Adv. Descriptive Statistics & Visualization

Business Analytics

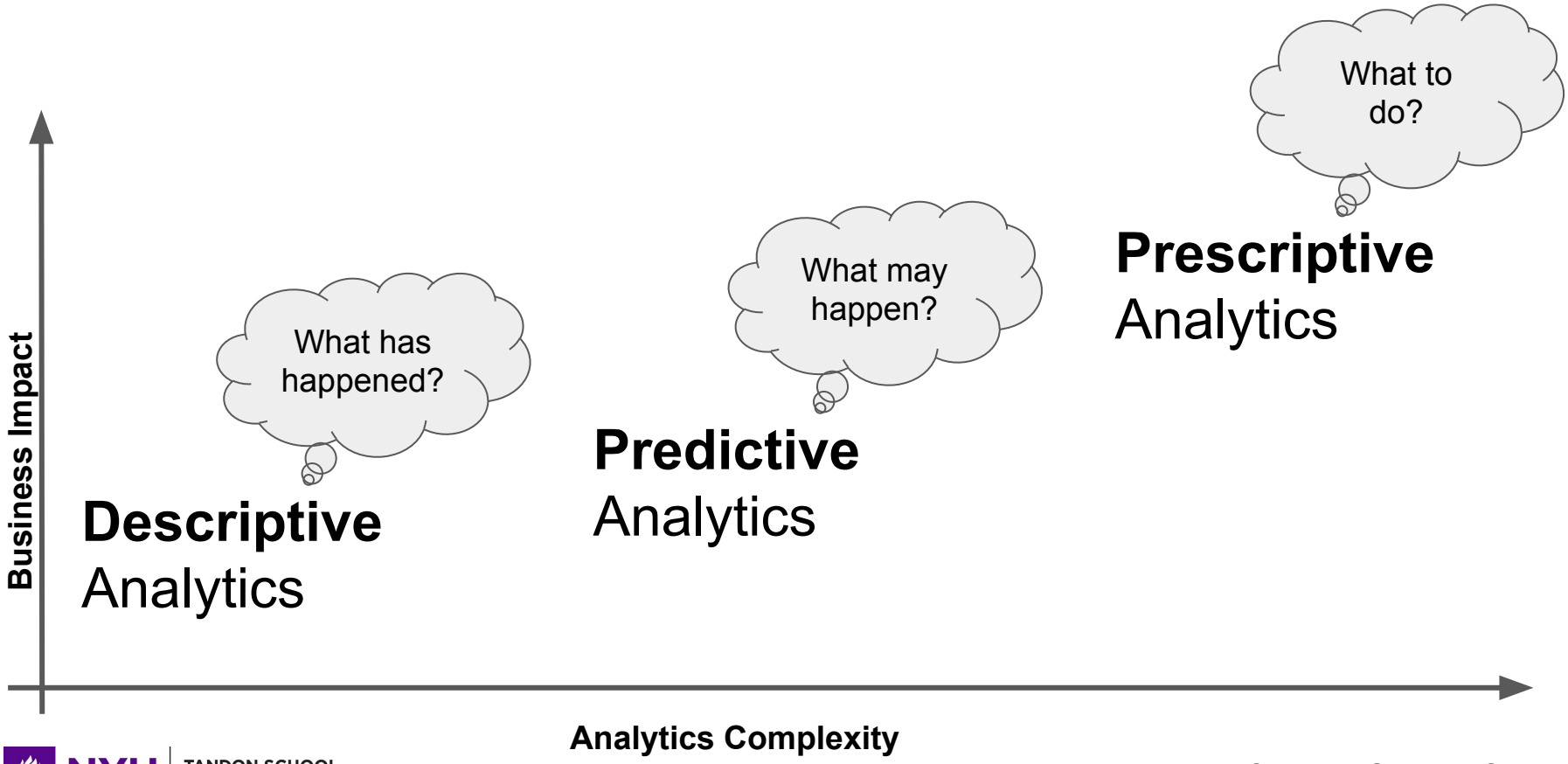
Business Analytics Definition

Business analytics refers to the application of data analysis and modeling techniques for understanding business situations and improving business decisions.

IMPLICATIONS:

- data → past business performance
- methods → statistics + mathematics + computational methods
- business decisions → actionable insight

Types of Analytics



Review

1. Descriptive Statistics
    a. Measures of central tendency (mean, median, mode)
    b. Measures of spread and variability (range, quartiles, variance, standard deviation)
    c. Measures of association (correlation)
    d. Frequency distributions

2. Introduction to R
    a. Data variables & basic operations
    b. Loading data and reading data
    c. Summary stats

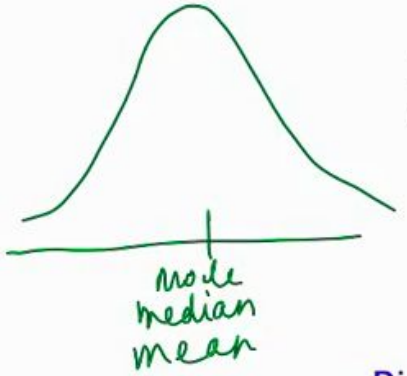
Lesson Objectives

1. Adv. Descriptive Statistics & Visualization
    a. Shape of Distributions & Statistical Graphics
        i. Histograms
        ii. Scatterplots
        iii. The Box Plot
    b. Z-Scores
    c. Hypothesis testing & statistical significance
    d. Exploratory Data Analysis
    e. Principles of Data Vizualization

Shape of Distribution

The relative location of the mode, median, and mean in a unimodal distribution:

Symmetric

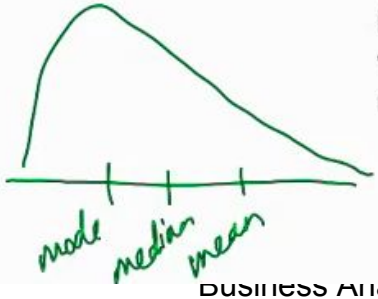


For a symmetric distribution, the mean, median, and mode are all approximately the same.

Left-skewed

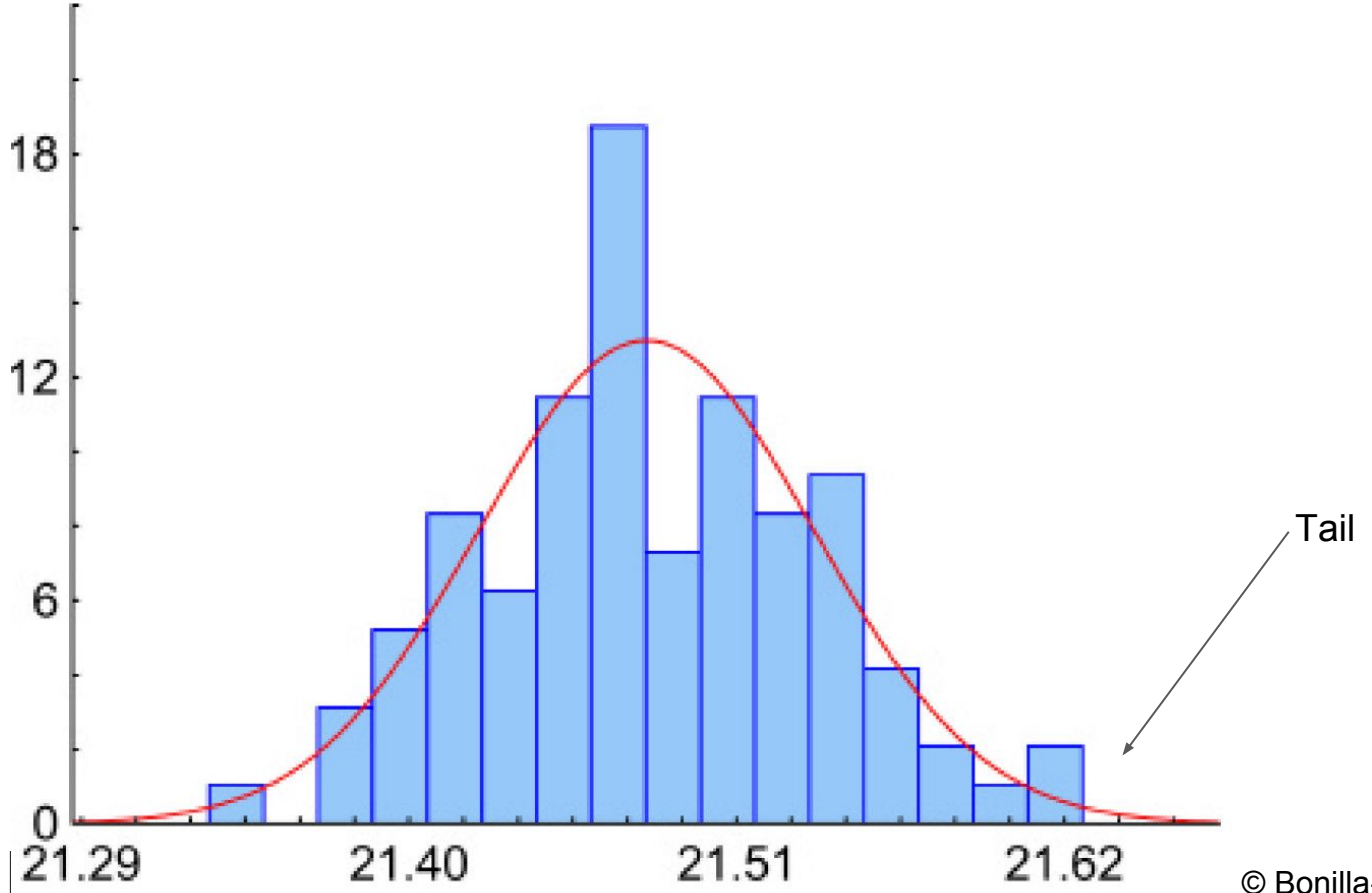
For a left-skewed distribution, the mode is larger than the median which is larger than the mean.

