Statistics One

Lecture 3
Variables, Distributions, & Scales

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Three segments

- Variables
- Distributions
- Scales

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Lecture 3 ~ Segment 1

Types of variables

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Variables

- Variables can take on multiple values
- In contrast, a constant has only one value

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Apples and gravity

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Variables

- The size, shape, weight, and type of apple are all variables
- Gravity, or gravitational force, is a constant on Earth

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Types of variables

- Nominal
- Ordinal
- Interval
- Ratio

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Stevens (1946)

SCIENCE

Vol. 103, No. 2684 Friday, June 7, 1946

On the Theory of Scales of Measurement

S. S. Stevens

Director, Psycho-Acoustic Laboratory, Harvard University

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Types of variables

- Nominal variables
  - Used to assign individual cases to categories
    - For example, Coursera students come from many different countries
    - *Country of Origin* is a nominal variable

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Types of variables

- Ordinal variables
  - Used to rank order cases
    - For example, countries may be ranked according to overall population
    - *Ranking* is an ordinal variable

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Types of variables

- Interval variables
  - Used to rank order cases and the distance, or interval, between each value is equal
    - For example, each country has a longitude and latitude
    - *Longitude* and *Latitude* are interval variables

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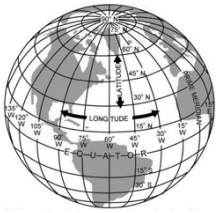
Types of variables



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Types of variables

- Ratio variables
  - The same as interval variables but they have a "true zero"
    - For example, *Population* (Population = 0 = extinct)
    - For example, *Age* (Age = 0 literally means NO age)
    - For example, *Temperature K°* (the Kelvin scale)

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Stevens (1946)

TABLE 1

Scale	Basic Empirical Operations	Mathematical Group Structure	Permissible Statistics (invariantive)
NOMINAL	Determination of equality	*Permutation group* $x' = f(x)$ $f(x)$ means any one-to-one substitution	Number of cases Mode Contingency correlation
ORDINAL	Determination of greater or less	*Isotonic group* $x' = f(x)$ $f(x)$ means any monotonic increasing function	Median Percentiles
INTERVAL	Determination of equality of intervals or differences	*General linear group* $x' = ax + b$	Mean Standard deviation Rank-order correlation Product-moment correlation
RATIO	Determination of equality of ratios	*Similarity group* $x' = ax$	Coefficient of variation

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Types of variables

- Preview of variables in this course
  - Nominal variables
    - Independent variables in experimental research
      - For example, treatment to prevent polio (vaccine, placebo)
    - Quasi-independent variables in correlational research
      - For example, gender (female, male)

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Types of variables

- Preview of variables in this course
  - Interval and Ratio variables
    - Dependent variables in experimental research
      - For example, rate of polio in a community
    - Measured variables in correlational research
      - For example, intelligence test scores

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Types of variables

- Preview of variables in this course
  - Discrete vs. continuous variables
    - Nominal variables are discrete (categorical)
    - Interval and ratio variables are continuous
    - Ordinal variables are technically discrete but they are often treated as continuous in statistical analyses (more on this later)

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Segment summary

- Types of variables
  - Nominal
  - Ordinal
  - Interval
  - Ratio

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END SEGMENT

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Lecture 3 ~ Segment 2

Distributions: Histograms

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Histograms

- A histogram is a type of graph used to display a distribution

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Histograms

- Why start with histograms?
  - To overcome the natural tendency to rely upon summary information, such as an average

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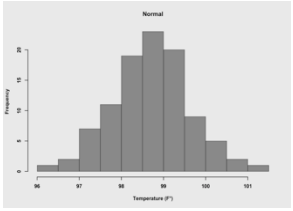
An example: Body temperature



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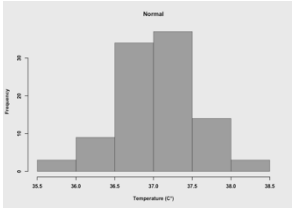
An example: Body temperature



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Histograms

- Histograms can reveal information not captured by summary statistics
  - Suppose a few children in a school are sick with influenza (flu) and have a high temperature
    - The distribution will be positively skewed

