

DATA COLECTION + EXPLORATORY DATA ANALYSIS

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Government 3990: Statistics in the Social Science

DATA COLLECTION + OBSERVATIONAL STUDIES AND EXPERIMENTS

USE A SAMPLE TO MAKE INFERENCES
ABOUT THE POPULATION

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Your Turn

Suppose we want to know how many offspring female lemurs have, on average. It's not feasible to obtain offspring data from on all female lemurs, so we use data from the Cornell Lemur Center. We use the sample mean from these data as an estimate for the unknown population mean. Can you see any limitations to using data from the Cornell Lemur Center to make inferences about all lemurs?

SAMPLING IS NATURAL



- When you taste a spoonful of soup and decide the spoonful you tasted isn't salty enough, that's **exploratory analysis**
- If you generalize and conclude that your entire soup needs salt, that's an **inference**
- For your inference to be valid, the spoonful you tasted (the sample) needs to be **representative** of the entire pot (the population)

SAMPLING IS NATURAL



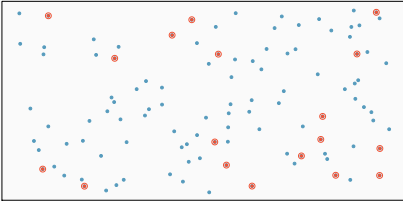
SAMPLING IS NATURAL



IDEALLY USE A SIMPLE RANDOM SAMPLE,
STRATIFY TO CONTROL FOR A VARIABLE,
AND CLUSTER TO MAKE SAMPLING EASIER

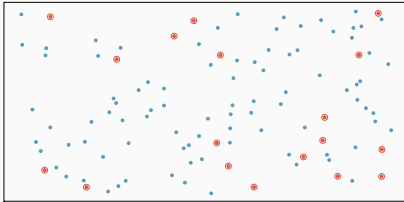
Simple random:

Drawing names from a hat



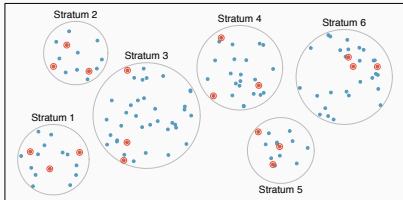
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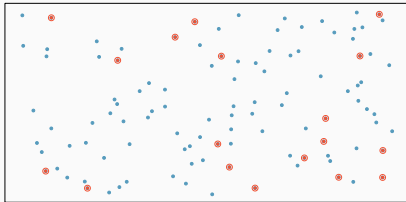
Stratified: homogenous strata

Stratify to control for SES



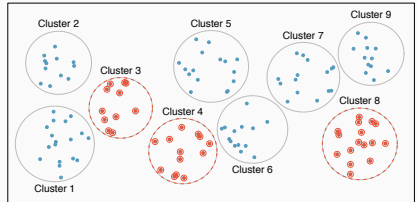
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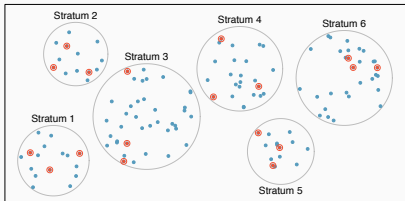
Cluster: heterogenous clusters

Sample all chosen clusters



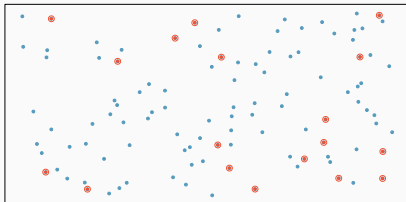
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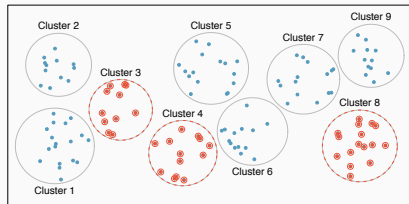
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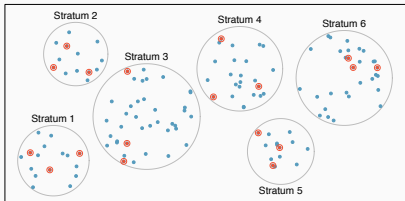
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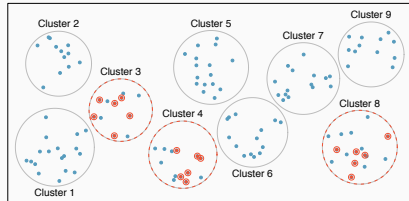
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Multistage:

Random sample in chosen clusters



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A city council has requested a household survey be conducted in a suburban area of their city. The area is broken into many distinct and unique neighborhoods, some including large homes, some with only apartments, and others a diverse mixture of housing structures. Which approach would likely be the *least* effective?

- (a) Simple random sampling
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- **Convenience sample:** Individuals who are easily accessible are more likely to be included in the sample

Your Turn

A school district is considering whether it will no longer allow high school students to park at school after two recent accidents where students were severely injured. As a first step, they survey parents by mail, asking them whether or not the parents would object to this policy change. Of 6,000 surveys that go out, 1,200 are returned. Of these 1,200 surveys that were completed, 960 agreed with the policy change and 240 disagreed. Which of the following statements are true?

