Lab 4: Hypothesis Testing Using Randomization
KEY

Javier E. Flores

February 27, 2019

Total Possible Points: 48

Refresher

Q1) [2pts] State the null and alternative hypotheses that would be appropriate for this research question.

A1) The null hypothesis is that the mean difference in the number of concussions between male and female collegiate athletes is zero. [1 pts] The alternative hypothesis is that the mean difference in the number of concussions between male and female collegiate athletes is different from zero. [1 pts]

Q2) [2pts] Given this p-value, what would you conclude? State your conclusion in the context of the original research question. Be sure to state whether we reject or fail to reject the null hypothesis described in **Q1)**.

A2) Assuming the traditional threshold for statistical significance of 0.05, a p-value of 0.587 would not be considered statistically significant. Therefore, we fail to reject the null hypothesis and conclude that the average number of concussions does not differ between male and female collegiate athletes. [2 pts]

Randomization Testing: Single Mean

Q3) [2pts] Why are the shifted data sampled with replacement?

A3) These data are sampled with replacement for the same reason that we sample with replacement to form bootstrap distributions. If we were to sample without replacement, we would obtain the exact same sample every time. Sampling with replacement induces variability in the statistics computed from randomization sample to randomization sample. [2 pts]

Q4) [4pts] The next few questions require the use of the "Net Profit" dataset. Consider the following research question: "Among small department stores in 1925 (sales under $1,000,000) was there, on average, a net profit different from 0?"

- Using proper statistical notation, state the null and alternative hypotheses.
- Input the necessary data and make sure that the null hypothesis is correctly specified in StatKey.
- Generate 10 randomized samples one at a time and track the standard deviation of each in the table below.

A4) Using proper statistical notation, the null and alternative hypotheses would be:

$$H_0 : \mu = 0$$

$$H_A : \mu \neq 0$$

[2 pts] The randomization samples I generated yielded the standard deviations shown below:

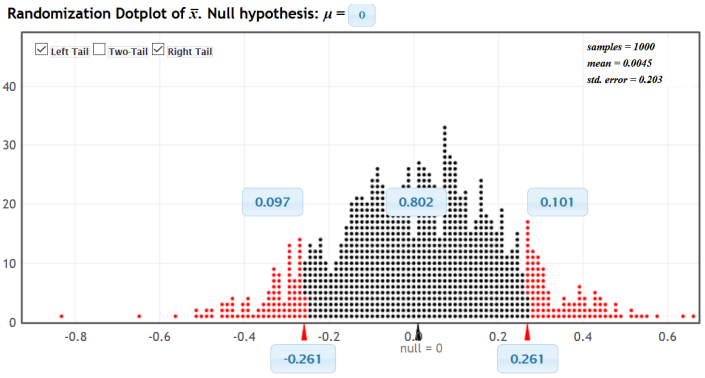
Randomization Sample	Standard Deviation
1	3.821
2	3.381
3	3.714
4	4.138
5	3.957
6	3.635
7	3.730
8	4.150
9	3.810
10	3.897

[2 pts]

Q5) [3pts] How do the standard deviations of each randomization sample compare to that of your original sample? How would you expect them to compare? Why?

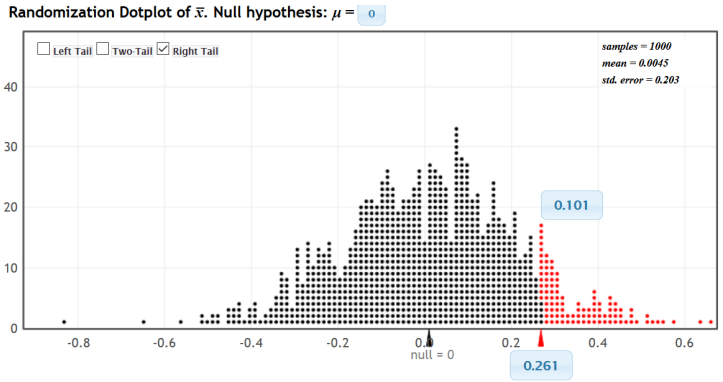
A5) The standard deviation of the original sample is 3.854. Looking at the table above, it is clear that each randomization sample has a standard deviation that is very close to that of the original sample. [1 pts] This is what we expect. In generating the randomization distribution, we are shifting every datapoint by the same amount and sampling with replacement - neither of which substantially affect the original variability in the sample. [2 pts]

