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Unit 3 – Data Ethics and Measurement

Your Gametime Professor Colton

Unit 3 - Outline

Measuring

- Motivating Example
- Basic Principles
- Validity
- Bias
- Reliability

Do the Numbers Make Sense?

- Check Measurements for Sensibility
- Examples

Motivating Example

Setup: How big a brain you got? Do people with larger brains have more intelligence?

GOAL:

- To answer this question, we have to measure intelligence.
- This requires us to reduce the vague idea to a number that can go up or down.

<u>Considerations</u>

- What do we mean by intelligence?
  - Does knowledge about lots of subjects make you smart? Or is it lots of knowledge about one subject?
  - Problem solving abilities via puzzles? Complicated Math calculations?
- Okay, once we decide that. Then how do we get a number??
  - Do we just give people a test?
  - Look at their grades in school?
- Can we trust this number?
  - Does it actually measure what we want it to?

This is NOT a straightforward task….

Review + New

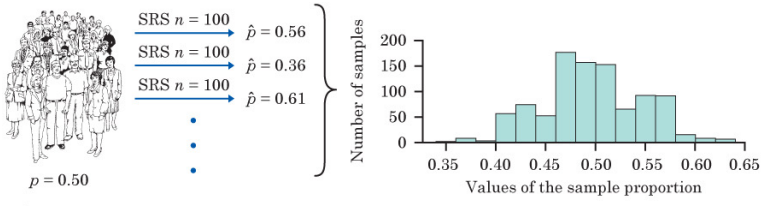


Figure 3.1
Moore/Notz, *Statistics: Concepts and Controversies*, 9e, © 2017 W. H. Freeman and Company

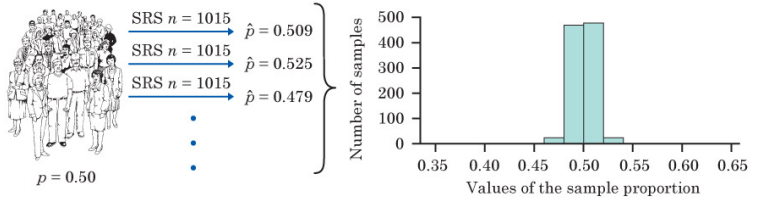


Figure 3.2
Moore/Notz, *Statistics: Concepts and Controversies*, 9e, © 2017 W. H. Freeman and Company

<u>Statistics and Data</u>

- <u>Statistics</u> is the science of getting information from <u>data</u>.
  - The information we get is only as good as the data we collect.

<u>Good Sampling Methods</u>

- Techniques to use to **reduce bias** when selecting our sample (<u>random chance</u>).

<u>Larger Samples</u>

- **Decrease variability** of our estimates by selecting <u>larger</u> samples.

<u>NOW</u>

- Once I select my sample, I now have to **measure** the characteristic of interest.

Measurement: The Basics

Measure

- To **measure** is the process of assigning a numerical value to the characteristic of interest.

Variable

- The result of a measurement is a numerical variable since the values of the measurement vary for each individual in the sample.

Good Measurements

- To take a good measurement, I must know…
  - What characteristic I want to measure.
  - Decide the best way to assign a numerical value to that characteristic.
- For example, if I am trying to measure my weight:
  - I need an instrument, logically a scale. What type of scale?
  - How to measure weight consistently for everyone? Shoes or no shoes? Adjust for clothing?
  - Units? Lbs or Kg?

Final Result

- If I measure the weight of all the individuals in my sample, then I have the values of a numerical variable called weight.

Measurement: Properties

Properties of Measurements

- Any measurement I take must also possess the following properties:
  1. The measurement must be **valid**.
  2. The measurement cannot be **biased**.
  3. The measurement must be **reliable**.

Measurement: Validity

Validity

- A measurement is **valid** if that measurement represents an appropriate way to assign a numerical value to the characteristic I am measuring.
    - It is valid to measure length with a tape measure.
    - It is not valid to measure a student's readiness for college by recording her height.

Improving Validity

- Use the **rate** at which something occurs rather than the **count** of occurrences!
- For example: If I am totaling my correct points on a test…
    - If I score a 40 on Stats and a 215 on Biology? Which did I do better on???
    - Now if we know Stats was 40 out of 50 (90%) and Biology was 215 out of 300 (72%)….
- So a rate is a more valid (appropriate) **measure** that a simple count.

Considerations

- Often hard to find a valid measure for some abstract ideas, such as psychological states or other characteristics that are not physical.
- For example, what is a valid way to measure depression?

Measurement: Validity

Setup: Is the SAT a valid measure of readiness for college?

- "Readiness for college academic work" is a vague concept that probably combines many factors.
- Opinions will always differ about whether SAT scores (or any other measure) accurately reflect this vague concept.
- Instead, we ask a simpler and more easily answered question: Do SAT scores help predict students' success in college?

More Promising Solution: Success in college is a clear concept, measured by whether students graduate and by their college grades.

