

STAT 113: ANOVA Practice Problems

Do Not Circulate!

Last Revised December 7, 2020

List of Problems:

- 8.17 (modified)
- 8.38 (modified)

Specific Learning Objectives:

D7: Techniques for Comparing Quantitative Data From More than Two Groups

Problems:

8.17 (modified) **The Color Red and Performance** Color affects us in many ways. For example, Exercise C.92 on page 498 describes an experiment showing that the color red appears to enhance heterosexual men's attraction to women. Previous studies have also shown that athletes competing against an opponent wearing red perform worse, and students exposed to red before a test perform worse.

Another study states that "red is hypothesized to impair performance on achievement tasks, because red is associated with the danger of failure." In the study, US college students were asked to solve 15 moderately difficult, five-letter, single-solution anagrams during a 5-minute period. Information about the study was given to participants in either red, green, or black ink just before they were given the anagrams. Participants were randomly assigned to a color group and did not know the purpose of the experiment, and all those coming in contact with the participants were blind to color group.

The red group contained 19 participants and they correctly solved an average of 4.4 anagrams. The 27 participants in the green group correctly solved an average of 5.7 anagrams and the 25 participants in the black group correctly solved an average of 5.9 anagrams.

- (i) State null and alternative hypotheses, in words and (for the null) in terms of parameters of interest.
- (ii) Complete the ANOVA table below.

Source	df	SS	MS	F
Color		27.7		
Residuals		57.0		N/A

- (iii) Use the test statistic to find the P-value.
- (iv) Interpret the results of the test in context (use $\alpha = 0.05$).
- (v) Give and interpret the R^2 value for the association between color and performance
- (vi) If you found significant evidence that the population means are different, perform a follow-up hypothesis test to test whether there is evidence that mean performance when receiving instructions in red ink and mean performance when receiving instructions in green ink are different. This is a test of differences in means, with the following small changes: to calculate standard error:
- We use $MS_{Residuals}$ from the ANOVA table in place of the squared sample standard deviations (this makes life easier since it's the same number for all pairs)
 - For the df of the t -distribution, use $df_{Residuals}$ from the ANOVA table.
- (vii) Calculate and report a 95% confidence intervals for the difference between mean performance when receiving instructions in red ink and mean performance when receiving instructions in green ink. Use the modified standard error and degrees of freedom that you used for the tests.

8.38 **Fish Ventilation** Most fish use gills for respiration in water and researchers can observe how fast a fish's gill cover beats to study ventilation, much like we might observe breathing rate for a person.

Professor Brad Baldwin is interested in how water chemistry might affect gill beat rates. In one experiment he randomly assigned fish to tanks with different levels of calcium. One tank was low in calcium (0.71 mg/L), the second tank had a medium amount (5.24 mg/L), and the third tank had water with a high calcium level (18.24 mg/L).

His research team counted gill rates (beats per minute) for samples of 30 fish in each tank. The results are stored in `FishGills3`.

(Note: You may also see a file called `FishGills12` which is a more extensive experiment with 12 tanks.)

- (i) State null and alternative hypotheses for testing whether calcium level affects mean gill rate in this population of fish.
- (ii) Produce an appropriate plot of the data that is informative for this question.
- (iii) Check whether the conditions for ANOVA are reasonable for this data.
- (iv) If the conditions are met, use find the ANOVA table (you can use the built-in `aov()` function in R) and complete the test. If the conditions are not reasonable, use a randomization test (scrambling the calcium levels) to complete the test instead.
- (v) State the conclusion of the test in context.