Q6) [3pts] Conduct a *two-sided randomization test* at the $\alpha = 0.05$ level. State your p-value, whether you reject or fail to reject your null hypothesis, and the conclusion you reached in the context of the original research question.



A6) Using the figure above, we compute a p-value of $0.101 + 0.097 = 0.198$. [1 pts] At the $\alpha = 0.05$ level, we fail to reject the null hypothesis. [1 pts] There is insufficient evidence to reject the claim that the average net profit for small department stores in 1925 is 0. [1 pts]

Q7) [4pts] Conduct a *one-sided randomization test* at the $\alpha = 0.10$ level for whether the average net profit is greater than 0. State the appropriate null and alternative hypotheses, your p-value, whether you reject or fail to reject your null hypothesis, and the conclusion you reached in the context of this new research question.



A7) The null hypothesis is that the net profit is less than or equal to 0, and the alternative is that the net profit is greater than 0. [1 pts] Using the figure above, we compute a p-value of 0.101. [1 pts] At the $\alpha = 0.10$ level, we fail to reject the null hypothesis. [1 pts] There is marginal evidence to suggest that the average net profit in small 1925 department stores is greater than 0. [1 pts]

Randomization Testing: Single Proportion

Q8) [2pts] The next couple of questions require the use of the "Blues Hands" dataset. Consider the following research question: "Is the extended hand posture the most popular (i.e. used by more than half) among blues musicians between 1874 and 1940?"

- Using proper statistical notation, state the null and alternative hypotheses.
- Using Minitab, create a new binary categorical variable that identifies blues musicians who use the extended hand posture.

A8) Using proper statistical notation, the null and alternative hypotheses would be:

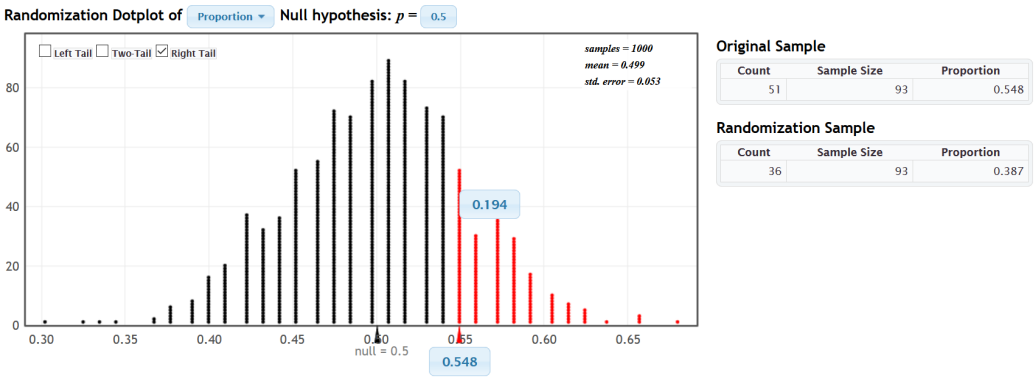
$$H_0 : p = 0.50$$

$$H_A : p > 0.5$$

[2 pts]

Q9) [3pts] Input the appropriate data into StatKey and conduct a *one-sided randomization test* at the $\alpha = 0.05$ level. State your p-value, whether you reject or fail to reject your null hypothesis, and the conclusion you reached in the context of the original research question.

A9) The randomization distribution I generated is shown below.



