of marital status, and fill in the table below with the results of the analysis (technically this could be a t-test, but go ahead and do an ANOVA). [1.5 Points]

|  |  |  |  |
| --- | --- | --- | --- |
|  | DF | F | P |
| Group: Divorced | - | - | - |
| Sex | 1 | 16.92 | <.001 |
| Within | 68 | - | - |
| Group: Married | - | - | - |
| Sex | 1 | 64.42 | <.001 |
| Within | 360 | - | - |
| Group: Never Married | - | - | - |
| Sex | 1 | 0.65 | .428 |
| Within | 23 | - | - |
| Group: Separated | - | - | - |
| Sex | 1 | 4.35 | .059 |
| Within | 12 | - | - |
| Group: Widowed | - | - | - |
| Sex | 1 | 12.81 | <.001 |
| Within | 334 | - | - |

1. Interpret the results of the analysis (i.e., Part A and Part C). You should have a statement for the overall ANOVA (one sentence or more), and a statement for the simple effect analysis (one sentence or more). [1 Point]

Hint: For the overall ANOVA, what can be concluded based on the analysis? For the simple effects analysis, which groups significantly differed in weight, and in what direction? Which groups did not differ? It may be helpful to describe each effect, or to list comparisons that were significant in the same direction in the same sentence (please describe the significant comparisons first). *Please see the example in the lab script for what is expected.*

The two-way factorial ANOVA shows a significant interaction between sex and marital status in explaining weight differences. That means that the effect of sex on weight is not constant across levels of marital status. The simple effect analyses indicated that females weigh less than males on average across Divorced, Separated, and Widowed groups. Among those who were Never Married or Separated, there were no significant differences between the sexes.

Extra Credit:

1. Conduct the post-hoc comparisons for 2A using pairwise t-tests with Bonferroni correction. How do your conclusions for the Divorced versus Separated group compare to the conclusions you drew in 2B? [1.5 Points]

After adjusting for multiple comparisons, the difference in Bible reading frequency between Divorced and Separated was not significant. This result contrasts the previous finding using planned contrasts, in which we found a significant difference between these two groups with respect to the same outcome.

Syntax for Question 2:

library(dplyr)

library(car)

library(ggplot2)

library(patchwork)

dat <- readr::read\_csv("23-Fall/psc204-fq23/lab6/age\_religion\_health.csv") |>

dplyr::mutate(married\_04 = factor(married\_04,

levels = c("Widowed",

"Married",

"Never Married",

"Divorced",

"Separated"

)))

anova\_marital <- aov(Bible\_04 ~ married\_04, data=dat)

summary.aov(anova\_marital)

# B -----------------------------------------------------------------------

c1 <- c(-1, 1/4, 1/4, 1/4, 1/4)

c2 <- c(0, -1, -1, 1, 1)

c3 <- c(0, 1, -1, 0, 0)

c4 <- c(0, 0, 0, 1, -1)

cont\_matrix <- cbind(c1, c2, c3, c4)

contrasts(dat$married\_04) <- cont\_matrix

cont\_matrix

anova\_marital <- aov(Bible\_04 ~ married\_04, data=dat)

split\_list <- list(

married\_04 = list(

"Widowed vs all" = 1,

"Divorced and Separated vs Married and Never Married" = 2,

"Married vs Never married" = 3,

"Divorced vs Separated" = 4

)

)

s\_aov <- summary.aov(anova\_marital, split = split\_list)

# C -----------------------------------------------------------------------

contr\_data = dat |>

mutate("widowed\_v\_rest" = case\_when(

married\_04 == "Widowed" ~ "Widowed",

TRUE ~ "Marr, NM, Div, Sep"),

"MarNM\_v\_DivSep" = case\_when(

married\_04 == "Married" | married\_04 == "Never Married" ~ "MarNM",

married\_04 == "Divorced" | married\_04 == "Separated" ~ "DivSep",

TRUE ~ NA\_character\_))

# Contrast 1: Widowed vs all

graph\_data\_c1 <- contr\_data |>

group\_by(widowed\_v\_rest) %>%

summarise(mean = mean(Bible\_04, na.rm = TRUE),

sd = sd(Bible\_04, na.rm = TRUE),

n = length(Bible\_04)) %>%

mutate(se = sd/sqrt(n))

graph\_c1 <- ggplot(data = graph\_data\_c1,

aes(x = widowed\_v\_rest,

y = mean))+

geom\_bar(stat = "identity",

color = "black", fill = "peachpuff4")+

geom\_errorbar(width = .3, aes(ymin = mean - se,

ymax = mean + se))+

theme\_classic()+

labs(x = "Marital Status",

y = "Frequency Reading Bible",

title = "Contrast 1")

