

## Chapter 5: Homework with Minitab Instructions

### Schistosomiasis: An Introduction to Randomization and Permutation Tests

1. Calculate appropriate summary statistics for each group of data and produce an individual value plot to compare number of worms for both the male and female mice. [In Minitab, type in the labels and word counts as listed in the table above. Graph -> Individual Value Plot -> Multiple Y's Simple, OK, select all four data columns, OK]
2. To get a feel for the concept of p-value, put the 10 female worm counts onto 10 index cards. Shuffle the cards, and then draw out 5 cards at random (without replacement). Call these 5 cards the treatment group and the 5 un-picked cards the control group. Under the devil's advocate position (i.e. the null hypothesis), this allocation mimics precisely what actually happened in our experiment, since the only group differences under the devil's reasoning was random allocation.  
  
Calculate the mean of the 5 cards representing the treatment group and the mean of the 5 cards representing the control group. What is the mean difference between control and treatment groups that you obtained in your allocation?
3. If you were to do another random allocation, would you get the same difference in means? Explain.
4. Now, perform 9 more random allocations, each time computing and writing down the difference in mean worm count between control group and treatment group. Make a dotplot of the 10 differences. What proportion of these differences is 7.6 or larger?
5. What if you performed the simulation many times? Do you expect the proportion of times the mean differences exceeds 7.6 to be large or small? Explain.
6. Insert that data into a statistical software package and randomly allocate each of the 10 female worm counts to either a treatment or control group. [In Minitab, click anywhere on the session window, Editor -> Enable commands. Data -> Stack-> Columns, select C1 and C2 and use C5 as the Column of Current worksheet and C6 to store subscripts. Use variable names in subscript column should be checked.] Note that when the editor command is on, the programming code shows in the session window.  
  
[In Minitab, Calc->Random Data-> Sample from columns, sample 10 rows from C5 and store samples in C7. Do not sample with replacement, OK]
7. Calculate the average difference between the treatment and the control sample. [In Minitab, Data->Unstack Columns ->, unstack the data in C7 Using subscripts in C6. Select After last column in use. OK. In the following in the prompt MTB> let C10 = mean(C8) - mean(C9)]. C10 is the difference between the mean of two randomly allocated groups.

8. Write a program, function, or macro to run more than one iteration.

Open Notepad and type in the following six lines.

```
sample 10 c5 c7
unstack c7 c8 c9;
subs c6;
varnames.
let c10(k1) = mean(c8)-mean(c9)
let k1=k1+1
```

Save this file as “schistosome.mtb” (The quotes force the computer to save the file in exactly this form. Without the quotes, the computer may save the file as schistosome.mtb.txt. If you forget the quotes and your computer automatically saves it as schistosome.mtb.txt open the file folder where the document is saved and select Tools->Folder Options->View and ensure that Hide Extensions for known file types is not selected).

9. Run the macro/program 10 times. [In the Minitab prompt type MTB> let k1=1 then select File->Other Files->Run an exec. Execute the file 10 times, and select the schistosome.mtb file.] C10 now represents 10 simulated differences between two randomly selected groups.

In the Minitab prompt type MTB> print k1. What does k1 do in this exec file? Remember to set k1=1 before starting to run any exec file.

Now run the macro/program 990 more times. Count the number of simulations that resulted in a mean difference greater than or equal to 7.6 and report the empirical p-value. [In the Minitab prompt, MTB > let c11 = (c10 >= 7.6), then MTB > sum C11] The p-value is the sum of all the counts greater than or equal to 7.6 divided by the number of executions. Create a histogram of the 1000 mean differences and comment on the shape. [In Minitab, Graph->Histogram, OK, select C10, OK. After the graph is produced double click the horizontal axis, select the binning tab and choose the number of intervals to be 10.]

10. Based upon Question 9, assuming that the treatment is not more effective than the placebo about how frequently would one obtain a mean difference as large as or larger than 7.6 by random allocation alone?
11. Does your answer to 10 lead you to believe the devil’s advocate position (aka, null hypothesis) or does it lead you to believe that K11777 has a positive, inhibitory effect on the schistosome worm in female mice? Explain!
12. Run the simulation study again to find the empirical p-value for testing the 2-sided hypothesis test to determine if there is a difference between the treatment and control for female mice. [In Minitab, Stat -> Tables -> Tally Individual Variables can also be used to count the frequency of each simulation as shown in Table 4.2 below] Was the number of simulations resulting in a difference greater than or equal to 7.6 identical to the number of simulations resulting in a difference less than or equal to -7.6? Explain!

