Lecture 1 - Introduction to Statistics

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Introduction

Why statistics?

You grew up in the “digital age”. There is data about your entire life…
Google Timeline

And everybody wants your data

It's too late to stop the Snooper's Charter, so how should you protect yourself?

The intrusive bill passed into law on November 29 despite widespread concern, so how did we let this happen and what should you do next?

By Scott Carey | Dec 08, 2016

Share

It's easy to find places to lay the blame for the Investigatory Powers Act becoming UK law last month. Now, along with the power to hack and monitor the general public, internet service providers must now store your entire browsing history for 12 months and make it accessible to public authorities and the police - so called bulk powers.

Public and political distraction because of Brexit and everything else that has been going on in 2016 is a possibility. The speed at which government managed to get this bill through Parliament is another factor, and the weakness of opposition certainly didn't help in that regard.

What can you do with data?

- Data literacy is increasingly important in many jobs
- You can get insights from data to
  - Better understand social life
  - Predict sales and optimize marketing
  - Explore what activity in the brain is associated with observed behavior
- Data analysis is one of the most marketable concrete skills we teach at university

Difference between Methods and Statistics

Methods is about the procedures of research:

- What actions do we take to collect good data
- Which participants to include
- How to measure what we want to measure
- How to design studies that are suitable for answering our research questions

Difference between Methods and Statistics

Statistics is about analyzing data

- **Descriptive statistics**: describing/summarizing data
- **Inferential statistics**: Making best guesses about the population from a smaller sample
- **Statistical modeling**: Representing a theory mathematically
- Predicting important outcomes (sales, well-being, neurological disorders)
- Exploring data to find interesting patterns
- Performing tests to answer theoretical research questions

Dictionary of basic concepts

Tabular data

Most data in the social sciences is tabular, where each row represents an individual i observation, and each column j represents that individual's data on several variables:

About observations: Population

Population:

- The complete set of objects of interest
  - E.g., all people in NL, all students in this class
- Number of individuals in the population: N
  - N = 17.53 million, N = 75

About observations: Sample

Sample:

- Observed part of the population
- Number of observations: n

About variables: Construct

Construct:

- Abstract feature of interest for the population
  - E.g., Short Term Memory, intelligence, perseverance, education

Operational definition:

- Concrete measurable representation of the construct
  - E.g., Number of words recalled, the Wechsler Adult Intelligence Scale (WAIS), ability to withstand a tasty treat, highest degree obtained

About variables: Variable

Variable:

- (Mathematical) placeholder for specific values
- E.g., `WAIS` is a variable representing scores on the WAIS
- You can refer to a variable without (yet) knowing its specific values

Data:

- Specific values of a variable
- Example of data: Jen's score on the variable `WAIS` is 138

Role of data in scientific research

Empirical cycle

De Groot (1961)

Relationship between theory and empiricism

Relationship between theory and empiricism

Theory:
Construct A influences construct B

- E.g., being exposed to war increases depression

Empirical test:
Variable A predicts variable B

- E.g., being deployed (yes/no) predicts scores on the SCL-90 depression questionnaire

Sampling theory

Samples: why?

- We want to make a claim about the population
- It is not possible to access the entire population
- We observe a part of the population: the *sample*
- Sample statistics are also our best guess about population parameters
  - Of course, sample statistics are not *equal to* population parameters
  - You will learn ways to express uncertainty about your best guess

Samples: why?

- If the sample is *representative* of the population, your best guess will generalize better to the entire population and to new samples
- The best way to get a representative sample is *random sampling*
- Random sample:
  - Every population individual has the same probability of being included

Non-random samples

- Probability of inclusion unknown to the researcher
- Examples: convenience sampling, snowball sampling, cluster sampling
- Sampling bias
  - E.g., Individuals that are easy to access ave higher probability of being included

Measurement level

NOIR measurement levels

Measurement level: What kind of information is contained in a variable?