Right-skewed

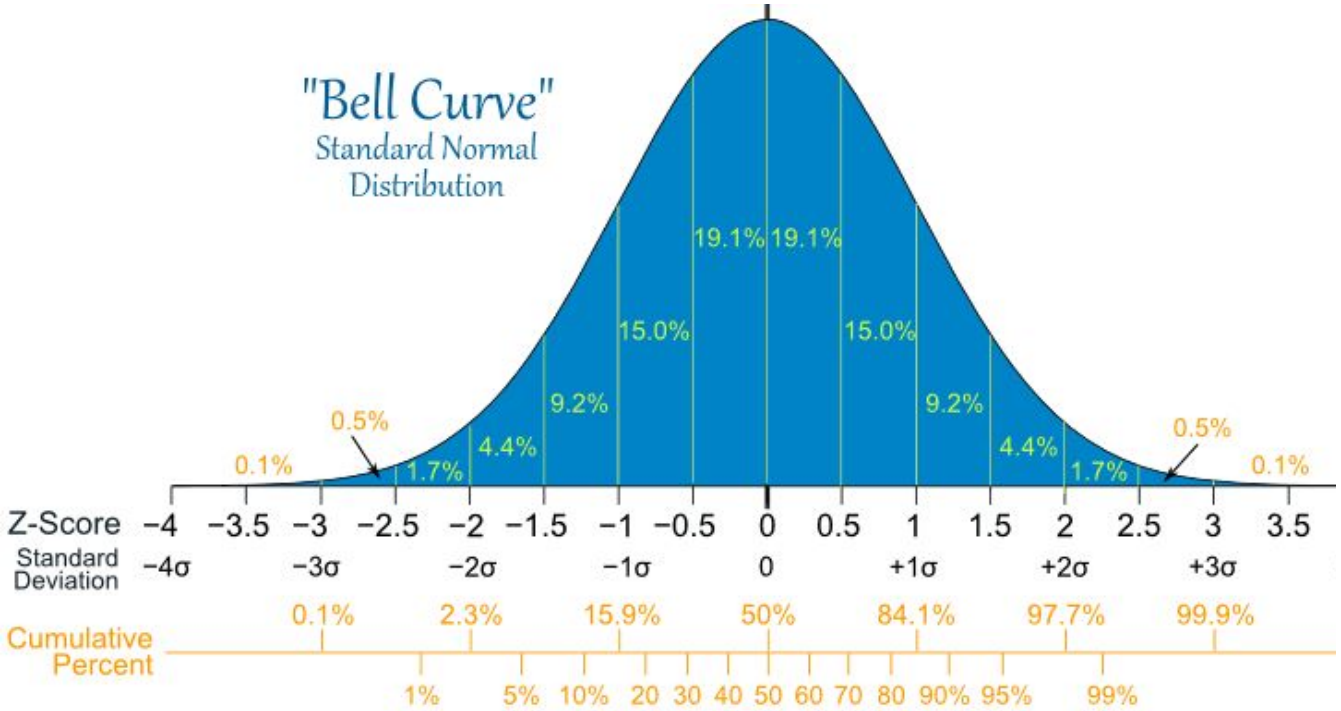


For a right-skewed distribution, the mode is less than the median, which is less than the mean.

Histograms & Distributions



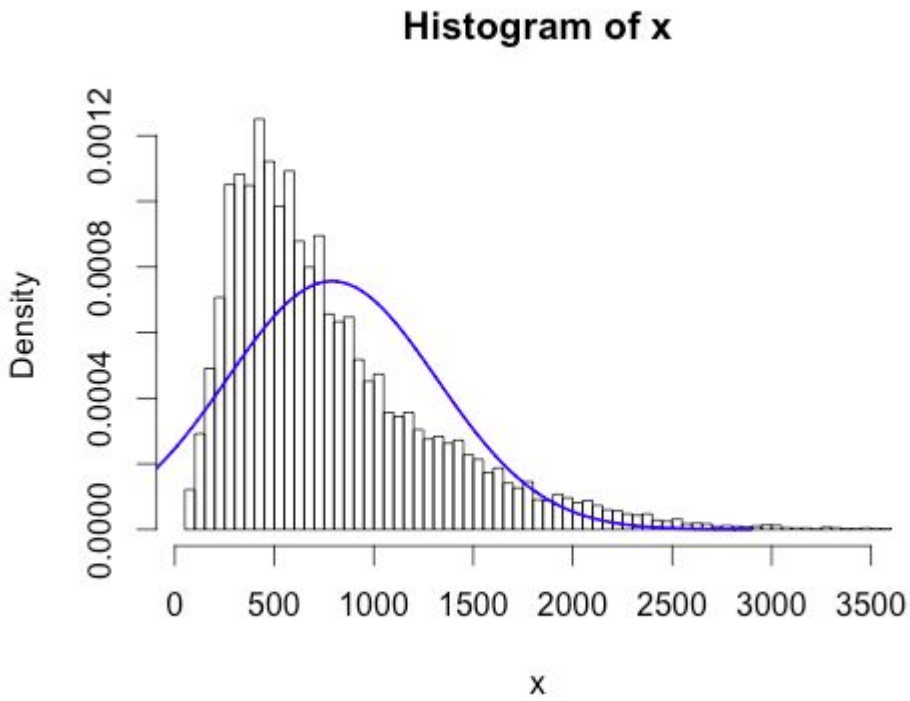
Normal Distribution



Properties:

- mean = median = mode
- symmetry about the center
- 50% of values less than the mean and 50% greater than the mean
- 68% of values are within 1 standard deviation of the mean
- 95% of values are within 2 standard deviation of the mean
- 99% of values are within 3 standard deviation of the mean

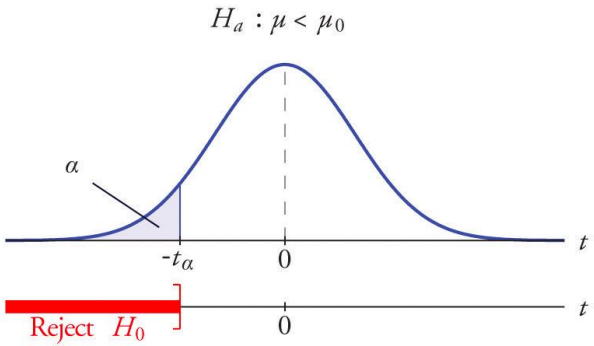
Normalizing Data → Fitting a distribution to data

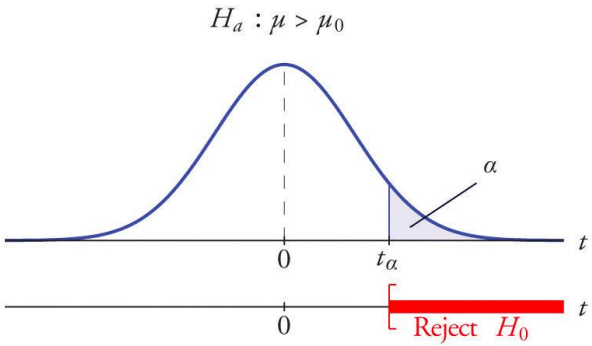


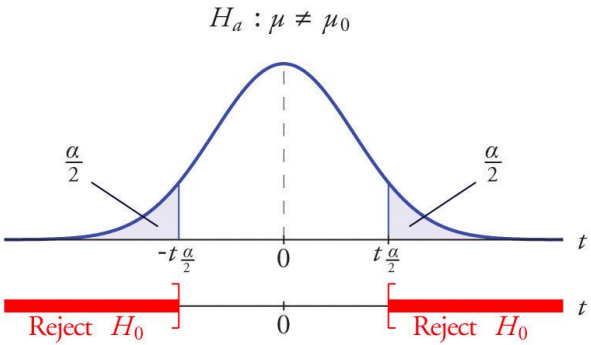
Normal curve centered at mean of data set with standard deviation equal to the deviation of the sample data.

How good is this model?

Significance Testing and Confidence Intervals







Statistical test provides a mechanism for making quantitative decisions about a process or processes.

The intent is to determine whether there is enough evidence to "reject" a conjecture or hypothesis about the process.

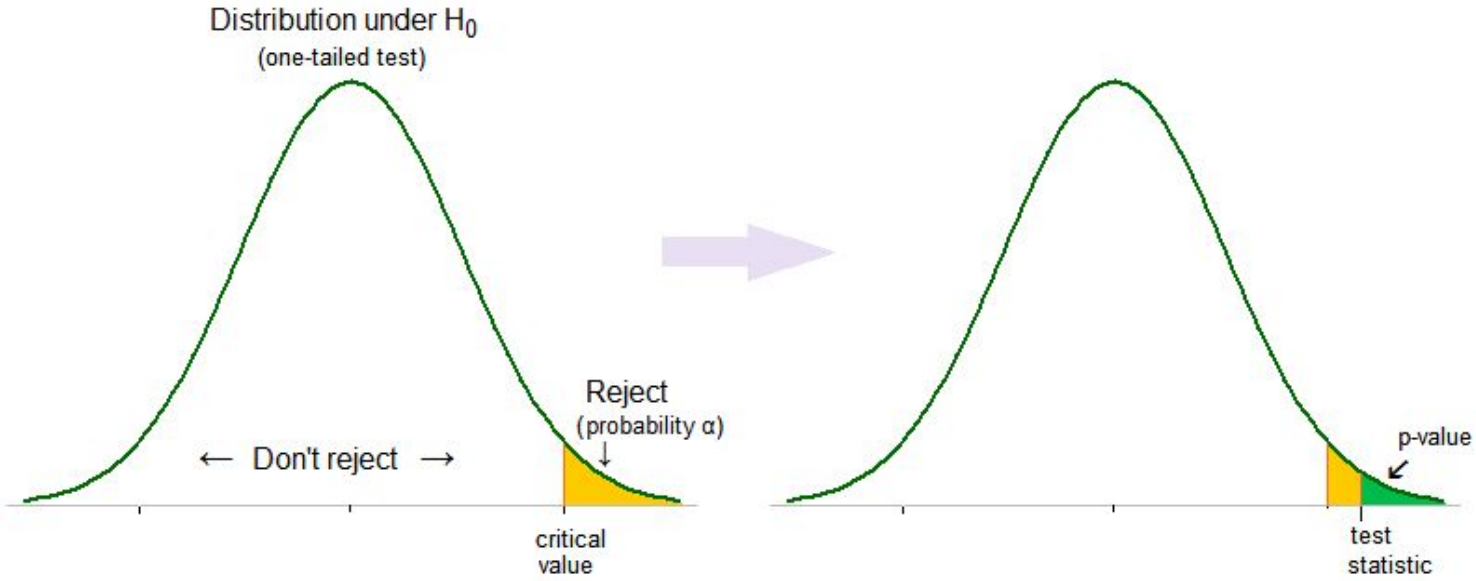
The conjecture is called the **null hypothesis**

Hypothesis Testing

Steps:

1. **State the hypotheses.** This involves stating the null and alternative hypotheses. The hypotheses are stated in such a way that they are mutually exclusive. That is, if one is true, the other must be false.
2. **Formulate an analysis plan.** The analysis plan describes how to use sample data to evaluate the null hypothesis. The evaluation often focuses around a single test statistic.
3. **Analyze sample data.** Find the value of the test statistic (mean score, proportion, t-score, z-score, etc.) described in the analysis plan.
4. **Interpret results.** Apply the decision rule described in the analysis plan. If the value of the test statistic is unlikely, based on the null hypothesis, reject the null hypothesis.