Using the previous figure, we obtain a p-value of 0.194.[1 pts] At the $\alpha = 0.05$ level, we fail to reject the null hypothesis. [1 pts] Based on these results, there is insufficient evidence to refute the claim that the extended hand position is not the most popular among blues musicians between 1874 and 1940. [1 pts]

Randomization Testing: Difference in Proportions

Q10) [2pts] The next couple of questions require the use of the "ESP Skeptic" dataset. Consider the following research question: "Are the proportions of successful matches different between ESP skeptics and believers?"

- Using proper statistical notation, state the null and alternative hypotheses.
- Using Minitab, calculate the sum of "Count" separately for believers and non believers. This represents the total number of correct guesses for each group. Count the number of subjects in each group and multiply by 50. This represents the total number of trials for each group.

A10) Using proper statistical notation, the null and alternative hypotheses would be:

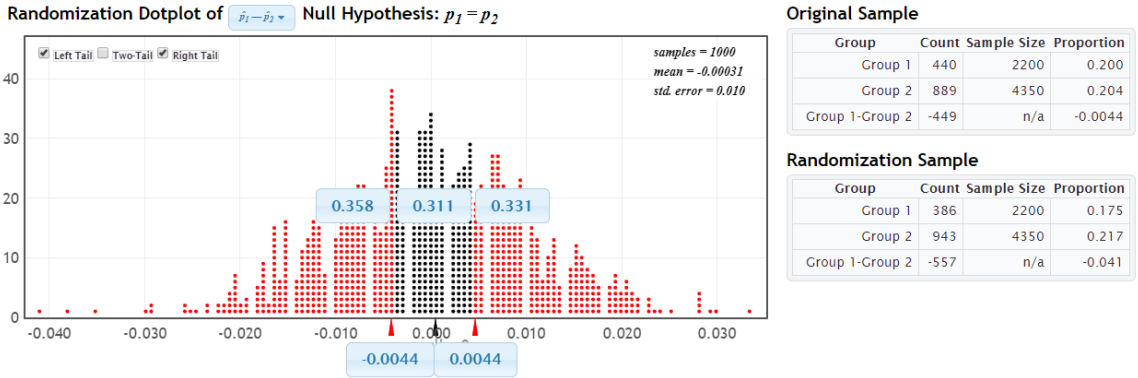
$$H_0 : p_{skep} - p_{bel} = 0$$

$$H_A : p_{skep} - p_{bel} \neq 0$$

The total number of correct guesses for each group are: 440 (Skeptics), 889 (Believers). The total number of trials for each group are: 2200 (Skeptics), 4350 (Believers) [2 pts]

Q11) [3pts] Use the "Edit Data" feature in StatKey to import the total correct guesses and total number of trials for each group. Conduct a *two-sided randomization test* at the $\alpha = 0.05$ level. State your p-value, whether you reject or fail to reject your null hypothesis, and the conclusion you reached in the context of the original research question.

A11) The randomization distribution I generated is shown below.



Using the previous figure, we obtain a p-value of 0.689. [1 pts] At the $\alpha = 0.05$ level, we fail to reject the null hypothesis. [1 pts] Based on these results, we may conclude that there is insufficient evidence to support the claim that the difference in proportion of correct guesses between ESP skeptics and believers is non-zero. [1 pts]

Randomization Testing: Slope/Correlation

Q12) [2pts] The next couple of questions require the use of the "Work Conflict" dataset. Consider the following research question: "Is the degree of unionization predictive of the degree of work conflict within a state?" State the explanatory and response variables.

A12) The explanatory variable is the degree of unionization and the response is degree of work conflict.[2 pts]

Q13) [4pts] Recall that both correlation and regression can be used to evaluate the relationship between two quantitative variables. For each of these methods, state the appropriate null and alternative hypotheses.