# Contrast 2: (Married, Never Married) vs (Divorced, Separated)

graph\_data\_c2 <- contr\_data |>

filter(!is.na(MarNM\_v\_DivSep)) |> # note that we filtered out the NA in the grouping variable

group\_by(MarNM\_v\_DivSep) |>

summarise(mean = mean(Bible\_04, na.rm = TRUE),

sd = sd(Bible\_04, na.rm = TRUE),

n = length(Bible\_04)) |>

mutate(se = sd/sqrt(n))

graph\_c2 <- ggplot(data = graph\_data\_c2,

aes(x = MarNM\_v\_DivSep,

y = mean))+

geom\_bar(stat = "identity",

color = "black", fill = "peachpuff4")+

geom\_errorbar(width = .3, aes(ymin = mean - se,

ymax = mean + se))+

theme\_classic()+

labs(x = "Marital Status",

y = "Frequency Reading Bible",

title = "Contrast 2")

# Contrast 3: Married vs Never Married

graph\_data\_c3 <- contr\_data |>

filter(married\_04 == "Married" | married\_04 == "Never Married") |>

group\_by(married\_04) |>

summarise(mean = mean(Bible\_04, na.rm = TRUE),

sd = sd(Bible\_04, na.rm = TRUE),

n = length(Bible\_04)) |>

mutate(se = sd/sqrt(n))

graph\_c3 <- ggplot(data = graph\_data\_c3,

aes(x = married\_04,

y = mean))+

geom\_bar(stat = "identity",

color = "black", fill = "peachpuff4")+

geom\_errorbar(width = .3, aes(ymin = mean - se,

ymax = mean + se))+

theme\_classic()+

labs(x = "Marital Status",

y = "Frequency Reading Bible",

title = "Contrast 3")

# Contrast 4: Divorced vs Separated

graph\_data\_c4 <- contr\_data |>

filter(married\_04 == "Divorced" | married\_04 == "Separated") |>

group\_by(married\_04) |>

summarise(mean = mean(Bible\_04, na.rm = TRUE),

sd = sd(Bible\_04, na.rm = TRUE),

n = length(Bible\_04)) |>

mutate(se = sd/sqrt(n))

graph\_c4 <- ggplot(data = graph\_data\_c4,

aes(x = married\_04,

y = mean))+

geom\_bar(stat = "identity",

color = "black", fill = "peachpuff4")+

geom\_errorbar(width = .3, aes(ymin = mean - se,

ymax = mean + se))+

theme\_classic()+

labs(x = "Marital Status",

y = "Frequency Reading Bible",

title = "Contrast 4")

graph\_c1 + graph\_c2 + graph\_c3 + graph\_c4

Syntax for Question 3:

aov\_int <- aov(Weight\_04 ~ married\_04 + sex + married\_04:sex, data= dat)

summary(aov\_int)

graph\_data <-

dat |>

group\_by(married\_04, sex) |>

filter(!is.na(married\_04)) |>

summarise(mean = mean(Weight\_04, na.rm=TRUE),

sd = sd(Weight\_04, na.rm=TRUE),

N = length(Weight\_04),

se = sd / sqrt(N))

p1 <- ggplot(data = graph\_data,

aes(sex, mean, fill = married\_04)) +

geom\_col(position = "dodge") +

geom\_errorbar(width = .5,

aes(ymin = mean - se, ymax = mean + se),

position = position\_dodge(.9)) +

theme\_classic() +

labs(y = "Weight",

x = "Sex",

fill = "Marital Status",

title = "Weight by Sex and Marital Status")

p2 <- ggplot(data = graph\_data,

aes(x = married\_04, y = mean, fill = sex)) +

geom\_bar(stat="identity", color = "black", position = position\_dodge()) +

geom\_errorbar(width = .5,

aes(ymin = mean - se, ymax = mean + se),

position = position\_dodge(.9)) +

theme\_classic() +

labs(y = "Weight",

fill = "Sex",

x = "Marital Status",

title = "Weight by Marital Status and Sex")

status <- levels(dat$married\_04)

purrr::map(status, ~summary(aov(Weight\_04 ~ sex, data = contr\_data,

subset = married\_04 == .x)))