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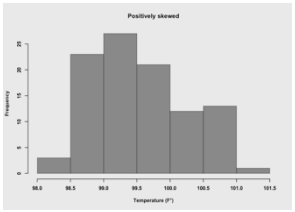
An example: Body temperature



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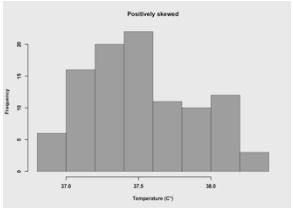
An example: Body temperature



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Histograms

- Not all distributions are normal
  - Suppose one group of children had the flu a week prior to a second sick group of children
  - Assume the first group received antiobiotics, which temporarily caused their body temperatures to be slightly below normal, while the second group was still above normal

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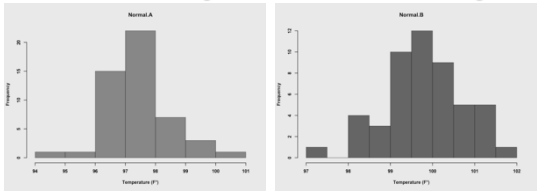
An example: Body temperature

Normal, below average **Normal, above average**



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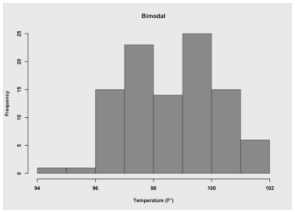
An example: Body temperature



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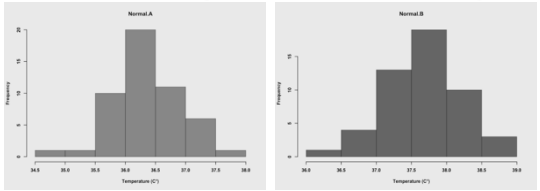
An example: Body temperature

Normal, below average **Normal, above average**



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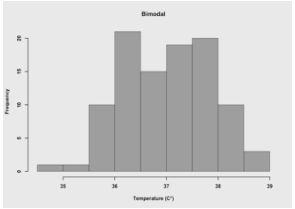
An example: Body temperature



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Histograms

- Not all distributions are normal
  - Simply viewing a histogram often reveals whether a distribution is normal or not normal
  - However, sometimes it is hard to determine
    - Summary statistics help in such cases

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Histograms

- Not all distributions are normal
  - As you view more and more distributions you will get a better sense of what is normal and what is not normal
  - So, let's look at more distributions

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Wine tasting!

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An example: Wine ratings

- Suppose that 100 wine experts rated the overall quality of 8 different wines on a scale of 1 to 100
  - Higher scores indicate higher quality

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An example: Wine ratings

- Suppose four countries submitted two wines each, one red and one white
  - Argentina
  - Australia
  - France
  - USA

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An example: Wine ratings

Malbec & Chardonnay

Shiraz & Pinot Grigio

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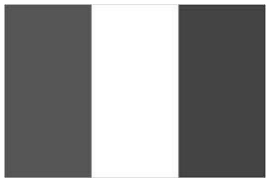
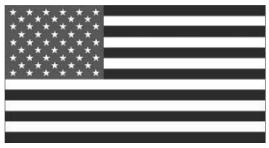
An example: Wine ratings

Bourdeaux & Sauvignon Blanc



Cabarnet & Reisling



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An example: Wine ratings

- Preview
  - The ratings of the red wines are normal
  - The ratings of the whites are not normal

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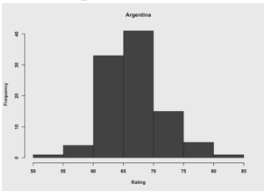
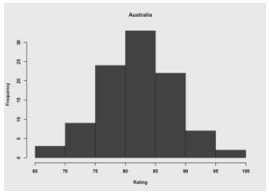
An example: Wine ratings

Red, Argentina



Red, Australia



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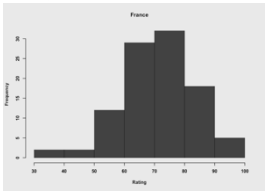
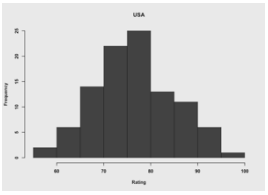
Four histograms