- I. Some of the mailings may have never reached the parents.
- II. Overall, the school district has strong support from parents to move forward with the policy approval.
- III. It is possible that majority of the parents of high school students disagree with the policy change.
- IV. The survey results are unlikely to be biased because all parents were mailed a survey.

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EXPERIMENTS USE RANDOM
ASSIGNMENT TO TREATMENT GROUPS,
OBSERVATIONAL STUDIES DO NOT

What type of study is this? What is the scope of inference (causality / generalizability)?¹

Facebook Tinkers With Users' Emotions in News Feed Experiment, Stirring Outcry

By VINDU GOEL JUNE 29, 2014

The New York Times

In [an academic paper](#) published in conjunction with two university researchers, the company reported that, for one week in January 2012, it had altered the number of positive and negative posts in the news feeds of 689,003 randomly selected users to see what effect the changes had on the tone of the posts the recipients then wrote.

The researchers found that moods were contagious. The people who saw more positive posts responded by writing more positive posts. Similarly, seeing more negative content prompted the viewers to be more negative in their own posts.

¹<http://www.nytimes.com/2014/06/30/technology/facebook-tinkers-with-users-emotions-in-news-feed-experiment-stirring-outcry.html>

4. EXPERIMENTS USE RANDOM ASSIGNMENT TO TREATMENT GROUPS, OBSERVATIONAL STUDIES DO NOT

Your Turn

A study that surveyed a random sample of otherwise healthy adults found that people are more likely to get muscle cramps when they're stressed. The study also noted that people drink more coffee and sleep less when they're stressed. What type of study is this?

What is the conclusion of the study?

Can this study be used to conclude a causal relationship between increased stress and muscle cramps?

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Muscle cramps might also be due to increased caffeine consumption

FOUR PRINCIPLES OF EXPERIMENTAL DESIGN: RANDOMIZE, CONTROL, BLOCK, REPLICATE

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Why is this important? Can you think of other variables to block for?

RANDOM SAMPLING HELPS
GENERALIZABILITY, RANDOM
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6. RANDOM SAMPLING HELPS GENERALIZABILITY, RANDOM ASSIGNMENT HELPS CAUSALITY

<i>ideal experiment</i>	Random assignment	No random assignment	<i>most observational studies</i>
Random sampling	Causal conclusion, generalized to the whole population.	No causal conclusion, correlation statement generalized to the whole population.	Generalizability
No random sampling	Causal conclusion, only for the sample.	No causal conclusion, correlation statement only for the sample.	No generalizability
<i>most experiments</i>	Causation	Correlation	<i>bad observational studies</i>

SUMMARY

SUMMARY OF MAIN IDEAS

1. Use a sample to make inferences about the population
2. Ideally use a simple random sample, stratify to control for a variable, and cluster to make sampling easier
3. Sampling schemes can suffer from a variety of biases
4. Experiments use random assignment to treatment groups, observational studies do not
5. Four principles of experimental design: randomize, control, block, replicate
6. Random sampling helps generalizability, random assignment helps causality

EXPLORATORY DATA ANALYSIS

**ALWAYS START YOUR EXPLORATION WITH
A VISUALIZATION**

FROM A CLASS SURVEY...

Do you see anything out of the ordinary?



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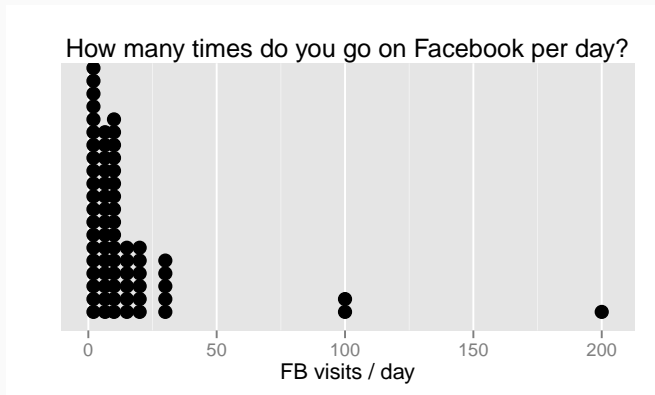
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Some people reported very low ages, which might suggest the survey question wasn't clear: romantic kiss or any kiss?