- Students with high SAT scores are more likely to graduate and earn (on the average) higher grades than students with low SAT scores.
- We say that SAT scores have predictive validity as measures of readiness for college.

Predictive Validity

- A measurement of a property has **predictive validity** if it can be used to predict success on tasks that are related to the property measured.

But… We must ask how *accurately* SAT scores predict college grades.

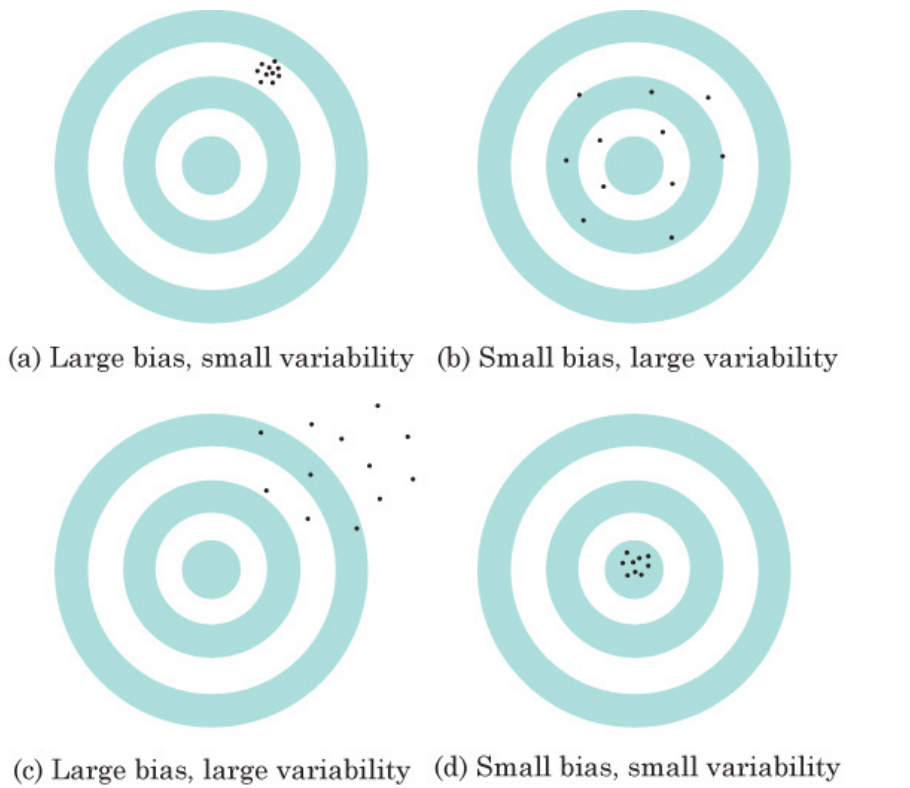
Measurement: Bias and Reliability

Bias

- A measurement is **biased** if it consistently underestimates or consistently overestimates the true value of the characteristic it measures.

Reliability

- A measurement is **reliable** if the results are repeatable.



(a) Large bias, small variability (b) Small bias, large variability

(c) Large bias, large variability (d) Small bias, small variability

Figure 3.3
Moore/Notz, *Statistics: Concepts and Controversies*, 9e, © 2017 W. H. Freeman and Company

Measurement: Bias and Reliability

Illustration

- Using a bathroom scale to measure your weight is valid, but the measurement may not be very accurate.
  - It measures weight, but it may not give the true weight.

- Let's say that, originally, your scale always read *three pounds too high*.
  - Measured weight = 138 Lbs (True Weight) + three pounds

- But scales often vary a bit…
  - They don't always give the same reading when you step off and step right back on.
  - Measured weight = 138 Lbs (True Weight) + three pounds – *one pound*
  - Try again: Measured weight = 138 Lbs (True Weight) + three pounds *+ 1.5 pounds*

Two Kinds of Error

- Always three pounds too much.
  - This systematic error that occurs every time we make a measurement is called **bias**.
- It changes the reading differs every time someone steps on the scale repeatedly.
  - We can't predict the error, so we call it **random error**.

SO we can think about our measured weight like this:

  - Measured weight = 138 Lbs (**True Weight**) + three pounds (**Bias**) + 1.5 pounds (**Random Error**)

Measurement = True + Bias + Random Error

Number Sense: Check Measurements for Sensibility

Statistics and Numbers

- Making sense of numbers and measurements is essential in the study of statistics.
- How do we understand data? By examining numbers!

How to Evaluate Claims

- As you encounter numbers, remember to ask the following questions as appropriate:

1. Is the measurement valid?
2. Is there missing information?
3. Are the units of measure appropriate?
4. Is the magnitude of the numbers appropriate?
5. Is the arithmetic correct?
6. Are there inconsistencies?
7. Are the numbers too regular or do they agree to well with what the author would like to see? If so, is there a hidden agenda?

Number Sense: Check Measurements for Sensibility

'What didn't they tell us?’

- This is the most valuable question to ask when reading conclusions about data.
- The most common way to mislead with data is to cite correct numbers that don't quite mean what they appear to say because the full story has not been disclosed.