Mnemonic: `n o i r` = black in French

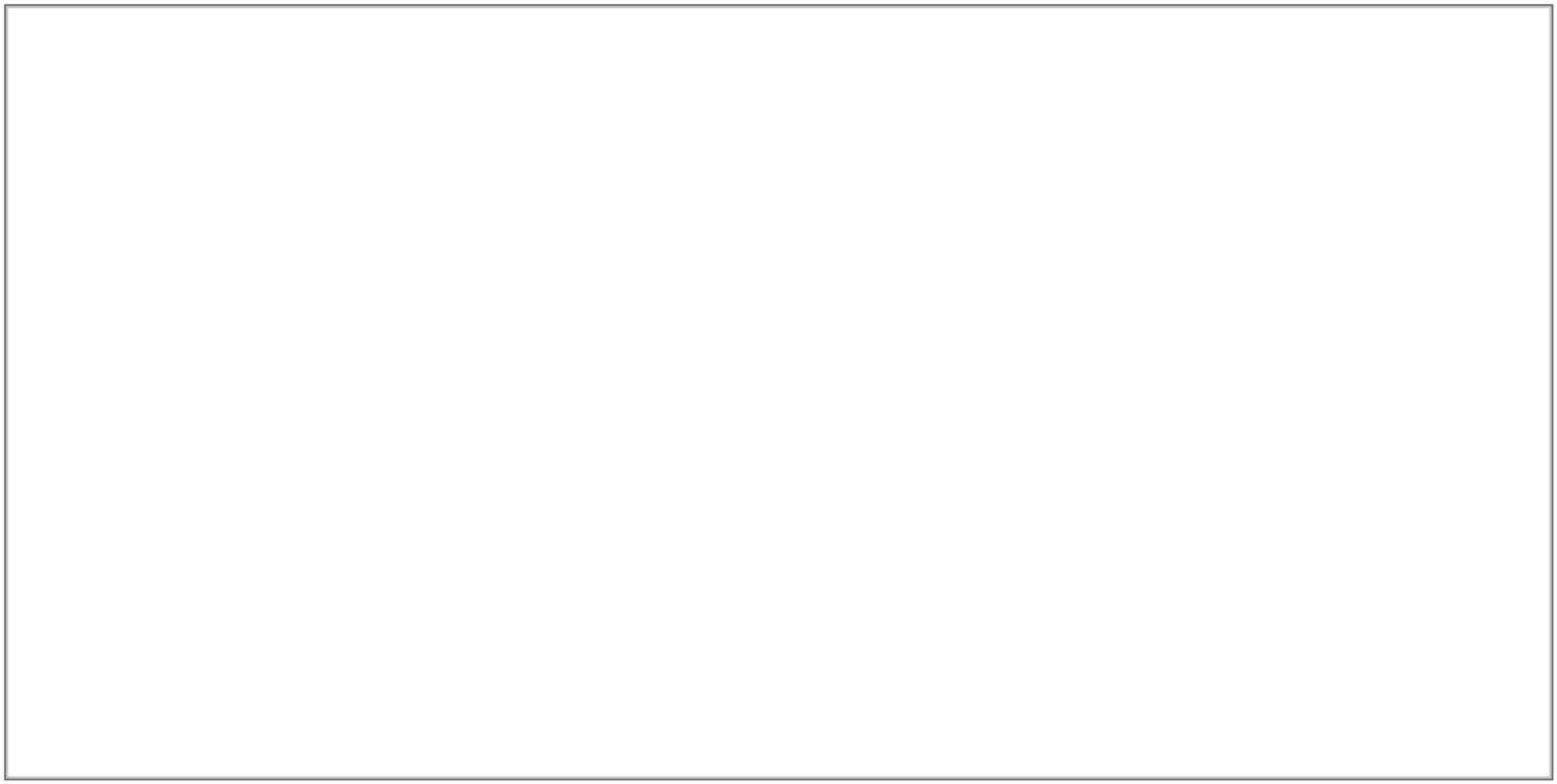
Subsequent levels carry incremental information