Significance Levels (α) & P-Values



Alpha sets the standard for how extreme the data must be before we can reject the null hypothesis.
The P-value indicates how extreme the data are.

- If the p-value is less than or equal to the alpha ($p < \alpha$), then we reject the null hypothesis, and we say the result is statistically significant.
- If the p-value is greater than alpha ($p > \alpha$), then we fail to reject the null hypothesis, and we say that the result is statistically nonsignificant (n.s.)

Statistically Significant Results

- A hypothesis test evaluates two mutually exclusive statements about a population to determine which statement is best supported by the sample data.
- A test result is statistically significant when the sample statistic is unusual enough relative to the null hypothesis that we can reject the null hypothesis for the entire population.
- The common alpha values of 0.05 and 0.01 are simply based on tradition.

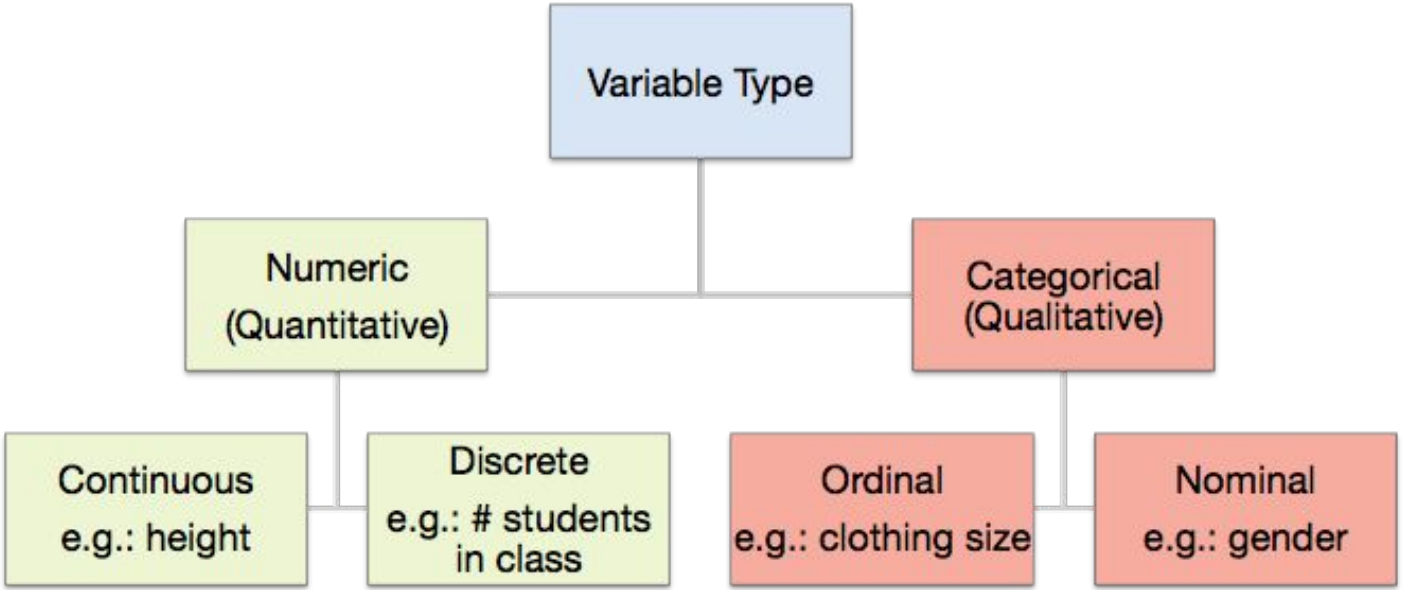
Business Implication

1. Load the Zagat file and run summary statistics study on “service”
2. Are there outliers?
   a. Run the “Outlier Detection & Z-score” Rscript
3. Normalize the data
   a. See section 3.3 on NYUClassess
4. Run a statistical test
   a. Use R function *t.test(x)*

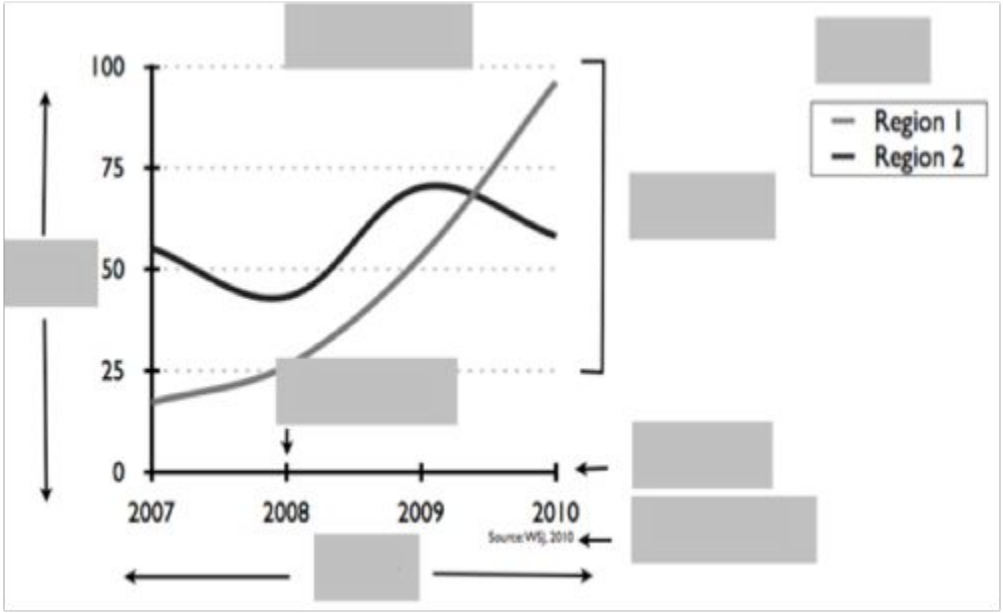
Visualization for Descriptive Analytics

- Data types
- Data transformation - percentages, proportions...
- Chart types - visualizing patterns, relationships, comparisons, or distributions?

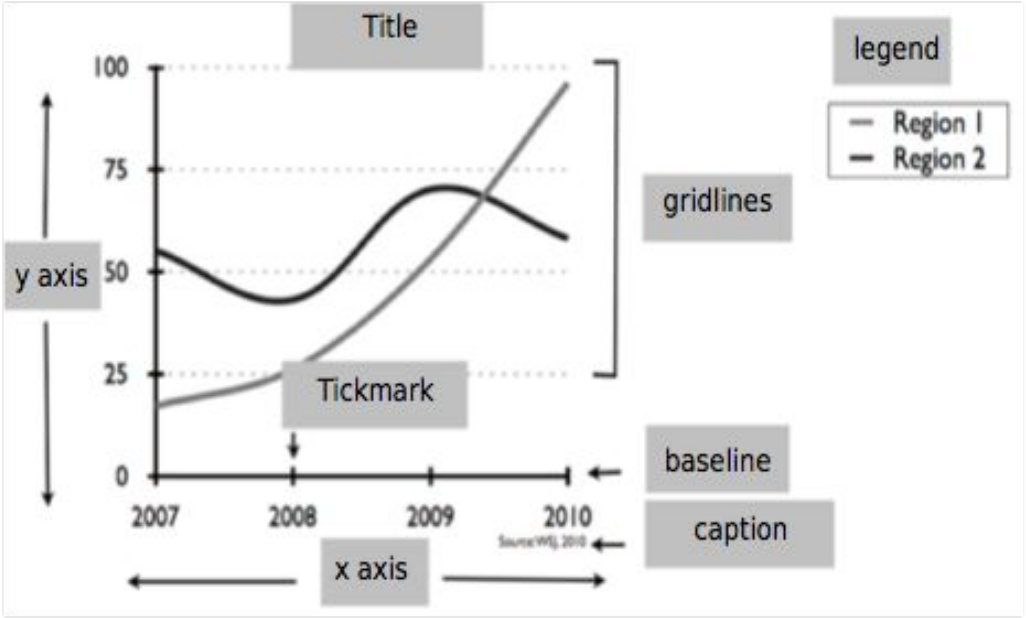
Data Types


Variable Type
Numeric
(Quantitative)
Categorical
(Qualitative)
Continuous
e.g.: height
Discrete
e.g.: # students
in class
Ordinal
e.g.: clothing size
Nominal
e.g.: gender