Example 1

Setup: In 1994, according to the Department of Labor, the median salary for government workers was $29,528, while the median salary for private workers was $26,494. Conservative groups have claimed that this shows that government workers are an overpaid "privileged class."

<u>Considerations</u>

- Does this make sense?

- What didn't they tell us???
  - Nature of jobs are so different that comparisons can be misleading
  - Lots of missing information!

Example 2

Setup: A.R.M., Allergy Relief Medicine switched to “new formula maximum strength.” But the old formula had 37.5 mg of active ingredient while the new formula had only 25 mg. So Consumer Reports (April 1985) queried the manufacturer.

<u>Considerations</u>

- What didn’t they tell us?

- FDA changed regulations to only allow max of 25 mg.
  - Very creative advertising but still misleading.

- Relative change = (New value – Old value) / Old value = (25 – 37.5) / 37.5 = -0.33 -> -33%

Example 3

Setup: Two papers were written on similar topics and it turned out that identical data points appeared in each paper, but the actual number of subjects cited was different for each paper.

<u>Considerations</u>

- Do you have any questions as to whether or not these are legitimate results?

- Regularity of data but inconsistent in number of subjects
- Falsified data or reported inaccurately

Example 4

Setup: In a student project (June 1999) the following statistics were given: A sample of 1000 M&M Peanut candies was investigated to determine the proportion of each color produced.

- Results: 20% Brown 20% Yellow 20% Red 20% Blue 10% Orange 10% Green

Considerations

- Numbers are too good to be true, too regular, too even
  - These are the EXACT population proportions.
- Fake data

Example 5

Setup: An article in the Durham Morning Herald, February 23, 1982 entitled “Most people surveyed like Chapel Hill parks” reports that “Three fourths of Chapel Hill residents are satisfied with the town’s parks and recreation programs, according to a survey conducted by the Chapel Hill Parks and Recreation Commission.

- Of 258 persons who answered the survey [on Chapel Hill parks], 96 percent were white.
- Thirty-eight percent of the 10 non-whites surveyed said they were satisfied with recreation services.
- 73 percent indicated they used the parks.”

<u>Considerations</u>

- Look at percentages: 10 x 0.38 = 3.8 people?????? Cause for concern, percentages maka no sense

Example 6

Setup: An Associated Press article in the Lafayette Journal and Courier June 12, 2000 entitled “TWA thinks positively as industry consolidates without it” states that “Southwest does, however, carry a far greater number of passengers, 65,288 in 1999 to TWA’s 25,790.”

<u>Considerations</u>

- Do these values seem believable?

- 600 million people flew in the US alone in 1997
- Only 65000 passengers for Southwest???? No, author meant 65 million……
- Inconsistent!

Example 7

Setup: An article in Forbes magazine (April 8, 1996) said that the computer maker “Packard Bell had sales of $20 billion over ten years and $45 million in profits, a profit margin of 2% of sales.”

<u>Considerations</u>

- Does this seem right to you?

- Check arithmetic: % = Part / Whole = Profit / Sales = 45 million / 20 billion = 0.00225 = 0.225% (10 times smaller than what was reported)

Example 8

Setup: Feminist guru Gloria Steinem claimed in Revolution from Within that in the United States “150,000 females die of anorexia each year.” The truth from the National Center for Health Statistics says about 50 die per year.

<u>Considerations</u>

- 150,000 to 200,000 women suffer from anorexia… Hidden agenda!
- Be wary of numbers reported from groups with a cause.

Example 9

Setup: An Affirmative Action poll appeared in The Press of Atlantic City on March 25, 1995, p. A6. Litton industries claimed: “76% of independent microwave oven technicians surveyed recommended Litton.”

<u>Considerations</u>

- PROBLEM: survey included only technicians who serviced Litton ovens and at least one other brand, some of whom were actually Litton dealers.
- What are some questions you could ask about these numbers?

- Hidden agenda? – Increased sales
- Biased sample

Example 10

Setup: A health club reports that of its members over 50 years of age, 45% are men and 25% are women.

<u>Considerations</u>

- Does this seem fishy to you?

- 45% + 25% = 70%! What about the other 30%?????
- Check the arithmetic!

Example 11

Setup: Samples of 20 individuals were taken from five different age groups at the health club.

- For each sample of 20 individuals, the percentage that used the swimming pool for exercise was reported as follows: 8% 14% 16% 21% 37%

<u>Considerations</u>

- What should you check about these numbers?

- Precents for 20 individuals are multiples of 5: 20/100 = 0.05 = 5%
- 14% of 20 is 2.8????
- Inconsistent data!

Number Sense: Questions

Questions to ask of numbers:

1. What didn't they tell us??
   - Missing data or information

2. Are the numbers consistent / plausible / too good to be true?
   - Distorted data
   - Fake or falsified data
   - Too much precision or regularity
   - Data could be from a biased sample

3. Is the arithmetic correct?
   - Check percentages!

4. Is there a hidden agenda?
   - Often need to do some research