A13) For correlation,

$$H_0 : \rho = 0$$
$$H_A : \rho \neq 0$$

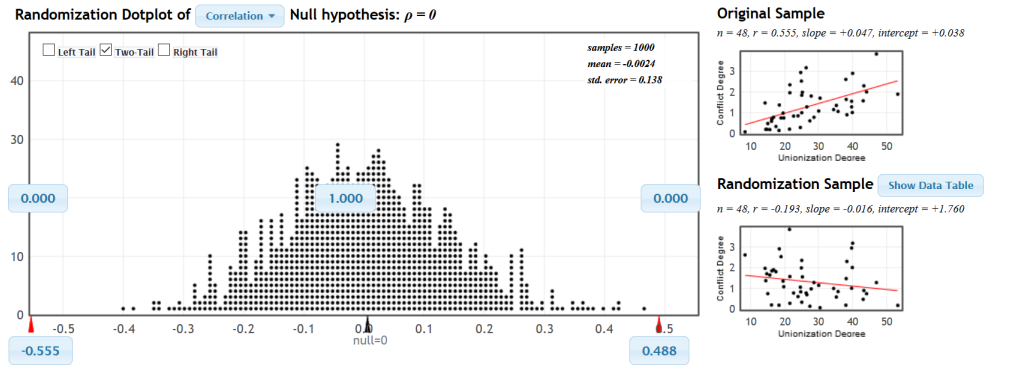
[2 pts] For regression,

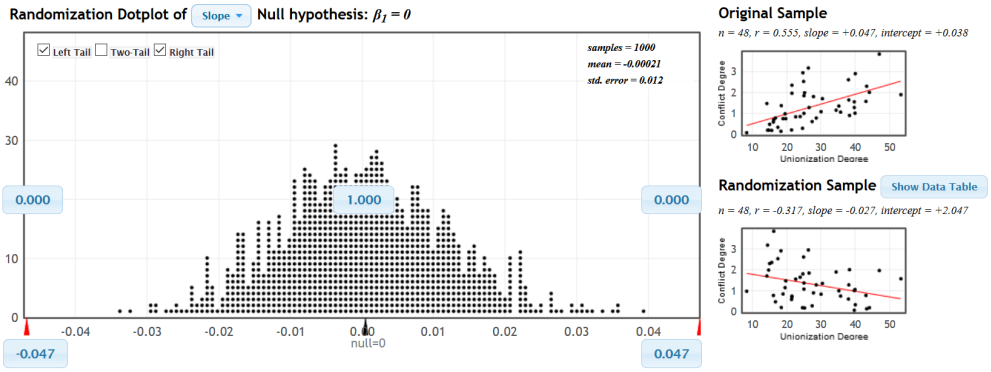
$$H_0 : \beta = 0$$
$$H_A : \beta \neq 0$$

[2 pts]

Q14) [6pts] Input the appropriate data into StatKey and conduct a *two-sided randomization test* at the $\alpha = 0.05$ level. State your p-value, whether you reject or fail to reject your null hypothesis, and the conclusion you reached in the context of the original research question. Do this for both the correlation and regression coefficients.

A14) The randomization distributions I generated are shown below. Correlation is presented first followed by the regression slope.





Correlation: Using the previous figure (corresponding to correlation), we obtain a p-value of (virtually) 0.000. At the $\alpha = 0.05$ level, we reject the null hypothesis. Based on these results, we may conclude that the degree of unionization and degree of work conflict are not uncorrelated. Therefore, degree of unionization is predictive of degree of work conflict. [3 pts]

Regression Coefficient: Using the previous figure (corresponding to the regression coefficient), we obtain a p-value of (virtually) 0.000. At the $\alpha = 0.05$ level, we reject the null hypothesis. Based on these results, we may conclude that the regression of degree of work conflict on degree of unionization does not have a non-zero slope. Therefore, degree of unionization is predictive of degree of work conflict. [3 pts]

Q15) [6pts] Using any one of these datasets or any other found in the "miscellaneous" dataset repository, formulate a research question that can be answered using any one of the testing methods covered in this lab. Be sure to clearly state:

- which dataset you are using
- your research question
- which testing procedure you feel is appropriate to answer the question
- your null and alternative hypotheses
- your p-value
- whether you reject or fail to reject your null hypothesis
- the conclusion you reached in the context of the original research question

A15) Several answers possible. Check whether each of the bulleted criteria were met. Award one point for each of bullets 2 through 7.