Red, France



Red, USA



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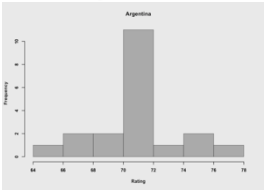
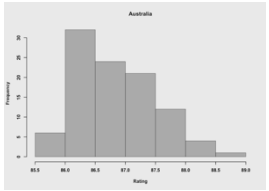
An example: Wine ratings

White, Argentina



White, Australia



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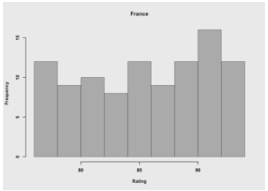
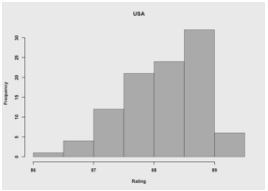
An example: Wine ratings

White, France



White, USA



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Segment summary

- Histograms are used to display distributions
- Many distributions are normal

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Segment summary

- Some distributions are not normal, for example:
  - Bi-modal
  - Positively skewed
  - Negatively skewed
  - Uniform (platykurtic)
  - Leptokurtic

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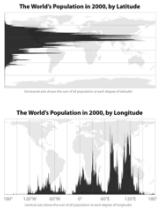
Advanced graphs



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Advanced graphs

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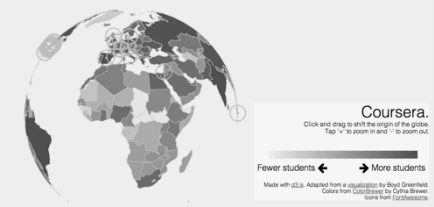
Advanced graphs



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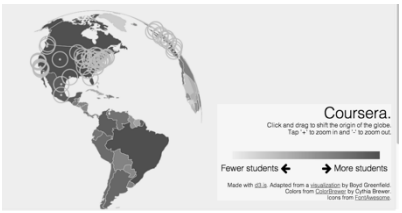
Advanced graphs



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END SEGMENT

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Lecture 3 ~ Segment 3

Scales of measurement

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Scales

- Scales of measurement
  - For example, in the last segment body temperature was presented in both Fahrenheit and in Celsius
    - Different scales but both measure temperature
    - F° can be converted to C° and vice-versa

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Scales

- In statistics, there is a standard scale
  - The Z scale
- Any score from any scale can be converted
  - To Z scores
- Allows for efficient communication

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Z scores

- Z = (X – M) / SD
  - X is a score on an original scale (raw score)
  - M is the mean
  - SD is the standard deviation

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Z scores

- Z = (X – M) / SD
  - The mean Z-score is Z = 0
  - Positive Z scores are above average
  - Negative Z scores are below average

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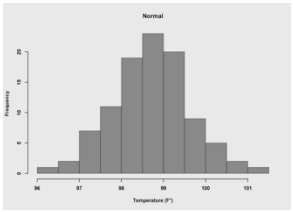
Body temperature F°



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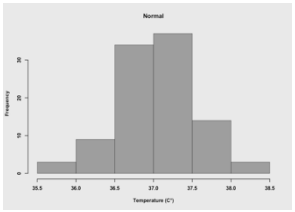
Body temperature C°



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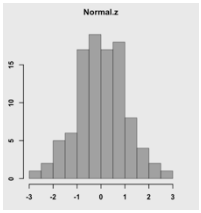
Body temperature Z



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Z scores

- For example, assume M = 98.6, SD = .5
- Suppose an individual, X = 99.6
- Convert X to Z

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Z scores

- Convert X to Z
  - Z = (X – M) / SD
  - Z = (99.6 – 98.6) / .5 = 2
  - Z = 2

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Percentile rank

- Percentile rank
  - The percentage of scores that fall at or below a score in a distribution
    - Assume a normal distribution
    - If Z = 0 then the percentile rank = 50th
    - 50 percent of the distribution falls below the mean

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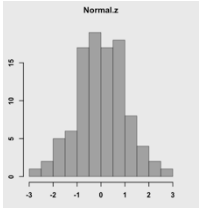
Body temperature Z



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Segment summary

- The Z-scale is the standard scale in statistics
- Raw scores can be converted to Z-scores
- Z-scores can be used to find percentile rank
  - Raw score ~ Z-score ~ Percentile rank

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END SEGMENT

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END LECTURE 3

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