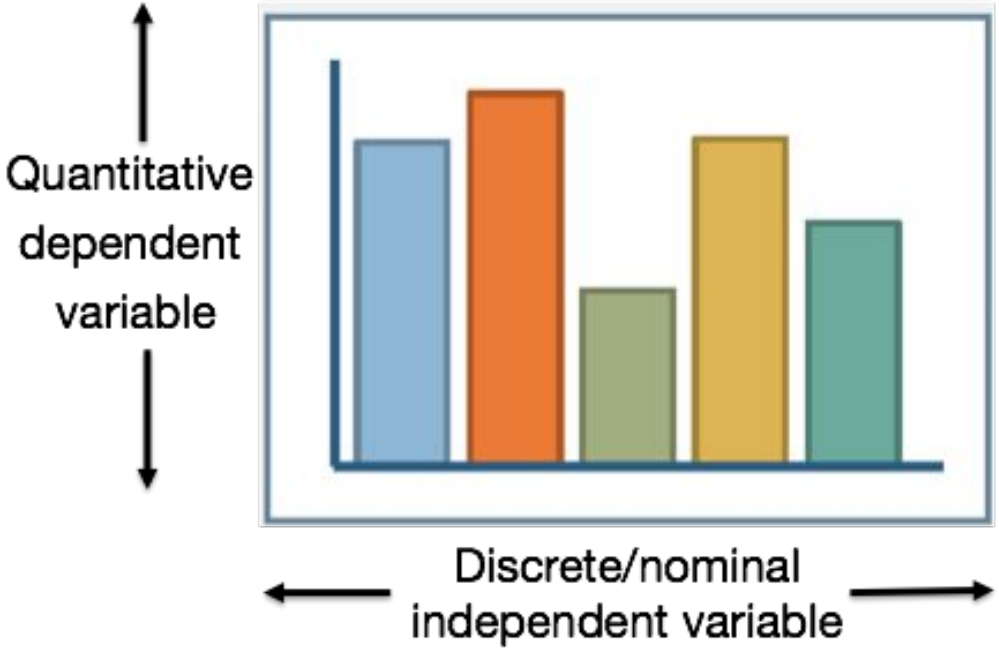
Basic Chart Terminology

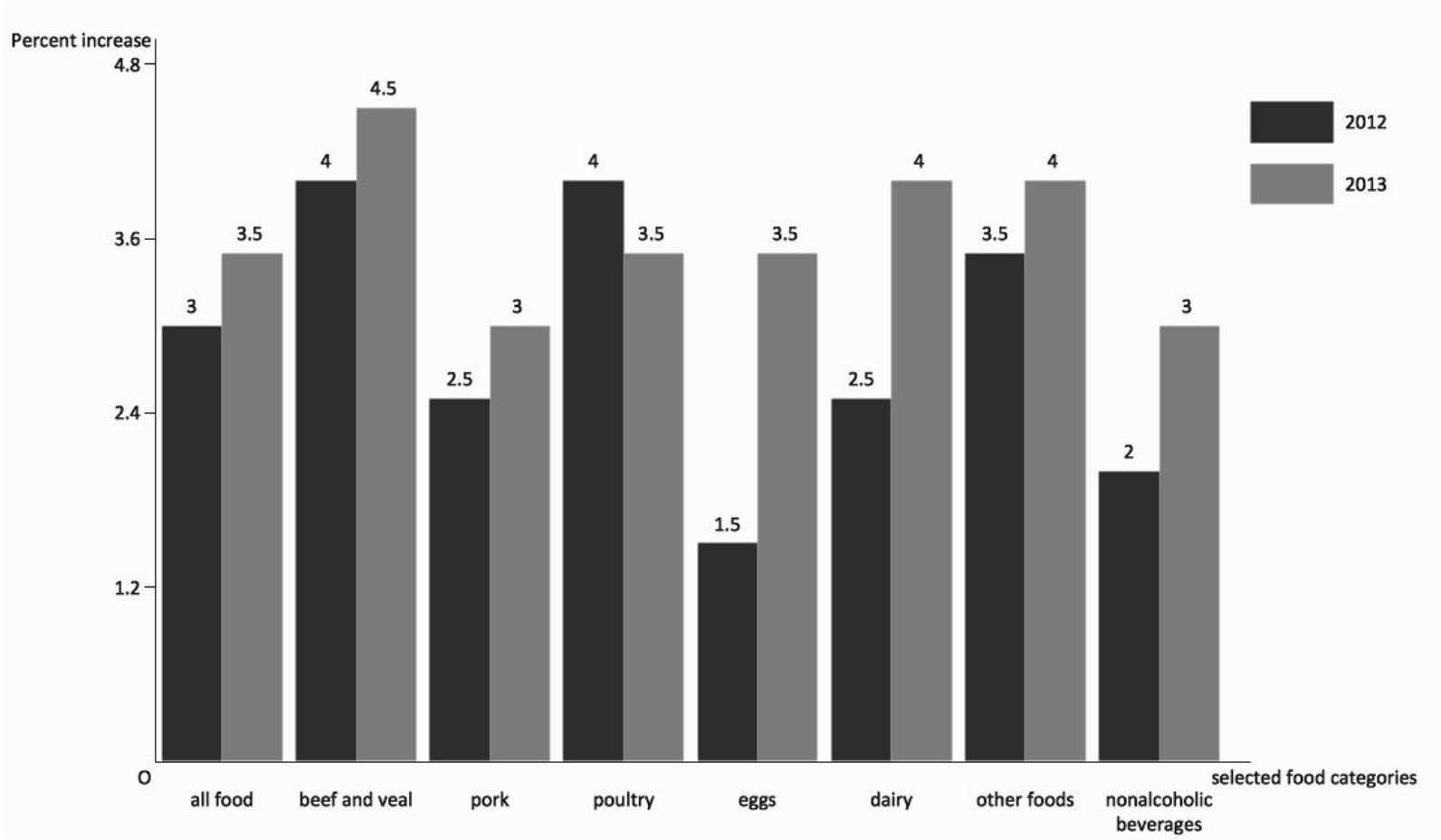


Basic Chart Terminology

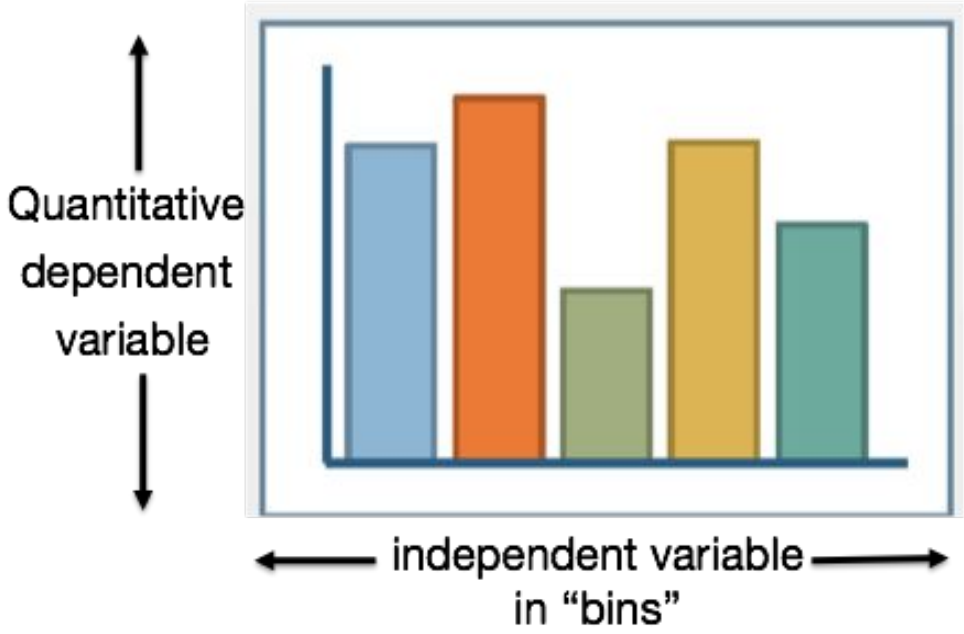


Bar Chart


Quantitative
dependent
variable
Discrete/nominal
independent variable


Percent increase
4.8
3.6
2.4
1.2
O
2012
2013
3
3.5
4
4.5
2.5
3
4
3.5
1.5
3.5
2.5
4
3.5
4
2
3
all food
beef and veal
pork
poultry
eggs
dairy
other foods
nonalcoholic beverages
selected food categories

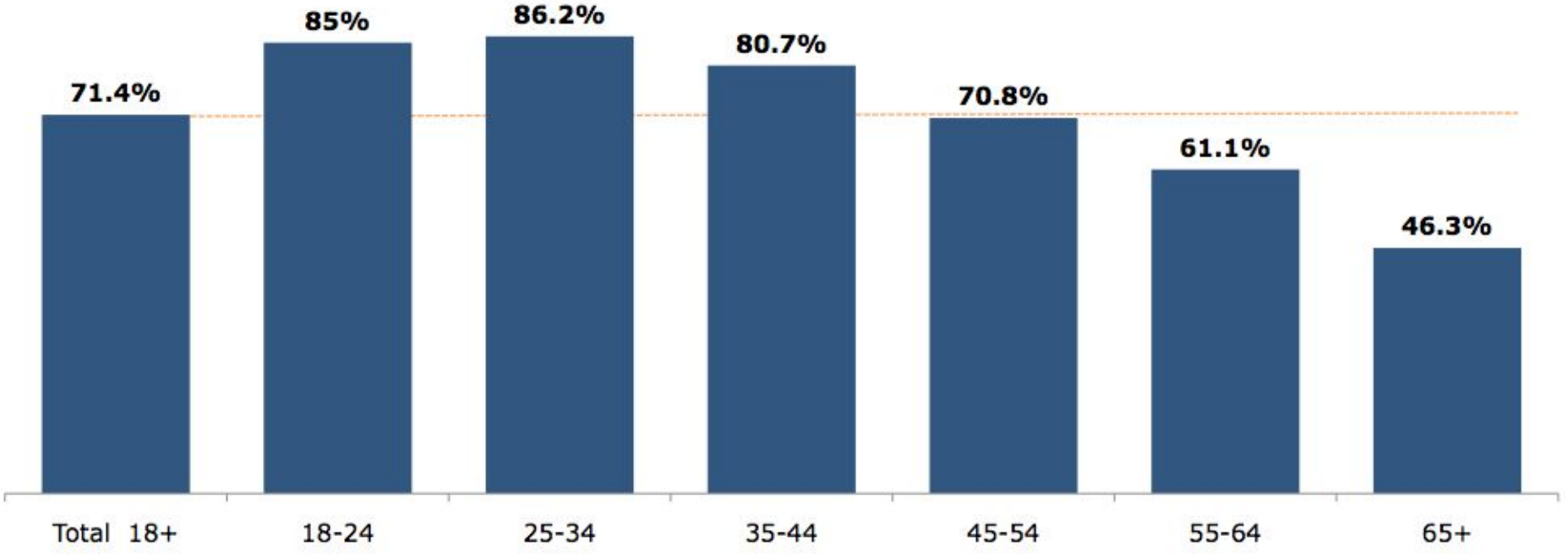
Histogram


Quantitative
dependent
variable
independent variable
in “bins”

