

STAT 213 (SUMMER 2021): HW8

DUE ELECTRONICALLY BY MONDAY 8/23/21

INSTRUCTIONS AND TECHNICAL TIPS

Write up your solutions and save/upload the file(s) to the RStudio server in the folder `stat213/turnin/hw8/` inside your Home directory. Include `hw8` (all lowercase) in your filenames.

Using an RMarkdown document is recommended, but not required.

RMarkdown Format. If you do use RMarkdown, R code should go in code chunks, and verbal commentary (and any math equations) should go outside code chunks.

Use section headings (a line starting with one or more `#` symbols) to demarcate the start of a problem. You can nest headings by using an additional `#` symbol for each level of nesting: one for a top-level heading, two for the next level within that, etc.

Periodically “Knit” your file to verify that it is working correctly.

“Knitting” Troubleshooting. If your code runs chunk by chunk but won’t Knit, try clearing your environment (broom icon in the upper right) and running chunk by chunk from the start again. The most common cause is an undefined variable. This can happen if you change your variable names some places but not others, but a very common reason is that you read in the data from a file using a menu button instead of using the `read.file()` command, which means the “reading in the data” step is not recorded in your document. If you can’t Knit, I won’t be able to run your code either!

If you aren’t able to Knit directly to `.pdf`, it may be because you are using special characters (such as `≠`) in your `.Rmd`. Replace these with plain text and try again.

If you have done this and are still unable to Knit directly to `.pdf`, convert your Knitted `.html` or `.docx` into a `.pdf` (possibly by “printing” the `html` from your browser to a file) and save that there. A uniform file format across students will make grading 64 problem sets much more streamlined. Thanks!

What to turn in. If using Markdown, turn in the source file (ending in `.Rmd`) and the Knitted output file (preferably as `.pdf`). Otherwise, just turn in a `.pdf`.

Date: August 23, 2021.

Verifying receipt of your work. When I run the script that collects your work after the due date, you will see a “receipt” file in the `~/stat213/receipts/hw8/` directory. If this does not appear within 24 hours or so of you submitting your assignment, let me know.

PROBLEMS

1. (SLO F1) **All False.** An instructor wants to investigate whether the font used on an exam affects student performance as measured by the final exam score. She uses four different fonts (Times, Courier, Helvetica, and Comic Sans) and randomly assigns each of her 40 students to receive the exam in one of those four fonts.

Suppose the scores are modeled with a one-way ANOVA model using font as the explanatory factor. The P -value from an ANOVA F -test turns out to be 0.003.

All of the following statements are **false**. For each, one explain **why it is false**.

- (a) The probability is 0.003 that the four groups have the same mean score
- (b) The data provides strong evidence that all four fonts produce different mean scores.
- (c) The data provides strong evidence that the comic sans font produces a different mean score than the other fonts.
- (d) The data provides little evidence that any of the fonts produces a different mean score from any of the other fonts.
- (e) Even if the conclusion from the hypothesis test is correct, we cannot conclude that a differences in fonts *causes* a difference in mean exam scores.
- (f) Conclusions from this analysis can be generalized to the population of all students at the instructor’s school.

2. (SLOs F3) **Child Poverty** A dataset includes information about the child poverty rate in each county of a sample of 12 counties in Iowa. Below is the ANOVA table relating child poverty rate to the size category of the county (small, medium, or large; defined by population cutoffs).

Source	df	SS	MS	F	P
Size	2	0.000291	0.000145	0.22	0.810
Residuals	9	0.006065	0.000674		
Total	11	0.006356			

- (a) (F3,F4) Write out the equation for the “effect-coded” ANOVA model corresponding to this table, and give interpretations of each coefficient (you do not have enough information to plug in numerical values for the coefficients; just write them as symbols).
- (b) (F3) Write out an equivalent model equation in the “regression form” using 0/1 indicator variables and “reference group” coding, and interpret the coefficients.
3. **Swahili Attitudes.** Hamisi Babusa, a Kenyan scholar, administered a survey to 480 students from the Pwani and Nairobi provinces of Kenya about their attitudes toward the Swahili language. In addition, the students took an exam on Swahili. From each province, the students were from 6 single-sex schools (3 girls’ schools and 3 boys’ schools), with 40 students sampled at each school, so half the students from each province were identified as male and half as female (based on their assignment to the school; not necessarily based on self-identification).

The survey instrument contained 40 statements about attitudes toward Swahili, and students rated their level of agreement on each question on a five point scale ranging from “strongly agree” to “strongly disagree”. Of these statements, 30 were positive and 10 were negative. Responses were coded on a 1 to 5 scale, with the most positive response being assigned a value of 5 and the most negative response being assigned a value of 1. Each student’s overall **Attitude** score was simply the sum of their responses to the 40 questions, with 40 being the most negative score possible 200 being the most positive score possible.

The data is available in the dataset **Swahili** in the **Stat2Data** package in R.

- (a) Write out the model equation for a two-way ANOVA model with **Attitude** as the response, and **Province** (Nairobi or Pwani), **Sex**, and their interaction as predictors. Interpret each parameter in context.
- (b) Produce an ANOVA table based on this model. For any effects for which you find statistically significant evidence, give an interpretation that explains the direction of the effect(s) in the context of the real-world variables.

4. (F2) **Familywise Error Rate.** We have discussed several methods used to control the familywise error rate when performing multiple hypothesis tests (and in particular when performing multiple pairwise comparisons among means). Each has advantages and disadvantages relative to each other and relative to not using them at all.
- (a) How will the use of a familywise error rate correction (such as Fisher's LSD, the Bonferroni correction, or Tukey's HSD) affect each of the following quantities, **compared to not using one** (assuming the same set of comparisons is being made either way).
- (i) The chance that a **particular** hypothesis test yields a result that we consider statistically significant
 - (ii) The chance that **some** hypothesis test yields a result that we consider statistically significant
 - (iii) The expected number of false discoveries (Type I Errors)
 - (iv) The expected number of missed discoveries (Type II Errors)
- (b) For each of the following quantities, indicate how it is affected by **the number of hypothesis tests being performed** if we are **not** employing any correction for familywise error rate. Then indicate how it is affected if we **are** correcting for familywise error rate (for this purpose, assume that the correction works as intended).
- (i) The chance that a **particular** hypothesis test yields a result that we consider statistically significant
 - (ii) The chance that **some** hypothesis test yields a result that we consider statistically significant
 - (iii) The expected number of false discoveries (Type I Errors)
 - (iv) The expected number of missed discoveries (Type II Errors)
- (c) We have discussed three specific methods to control the familywise error rate. For each of the pairs below, **give a reason why the first one might be preferred over the second**, and then **give a reason why the second one might be preferred over the first**.
- (i) Fisher's LSD vs Bonferroni adjustment
 - (ii) Fisher's LSD vs Tukey's HSD
 - (iii) Tukey's HSD vs Bonferroni adjustment