NOIR measurement levels

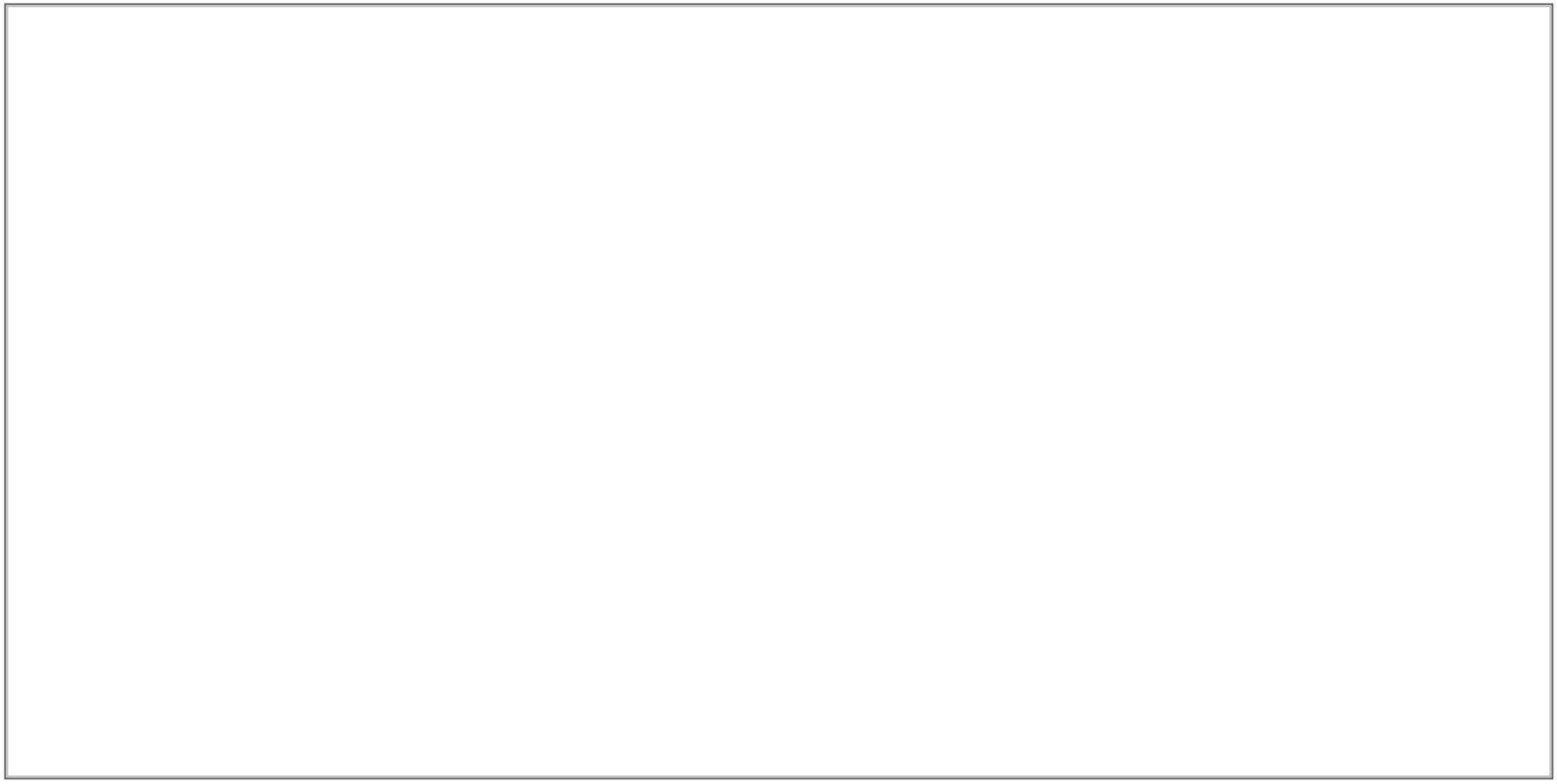
- Nominal
  - Categories; values differ in name only (e.g., majors)
- Ordinal
  - Categories; additionally, values have meaningful order (e.g., SES groups, bachelor year 1, 2, 3)
- Interval
  - Numeric; additionally, distance between values is meaningful
  - A step from 1 to 2 is equally large as a step from 2 to 3, or 5 to 6
- Ratio
  - Numeric; additionally has a meaningful zero-point
  - Because of this, ratios between two values are also meaningful