US Smartphone Penetration Rate, by Age Group

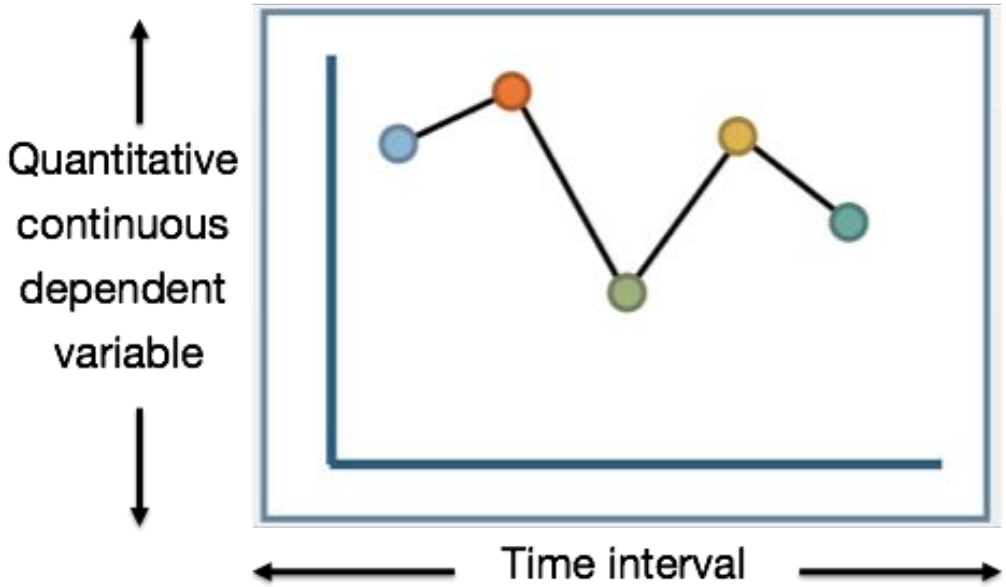
among mobile subscribers in the US

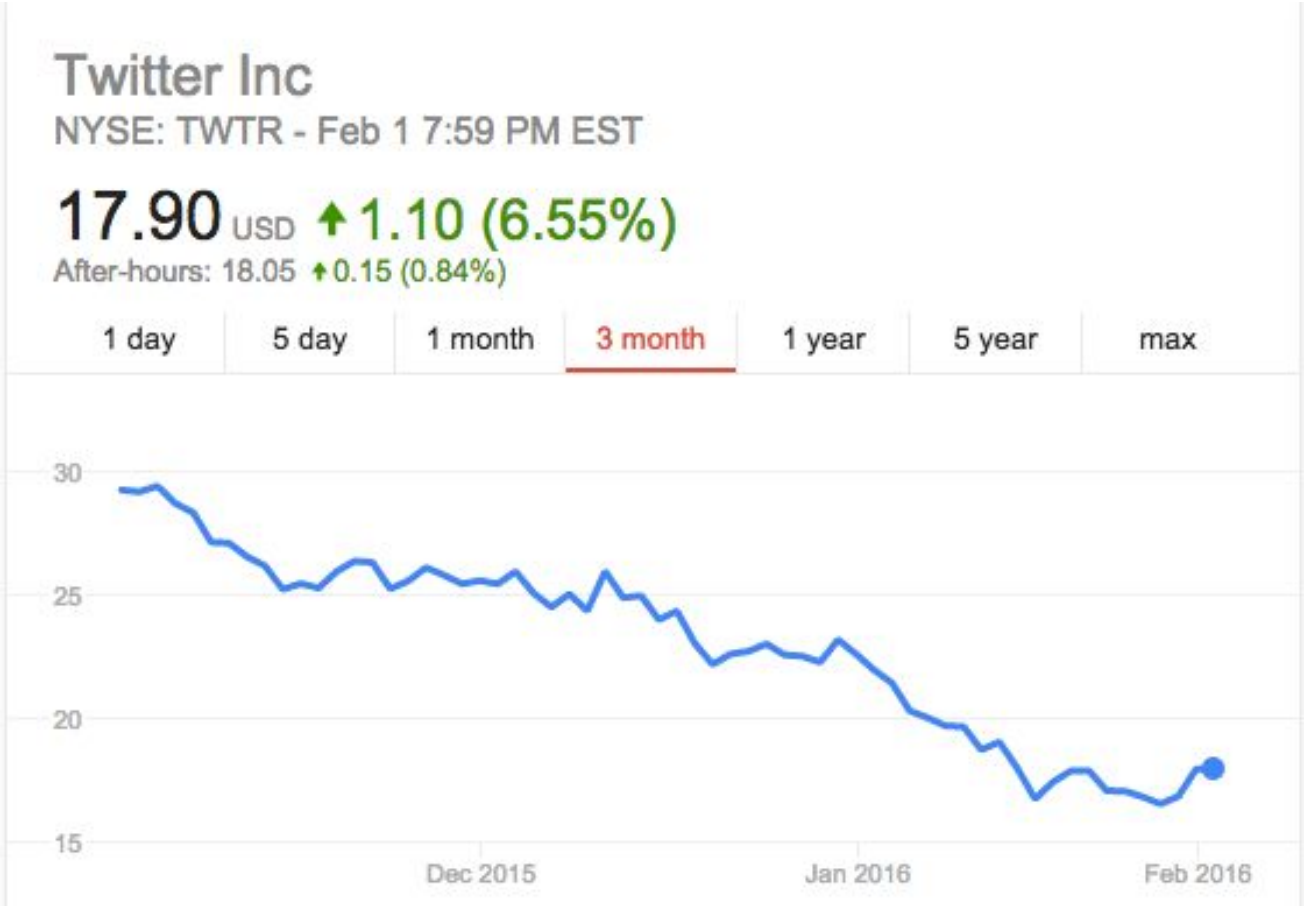
During Q2 2014



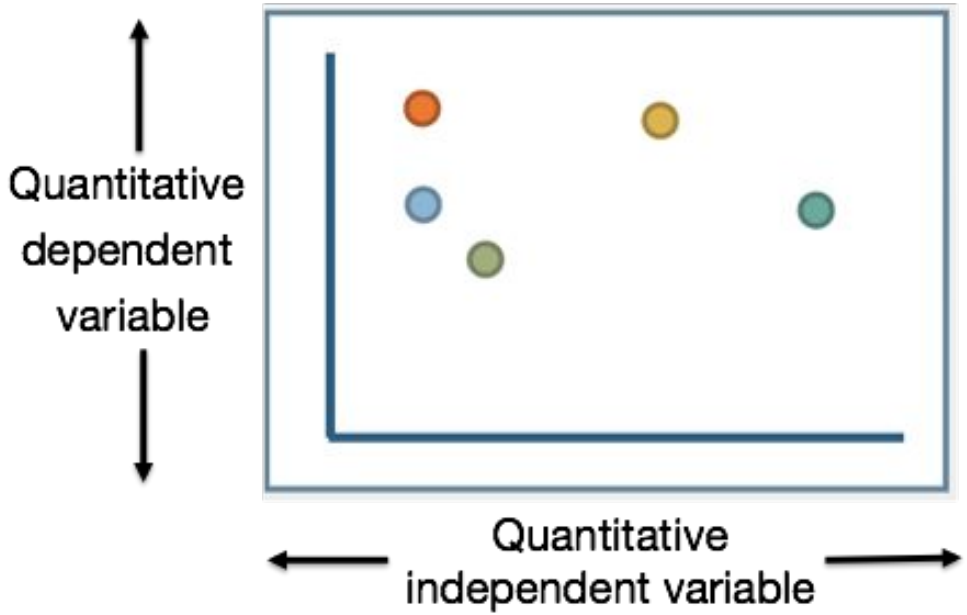
MarketingCharts.com | Data Source: Nielsen

