# 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 squirrels have, on average. It's not feasible to obtain offspring data from on all female squirrels, so we use data from the Cornell Squirrel 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 Squirrel Center to make inferences about all squirrels?

# 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)
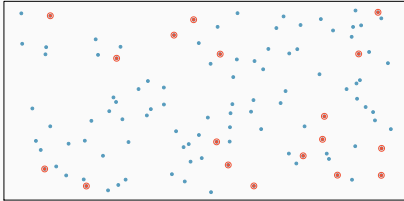
# Sampling is natural

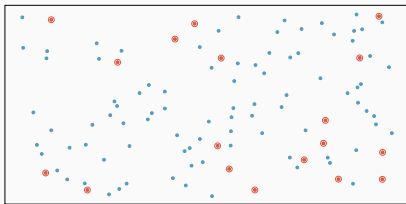**Ideally use a simple random sample, stratify to control for a variable, and cluster to make sampling easier**

Drawing names from a hat

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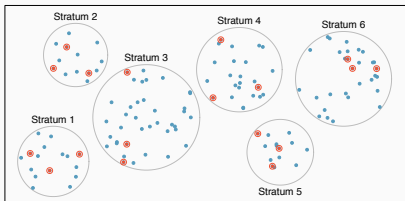


homogenous strata

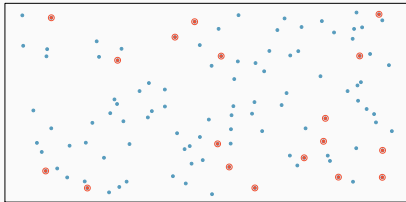Stratify to control for SES

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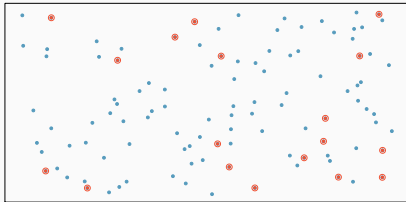


## Stratified: homogenous strata

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## Cluster: heterogenous clusters

Sample all chosen clusters

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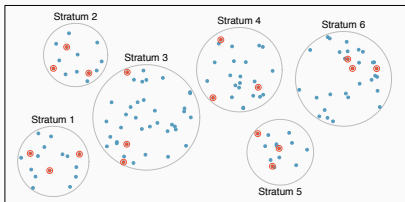
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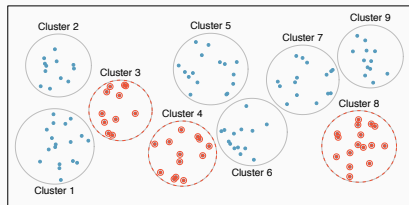
Multistage:

Random sample in chosen clusters
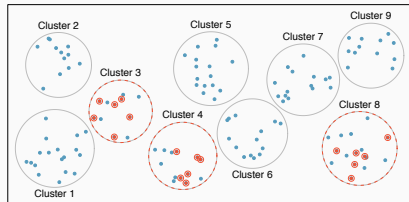
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### Your Turn

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

(b) Stratified sampling, where each stratum is a neighborhood

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- **Voluntary response:** Occurs when the sample consists of people who volunteer to respond because they have strong opinions on the issue since such a sample will also not be representative of the population
- **Convenience sample:** Individuals who are easily accessible are more likely to be included in the sample

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.

(a) Only I      (b) I and II      (c) I and III      (d) III and IV      (e) Only IV

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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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**What is the conclusion of the study?**

*There is an association between increased stress & muscle cramps.*

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*Observational*

### What is the conclusion of the study?

*There is an association between increased stress & muscle cramps.*

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

*Muscle cramps might also be due to increased caffeine consumption or sleeping less – these are potential confounding variables.*

# Four principles of experimental design: randomize, control, block, replicate

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  - Treatment: increased stress
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- It is suspected that the effect of stress might be different on younger and older people: block for age.

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

**Random sampling helps generalizability, random assignment helps causality**

|  | Random assignment | No random assignment |  |
|---|---|---|---|
| ideal experiment | | | most observational studies |
| 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 |
| most experiments | Causation | Correlation | bad observational studies |

# 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?



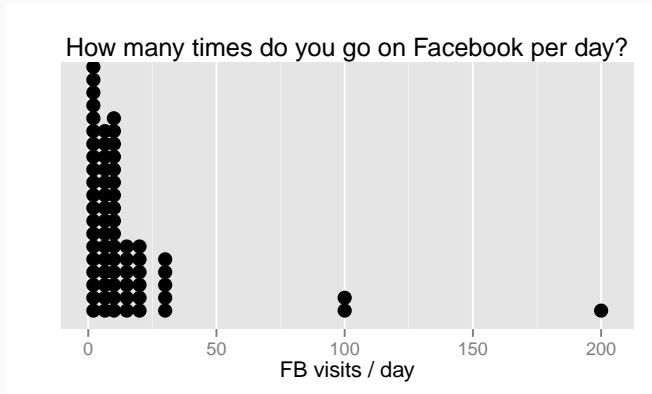How old were you when you had your first kiss?

