DATA 8

Spring 2020

Lecture 19

A/B Testing

Weekly Goals

- Monday
  - Comparing distributions
  - Hypothesis tests and p-values
- Wednesday
  - Making decisions with incomplete information
  - Error probabilities
- **Friday**
  - A/B testing
  - Permutation Test

Announcements

- This Week
  - Lab 6 due tonight 11:59PM
  - Homework 7 out today - due Thursday, March 12
- Next Week
  - Tutoring sections via Google Hangouts
  - Midterm Review Lab attendance will be optional
  - Midterm on March 13th, 7-9PM
    - **Midterm Review Cancelled**
      - Video/Slides uploaded before Wednesday
- Random functions guide

Review: Statistical Significance

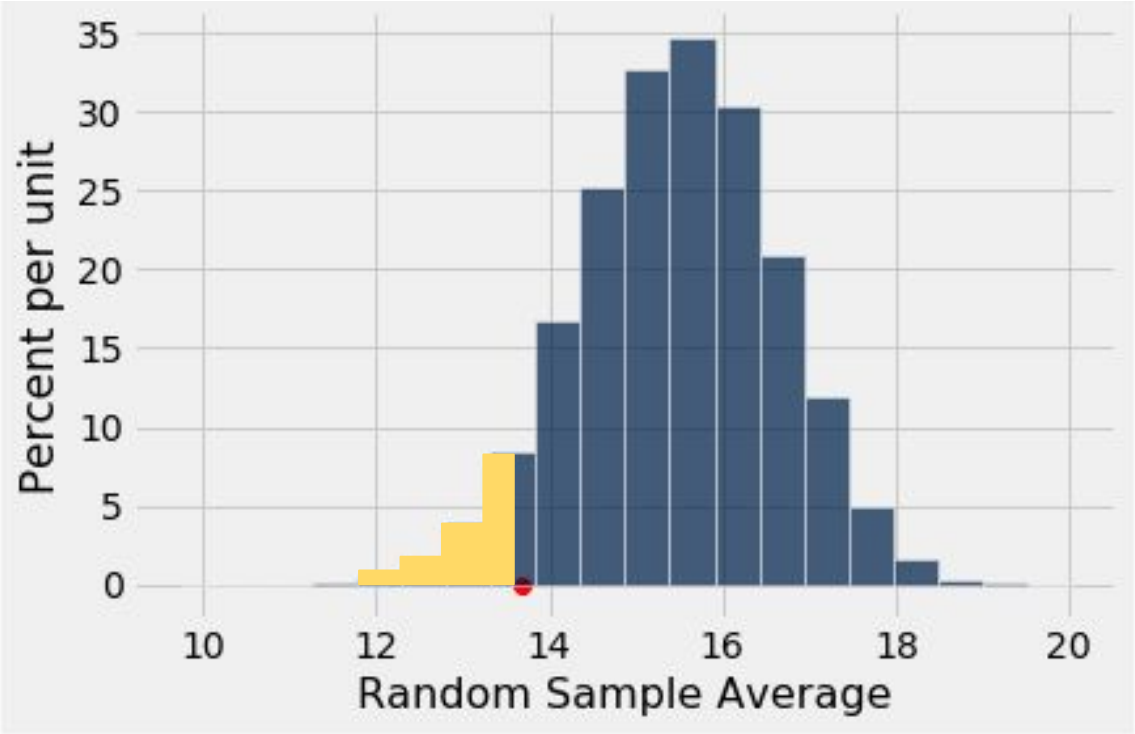
Conventions About Inconsistency

- **"Inconsistent with the null":** The test statistic is in the tail of the empirical distribution under the null hypothesis
- **"In the tail," first convention:**
  - The area in the tail is less than 5%
  - The result is "statistically significant"
- **"In the tail," second convention:**
  - The area in the tail is less than 1%
  - The result is "highly statistically significant"

The P-Value as an Area

Empirical distribution of the test statistic under the null hypothesis

The red dot is the observed statistic.



Definition of the *P*-value

Formal name: **observed significance level**

The *P*-value is the chance,

- if the null hypothesis is true,
- that the test statistic
- is equal to the value that was observed in the data
- or is even further in the direction of the alternative.

A/B Testing

Comparing Two Samples

- Compare values of sampled individuals in Group A with values of sampled individuals in Group B.
- Question: Do the two sets of values come from the same underlying distribution?
- Answering this question by performing a statistical test is called **A/B testing**.

(Demo)

The Groups and the Question

- Random sample of mothers of newborns. Compare:
  - (A) Birth weights of babies of mothers who smoked during pregnancy
  - (B) Birth weights of babies of mothers who didn’t smoke
- Question: Could the difference be due to chance alone?

Hypotheses

- Null:
  - In the population, the distributions of the birth weights of the babies in the two groups are the same. (They are different in the sample just due to chance.)
- Alternative:
  - In the population, the babies of the mothers who smoked weigh less, on average, than the babies of the non-smokers.

Test Statistic

- Group A: non-smokers
- Group B: smokers

- Statistic: Difference between average weights

  Group B average - Group A average

- Negative values of this statistic favor the alternative

(Demo)

The Data

Non-smoker

120 oz

Non-smoker

113 oz

Smoker

128 oz

Smoker

108 oz

...

...

Non-smoker

117 oz

Shuffling Labels Under the Null





Smoker	Non-smoker	Non-smoker	Smoker	...	Smoker
120 oz	113 oz	128 oz	108 oz	...	117 oz

Shuffling Rows

Random Permutation

- `tbl.sample(n)`
  - Table of n rows picked randomly with replacement
- `tbl.sample()`
  - Table with same number of rows as original `tbl`, picked randomly with replacement
- `tbl.sample(n, with_replacement = False)`
  - Table of n rows picked randomly without replacement
- `tbl.sample(with_replacement = False)`
  - All rows of tbl, in random order

(Demo)

Simulating Under the Null

- If the null is true, all rearrangements of labels are equally likely
- Plan:
  - Shuffle all group labels
  - Assign each shuffled label to a birth weight
  - Find the difference between the averages of the two shuffled groups
  - Repeat

(Demo)

How We've Tested Thus Far

Hypothesis Testing Review

- **1 Sample: One Category** *(e.g. percent of flowers that are purple)*
  - Test Statistic: `empirical_percent`, `abs(empirical_percent - null_percent)`
  - How to Simulate: `sample_proportions(n, null_dist)`
- **1 Sample: Multiple Categories** *(e.g. ethnicity distribution of jury panel)*
  - Test Statistic: `tvd(empirical_dist, null_dist)`
  - How to Simulate: `sample_proportions(n, null_dist)`
- **1 Sample: Numerical Data** *(e.g. scores in a lab section)*
  - Test Statistic: `empirical_mean`, `abs(empirical_mean - null_mean)`
  - How to Simulate: `population_data.sample(n, with_replacement=False)`
- **2 Samples: Numerical Data** *(e.g. birth weights of smokers vs. non-smokers)*
  - Test Statistic: `group_a_mean - group_b_mean`,

    `group_b_mean - group_a_mean`, `abs(group_a_mean - group_b_mean)`
  - How to Simulate: `empirical_data.sample(with_replacement=False)`