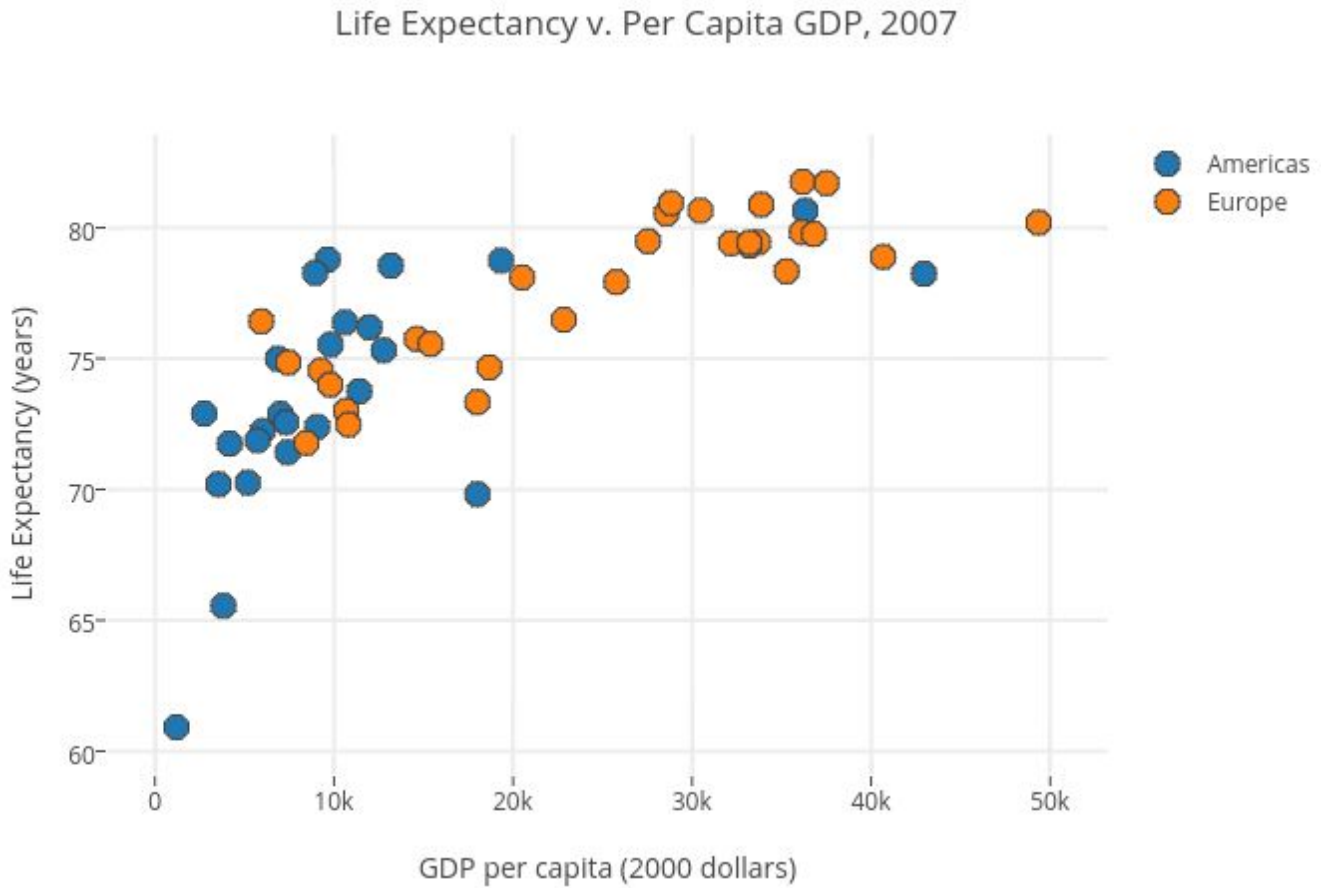
Time Series


Quantitative
continuous
dependent
variable
Time interval

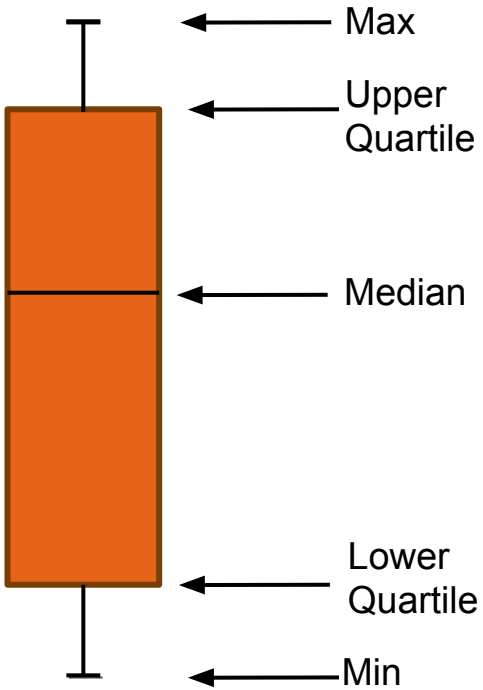

Twitter Inc
NYSE: TWTR - Feb 1 7:59 PM EST
17.90 USD ↑1.10 (6.55%)
After-hours: 18.05 ↑0.15 (0.84%)
1 day
5 day
1 month
3 month
1 year
5 year
max
30
25
20
15
Dec 2015
Jan 2016
Feb 2016

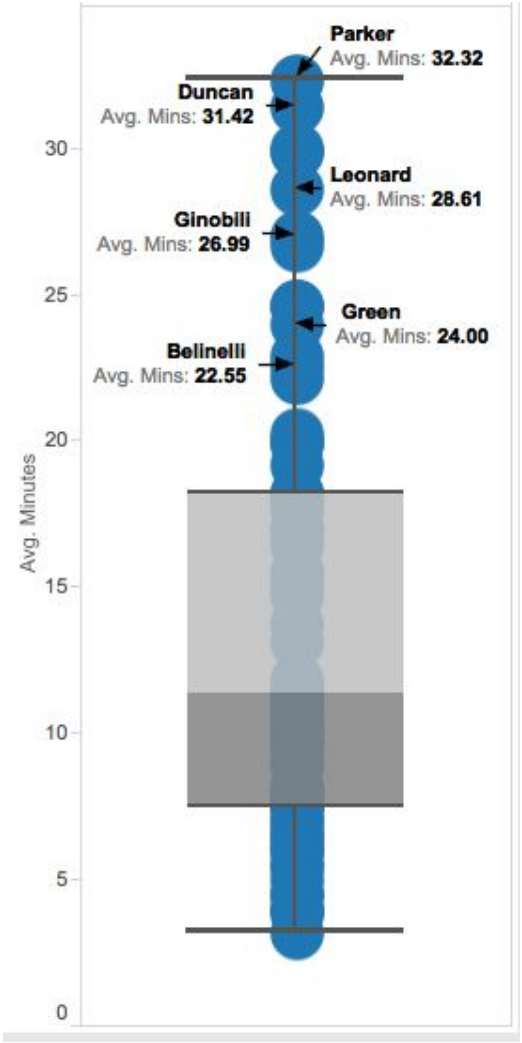
Scatter Plot




Life Expectancy v. Per Capita GDP, 2007
Americas
Europe
Life Expectancy (years)
80
75
70
65
60
0
10k
20k
30k
40k
50k
GDP per capita (2000 dollars)

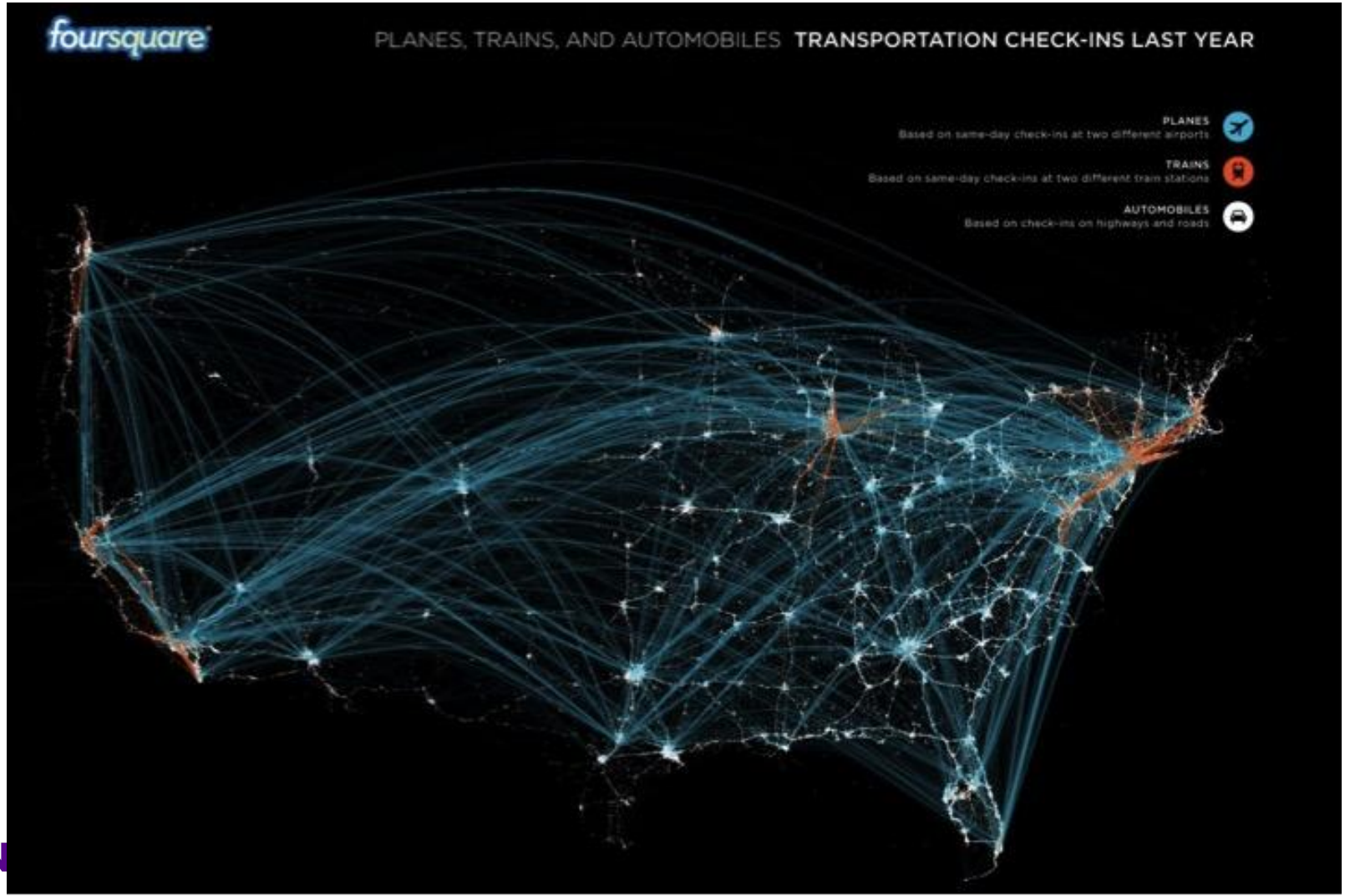
Box Plot (Box & Whisker diagram)

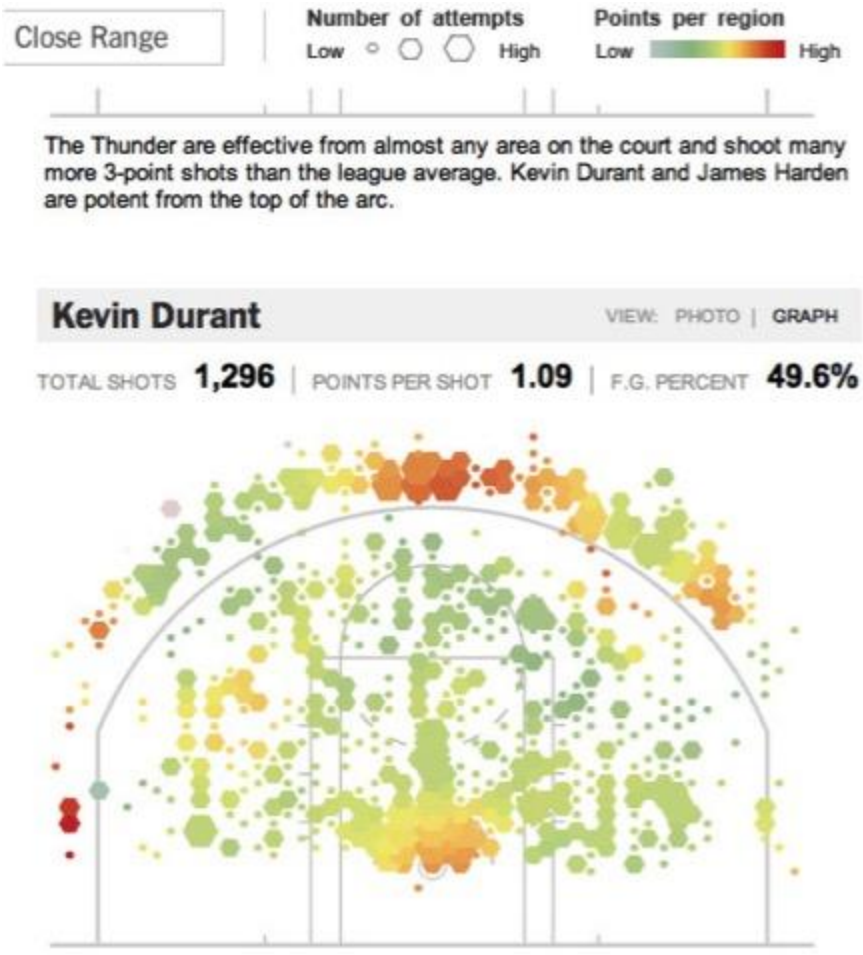



Parker
Avg. Mins: 32.32
Duncan
Avg. Mins: 31.42
Leonard
Avg. Mins: 28.61
Ginobili
Avg. Mins: 26.99
Green
Avg. Mins: 24.00
Belinelli
Avg. Mins: 22.55
Avg. Minutes
30
25
20
15
10
5
0

What is data visualization?