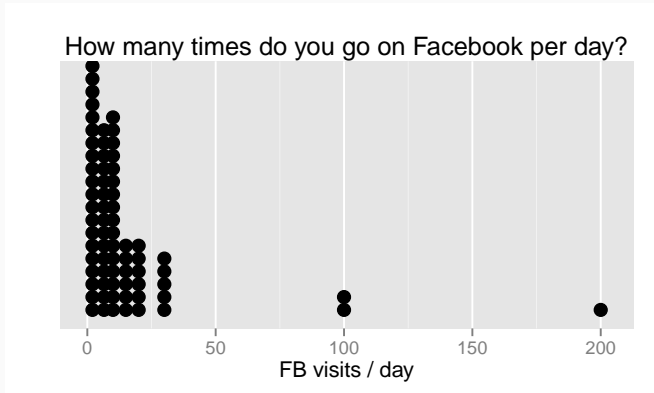
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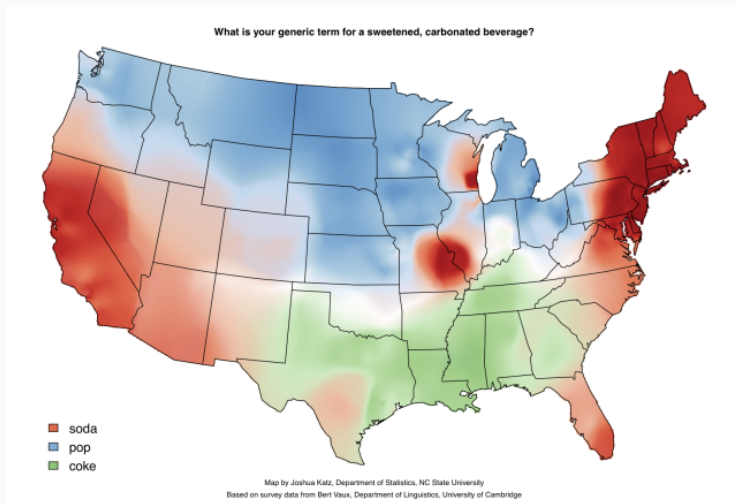
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Finer scale for lower numbers.

Describe the spatial distribution of preferred sweetened carbonated beverage drink.



What is missing in this visualization?



WHEN DESCRIBING NUMERICAL
DISTRIBUTIONS DISCUSS SHAPE, CENTER,
SPREAD, AND UNUSUAL OBSERVATIONS

- **Shape:** skewness, modality
- **Center:** an estimate of a **typical** observation in the distribution (mean, median, mode, etc.)
 - Notation: μ : population mean, \bar{x} : sample mean
- **Spread:** measure of variability in the distribution (standard deviation, IQR, range, etc.)
- **Unusual observations:** observations that stand out from the rest of the data that may be suspected outliers

Your Turn

Which of these is most likely to have a roughly symmetric distribution?

- (a) salaries of a random sample of people from North Carolina
- (b) weights of adult females
- (c) scores on an well-designed exam
- (d) last digits of phone numbers

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MEAN VS. MEDIAN

Your Turn

How do the mean and median of the following two datasets compare?

Dataset 1: 30, 50, 70, 90

Dataset 2: 30, 50, 70, 1000

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STANDARD DEVIATION AND VARIANCE

- Most commonly used measure of variability is the **standard deviation**, which roughly measures the average deviation from the mean
 - Notation: σ : population standard deviation, s : sample standard deviation
- Calculating the standard deviation, for a population (rarely, if ever) and for a sample:

$$\sigma = \sqrt{\frac{\sum_{i=1}^N (x_i - \mu)^2}{n}} \quad s = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}}$$

- Square of the standard deviation is called the **variance**.

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Why do we use the squared deviation in the calculation of variance?

- To get rid of negatives so that observations equally distant from the mean are weighed equally.
- To weigh larger deviations more heavily.

Our Turn

For the given data set: 7, 6, 5, 5, 9, 10, 11, 10, 9

Calculate

- Range
- Median
- The three quartiles
- Interquartile range (IQR)
- Draw a boxplot

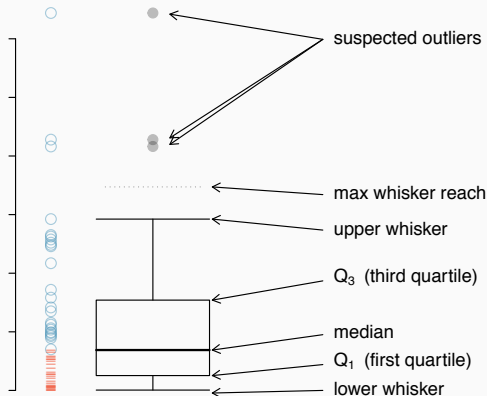
ROBUST STATISTICS ARE NOT EASILY
AFFECTED BY OUTLIERS AND EXTREME
SKEW

- Mean and standard deviation are easily affected by extreme observations since the value of each data point contributes to their calculation.
- Median and IQR are more robust.
- Therefore we choose median&IQR (over mean&SD) when describing skewed distributions.

USE BOX PLOTS TO DISPLAY QUARTILES,
MEDIAN, AND OUTLIERS

BOX PLOT

A **box plot** visualizes the median, the quartiles, and suspected outliers. An **outlier** is defined as an observation more than $1.5 \times \text{IQR}$ away from the quartiles.



Application Exercise

1.1 Distributions of numerical variables

SUMMARY

SUMMARY OF MAIN IDEAS

1. Always start your exploration with a visualization
2. When describing numerical distributions discuss shape, center, spread, and unusual observations
3. Robust statistics are not easily affected by outliers and extreme skew
4. Use box plots to display quartiles, median, and outliers