13. Run a simulation using the data from the male mice to decide if you feel that K11777 inhibits schistosome viability (i.e. reduces worm count) in male mice. Describe the results by including a histogram of the simulation results, the p-value, and a summary statement that indicates what your conclusion is about the research question of schistosome viability.
14. Modify the `female_ctl` data and run a simulation to test the two-sided hypothesis  $H_0: d = -1$  vs.  $H_0: d \neq -1$ . What p-value did you observe?
15. Instead of just integers, find more specific estimates of L and U for a 95% two-sided confidence interval for female mice to the nearest  $10^{\text{th}}$  of a worm. You may need to increase the number of simulations to 10,000 to get more specific estimates.
16. Estimate L for a 99% one-sided, “greater than” confidence interval for male mice (i.e. find all plausible integer values of  $d_0$  for the 1-sided hypothesis test  $H_0: d = d_0$  versus  $H_a: d > d_0$ .) Make an interpretive statement about the interval.

## Chapter 5B: Homework with Minitab Instructions

1. Run a permutation test using ‘age’ as the response variable and ‘layoff?’ as the group identifier to decide if a mean difference as large as represented in the data gives statistically significant data (use  $\alpha = .05$ ) that the mean age for those laid off exceeds the mean age for those not laid off. [Modify the `schistosome.mtb` macro and in the Minitab worksheet, C5 should list the ages and C6 whether the person was laid off or not. C1-C4 will not be needed for these data.]
2. One major advantage of randomization/permutation tests, over classical methods, is that they easily allow the use of test statistics other than the mean.
  - a. Modify the program/macro you created in question 1 to measure a difference in group medians instead of a difference in means for the Westvaco age data. [Modify the appropriate line in the code to “`let c10(k1) = median(c8)-median(c9)`”.] Report the p-value and compare your results to question 1.
  - b. One might also wonder if the treatment might change the variability in layoff groups. Modify the macro you created in question 1 to test if the variances of each layoff group are equal. Report the p-value and state your conclusion in both cases. [In Minitab use `stdev(c8)*stdev(c8)-stdev(c8)*stdev(c8)`]
3. Moore suspected that closed nests tend to be build by larger birds, but we will treat the alternative here as two-sided, since the evidence for her suspicion was based upon scanty evidence.
  - a. Use comparative dotplots or boxplots and summary statistics to describe the relationship between average body length and the nest type (the `closed?` variable). (Note: `closed? = 1` for closed nests; `closed? = 0` for open nests.) Does it appear that Moore’s initial suspicion is born out by the data?

- b. Now, run a permutation test using a two-sided alternative to determine if type of nest varies by body length. and interpret your results. Be sure to state your conclusions in the context of the problem and address how random allocation and random sampling (or lack of either) impacts your conclusions.
4. Anne and Anna decided to use a 1-sided test to show that fast music increased pulse rate more than slow music before they looked at the data. Why is it important to determine the direction of the test before looking at the data?
5. Create a simulation to test the Music data. Write a program/macro that will randomly multiply a 1 or a -1 to each observed difference. Thus randomly assigning an order (Fastdiff-Slowdiff or Slowdiff-Fastdiff). Then, for each iteration, calculate the mean difference for each group. Be sure to state your conclusions in the context of the problem and address how random allocation and random sampling (or lack of either) impacts your conclusions. [In Minitab, place Fastdiff-Slowdiff in C1 and in C2 alternate “1” and “-1” (to indicate the two possible orderings for listening) for a total of 14 each.] The following macro will randomly assign each observed difference to an order (Fastdiff-Slowdiff or Slowdiff-Fastdiff) by multiplying by 1 or -1. “1” will represent Fastdiff-Slowdiff and “-1” will represent Slowdiff-Fastdiff.

```
sample 28 c1 c5
let c6 = c2*c5
let c10(k1) = sum(c6)/28
let k1=k1+1
```

6. In a 1990 study by Suddath et al, reported in Ramsey and Schafer [2], researchers used magnetic resonance imaging to measure the volume of various regions of the brain for a sample of 15 monozygotic twins, where one twin was affected schizophrenia and the other was unaffected. The twins were from North America and comprise 8 male pairs, 7 female, and ranged in age from 25 to 44 at the time of the study. The sizes in volume  $\text{cm}^3$  of the hippocampus are in the file called *twins*. ). [In Minitab, create a column of randomly generated -1's or 1's, but here we need to randomly determine the number of -1's (and thus the number of 1's) in this column.]
- a. The explanatory variable here is whether or not a twin is affected by schizophrenia and clearly random allocation is not involved at all. This is an observational study, not an experiment. Nevertheless, would the conceptual design principle of an imaginary “random allocation” or would “matched pairs” seem more appropriate in considering the analysis of these data?
- b. Use appropriate graphics and summary statistics to describe the difference in brain volume for affected and unaffected twins.
- c. Use the appropriate permutation test to ascertain if the conclusion about differences in brain volume drawn in (b) is the result of schizophrenia or if it could be explained as a chance difference. Report your p-value and summarize your conclusion.

7. Using the t-test, compute the two-sided p-value for the bird nest study above and compare the results to what you found with the randomization test.
8. Using the t-test, compute the one-sided p-value for the music study above and compare the results to what you found with the randomization test.