## From a class survey…

How old were you when you had your first kiss?

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

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How are people reporting lower vs. higher values of FB visits?



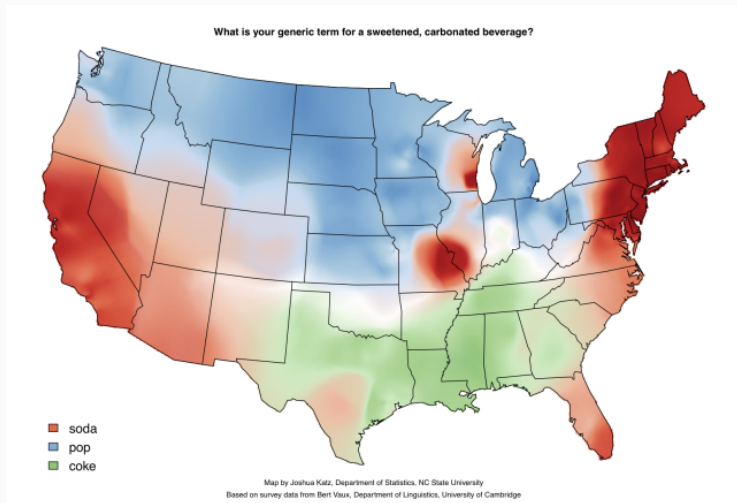How many times do you go on Facebook per day?

FB visits / day

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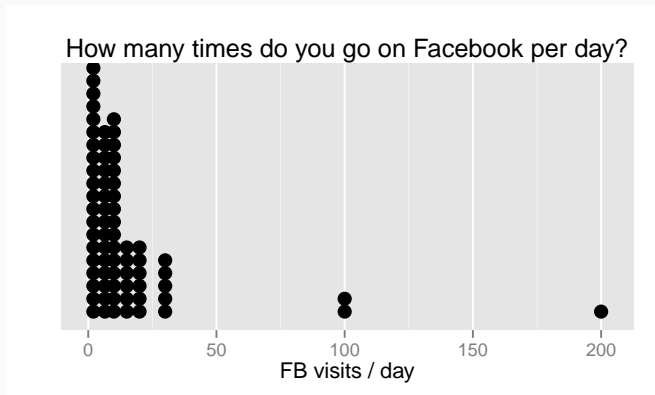
*Finer scale for lower numbers.*

Describe the spatial distribution of preferred sweetened carbonated beverage drink.



What is your generic term for a sweetened, carbonated beverage?

- soda
- pop
- coke

Map by Joshua Katz, Department of Statistics, NC State University
Based on survey data from Bert Vaux, Department of Linguistics, University of Cambridge

# What is missing in this visualization?

**When describing numerical distributions discuss shape, center, spread, and unusual observations**

## Describing distributions of numerical variables

- Shape: skewness, modality
- Center: an estimate of a typical observation in the distribution (mean, median, mode, etc.)
  - Notation: $\mu$: 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

(a) $\bar{x}_1 = \bar{x}_2$, $median_1 = median_2$

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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: $\sigma$: population standard deviation, $s$: sample standard deviation
- Calculating the standard deviation, for a population (rarely, if ever) and for a sample:

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

- Square of the standard deviation is called the variance.

Why divide by $n - 1$ instead of $n$ when calculating the sample standard deviation?

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Lose a "degree of freedom" for using an estimate (the sample mean, $\bar{x}$), in estimating the sample variance/standard deviation.

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.

## Range and IQR

### 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**

## Robust statistics

- 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 $1.5 \times$ IQR away from the quartiles.
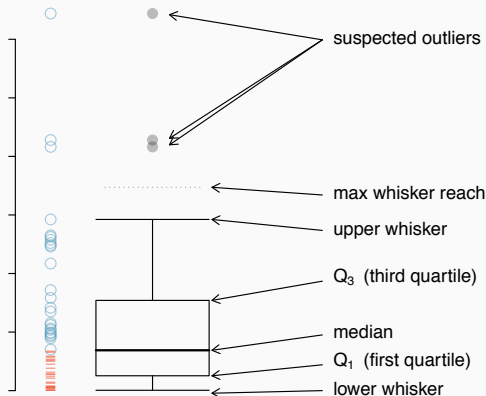
**Aplication Exercise**

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