Interval v Ratio

- Celsius and Fahrenheit are interval scales
- Kelvin is a ratio scale



Interval v Ratio



Measurement level matters

- Measurement level is a property of the construct and of the operational definition
  - Ideally, the measurement level of the construct and its variable are the same
  - E.g., sex assigned at birth: nominal
  - E.g., gender identification: ordinal or continuous
- Measurement level determines what statistics and analyses you can use

Other common distinctions

- Categorical variables: Nominal, Ordinal
- Continuous variables: Interval, Ratio
- Qualitative variable: Difference in kind, Nominal
- Quantitative variables: Differences in degree; ordinal, interval, ratio

Edge cases:

- Number of children (discrete ratio)
- Political orientation from liberal to conservative (ordinal, but which is higher/lower?)

Descriptive statistics

Descriptive Statistics

- Descriptive statistics summarize data across a sample
- You nearly always examine them to get a sense of your dataset
  - E.g., which major is most common among LAS students?
  - How old are my students, on average?
  - How much do the ages of my students vary?
  - What's the gender distribution?
- Descriptive statistics *may* also be relevant to answer research questions
  - E.g.: When evaluating exam questions: Is the proportion of correct answers on this MC question greater than chance?

Distributions

Type of variable	Central tendency	Graph
Nominal	Frequency distribution	Bar chart
Ordinal	(Cumulative) frequency distribution	Bar chart
Interval/ratio	(Normal) probability distribution	Histogram, density plot

A nominal variable

Major	Frequency	Percent
BE	5	0.07
CN	25	0.33
SS	45	0.60

Bar chart

An ordinal variable

SES	Frequency	Percent	Cumulative
Low	32	0.43	0.43
Medium	36	0.48	0.91
High	7	0.09	1.00

Bar chart

A continuous variable

Measures of central tendency

What is the average or most common response?

Type of measure	Type of variable	Definition
Mode	Nominal/Ordinal	Most common value
Median	Ordinal/Continuous	Middle value/50th percentile
Mean	Continuous	Average value

Measures of dispersion

How much variability is there in responses?

Type of measure	Type of variable	Definition
Frequency table	Nominal	Count/percentage of responses
Range	Ordinal/continuous	Minimum to maximum value
Variance	Continuous	Mean squared distance of observations to the mean

Calculating the variance

Variance:

$$S_X^2 = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n-1}$$

Units of S^2 are squared; if you measured height in CM, S^2_{height} is expressed in CM^2

Standard deviation (SD): $S_X = \sqrt{S_X^2}$

Median and Mode for ordinal variable

Median: middle value
Example 1: (*n* = unequal): 4, 5, 6, 7, 8, 9, 9 -> median is 7
Example 2: (*n* = equal): 4, 5, 6, 8, 9, 9 -> median 7 (mean of the two middle values)
Mode: Most frequent score; 9 in both examples

Mean, median, mode for continuous variable

The average Australian is a millionaire
But… most Australians are not!
https://www.volkskrant.nl/columns-opinie/australiers-zijn-gemiddeld-miljonair-maar-daar-hebben-de-meeste-australiers-helemaal-niks-aan~b8aa3fd3/

Skewed Distributions

Mean, variance

Bivariate descriptives

Describing associations

	Nominal	**Ordinal**	**Interval/Ratio**
Nominal	Contingency Table	Contingency Table	Contingency table
Ordinal		Contingency Table Spearman's correlation	Biserial Correlation
Interval/Ratio			Pearson Correlation Coefficient Scatter plot

Contingency table

Is there an association between gender and education?

Correlation

> **Correlation:** A standardized measure of the strength of linear association between two continuous variables.

- Standardized: ranges from [-1, 1]
- Sample correlation: r
- Population correlation: ρ
- r = -1: Perfect negative association
- r = 0: No association
- r = 1: Perfect positive association

Correlations

Error