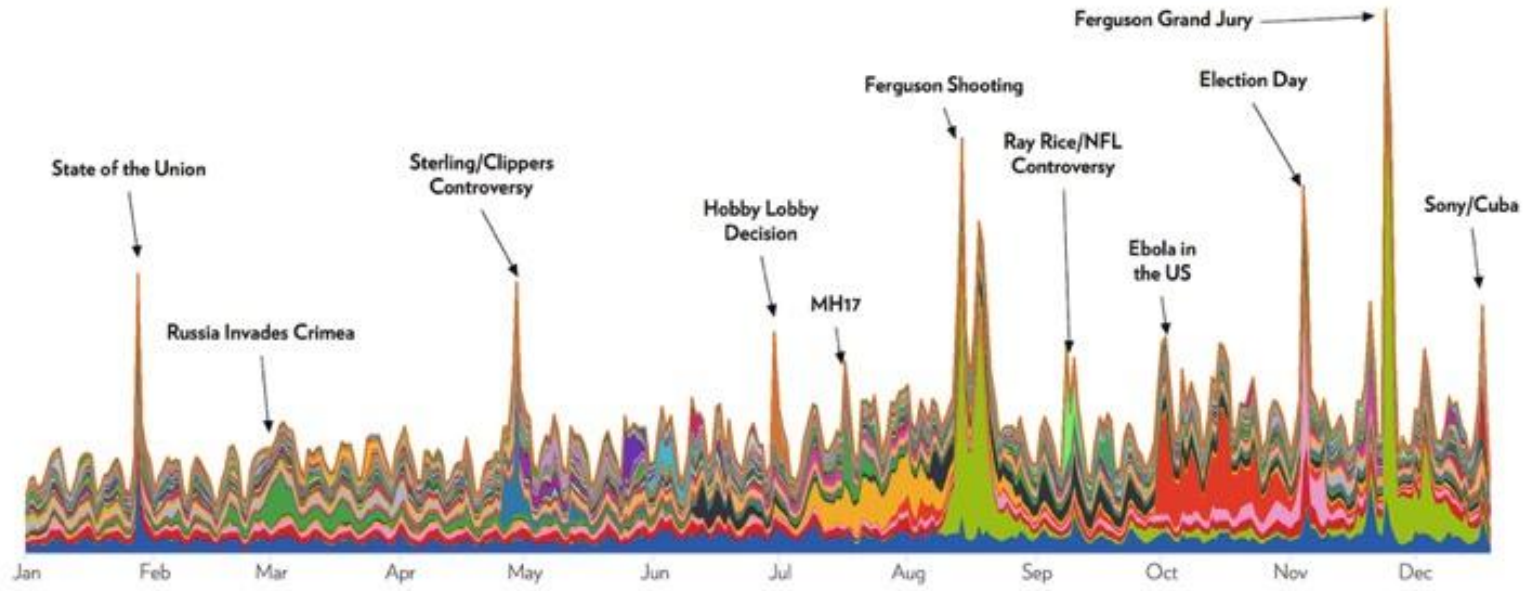
- Representation of data in a pictorial or graphical format.
- A general way of talking about anything that converts data sources into a visual representation:
  - charts, graphs, maps, sometimes even just tables
- Combination of many disciplines
  - statistics, perception, graphic design, cognitive psychology, information design, communications, and data mining


foursquare
PLANES, TRAINS, AND AUTOMOBILES TRANSPORTATION CHECK-INS LAST YEAR
PLANES
Based on same-day check-ins at two different airports
TRAINS
Based on same-day check-ins at two different train stations
AUTOMOBILES
Based on check-ins on highways and roads


Close Range
Number of attempts
Low
High
Points per region
Low
High
The Thunder are effective from almost any area on the court and shoot many more 3-point shots than the league average. Kevin Durant and James Harden are potent from the top of the arc.
Kevin Durant
VIEW: PHOTO | GRAPH
TOTAL SHOTS 1,296 | POINTS PER SHOT 1.09 | F.G. PERCENT 49.6%

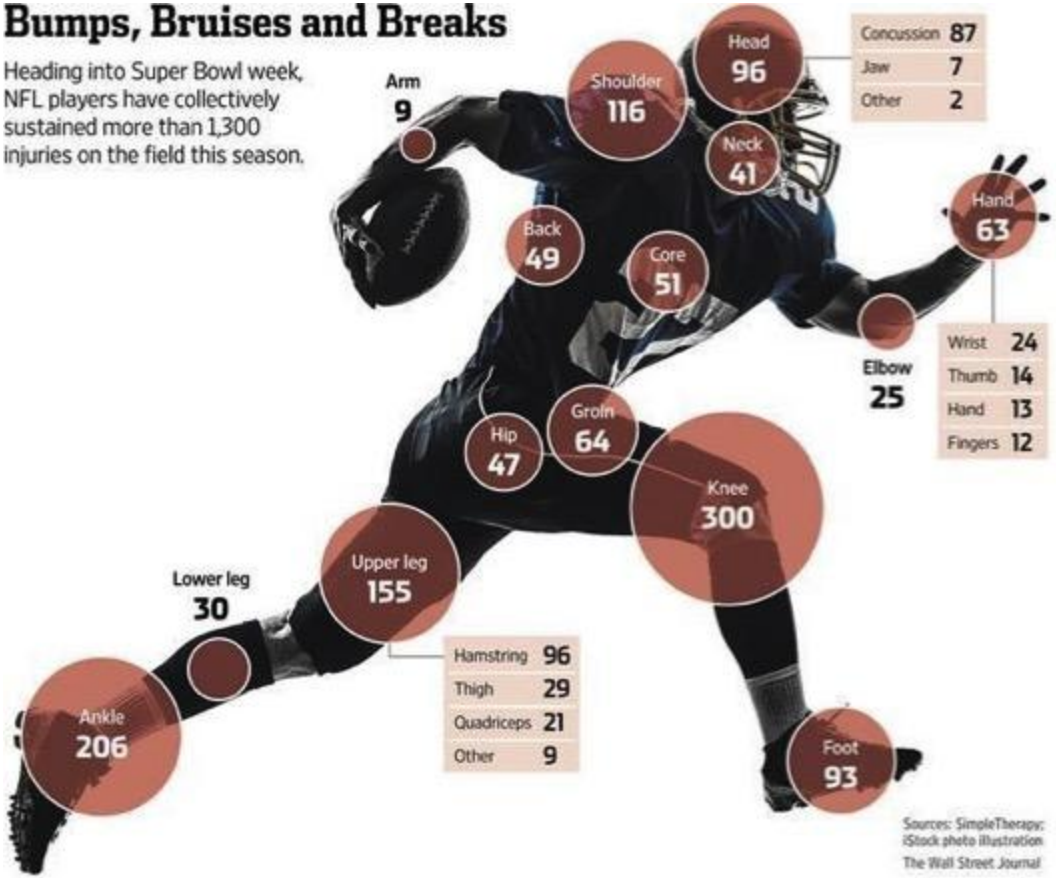
THE YEAR IN NEWS from ECHELON INSIGHTS

What America talked about in 2014, as viewed through 184.5 million Twitter mentions.



Bumps, Bruises and Breaks

Heading into Super Bowl week, NFL players have collectively sustained more than 1,300 injuries on the field this season.

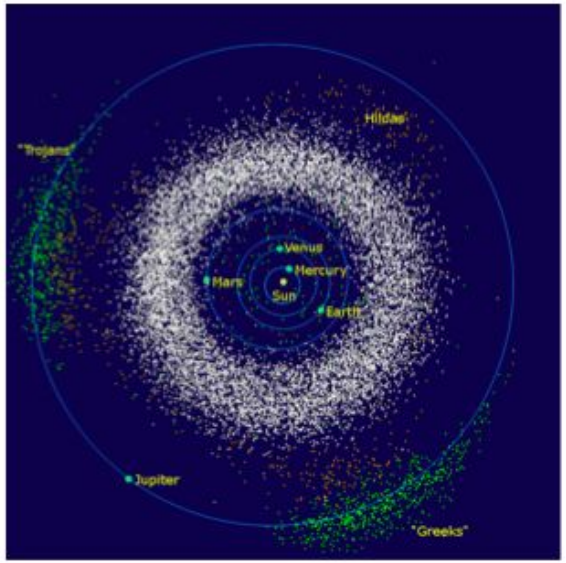


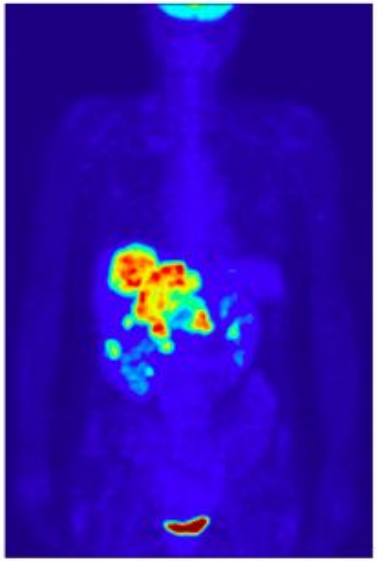
Sources: SimpleTherapy; iStock photo illustration

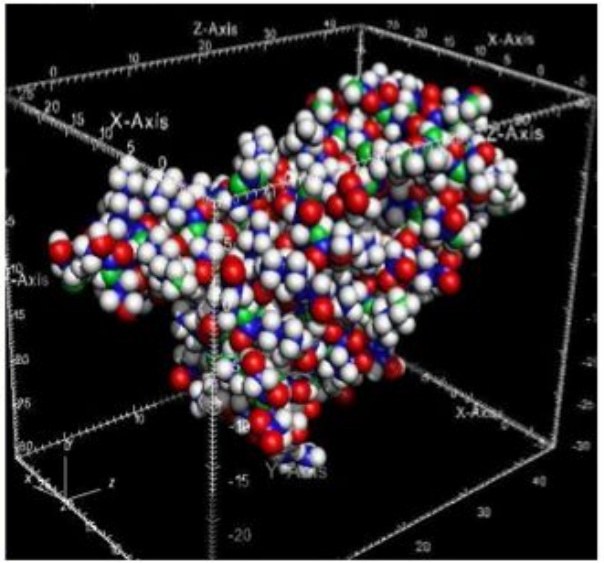
The Wall Street Journal

Types of Data Visualization

- Scientific visualization







Types of Data Visualization

- Information visualization
  - Covers statistical charts and graphs as well as other visual/spatial metaphors that can be used to represent data sets that don't have inherent spatial components.
  - Relies more heavily on processing abstract data into a more concrete form that can be more effectively perceived by an observer

Why data visualization?

- Exploring and analyzing
- Presenting and communicating

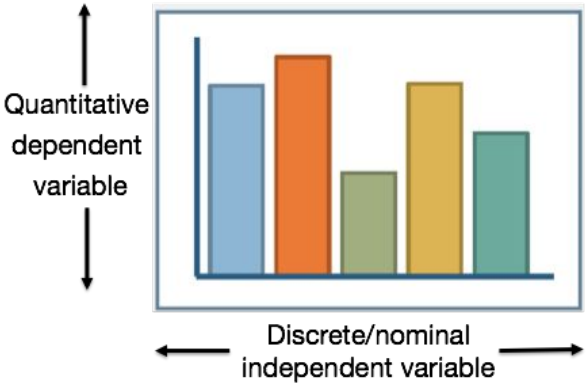
Types of Exploratory Data Analysis

- Non-graphical methods involve calculation of summary statistics.
- Graphical methods use charts and visual displays to summarize the data.
- Univariate methods look at one variable at a time.
- Multivariate methods look at two or more variables at a time to explore relationships.
- It is almost always a good idea to perform univariate EDA on each component of a multivariate EDA before performing the multivariate EDA.

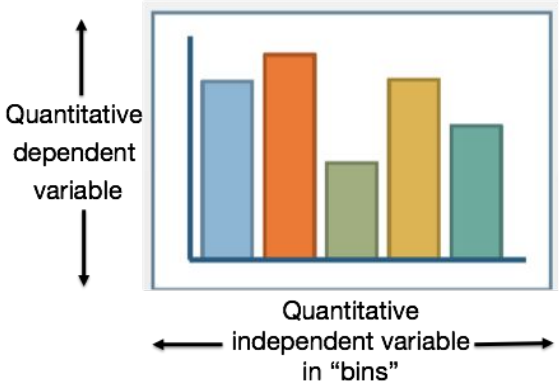
Univariate Graphical EDA

- Exploring the distribution of the sample graphically

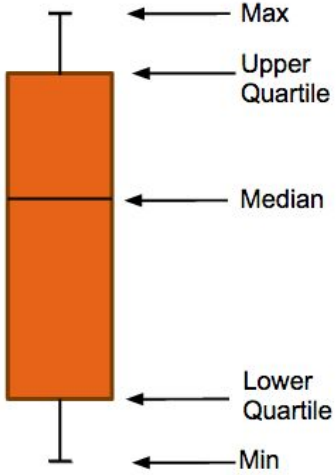
Bar Chart



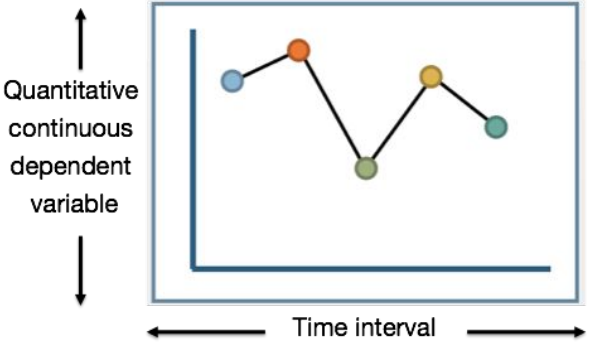
Histogram



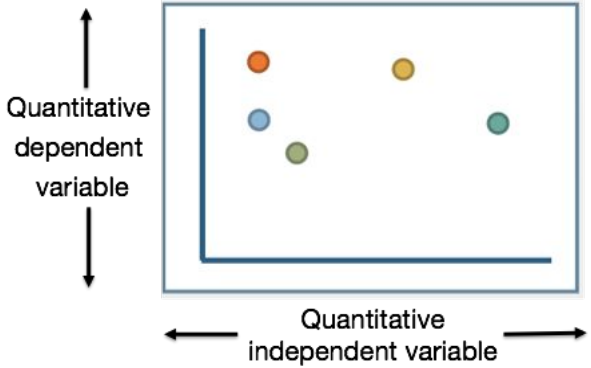
Box Plot



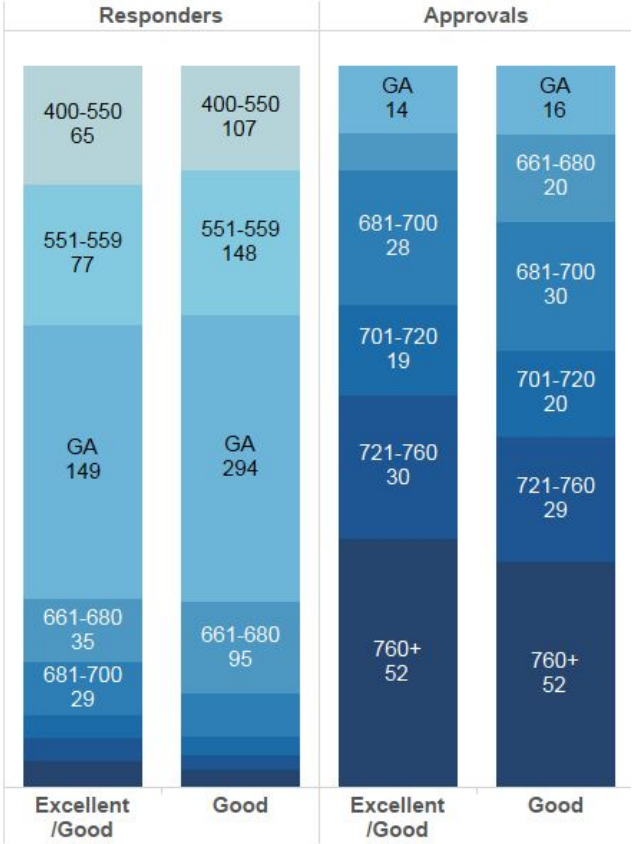
Time Series

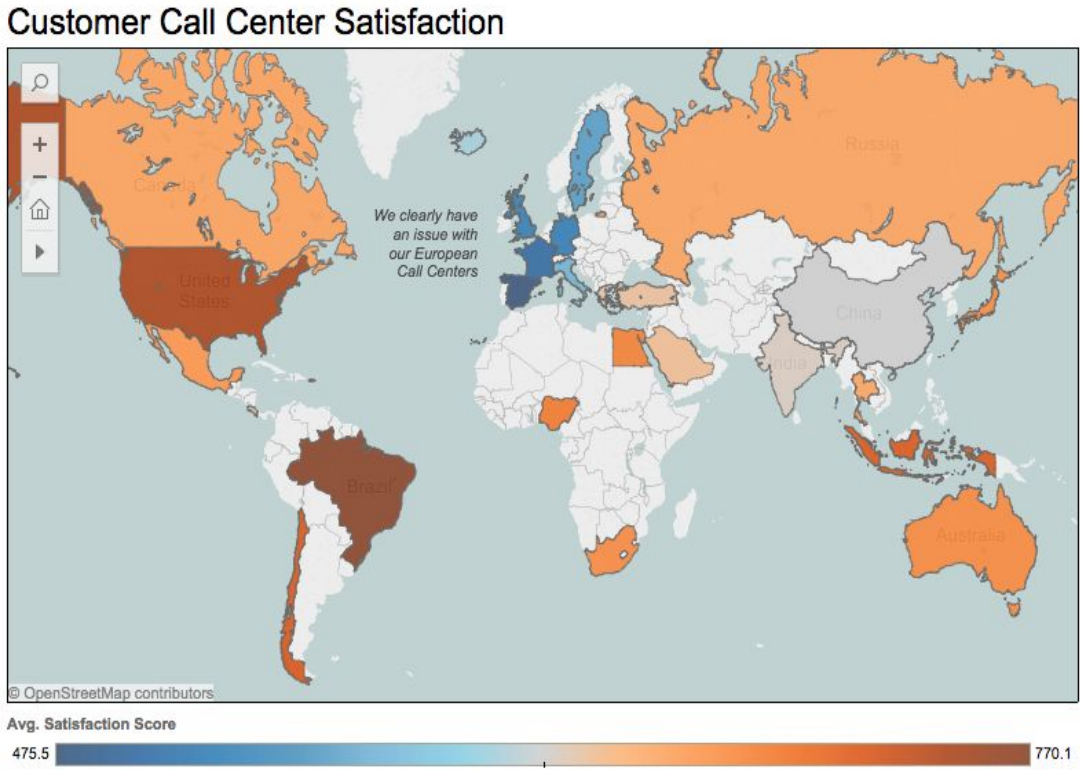


Scatter Plot



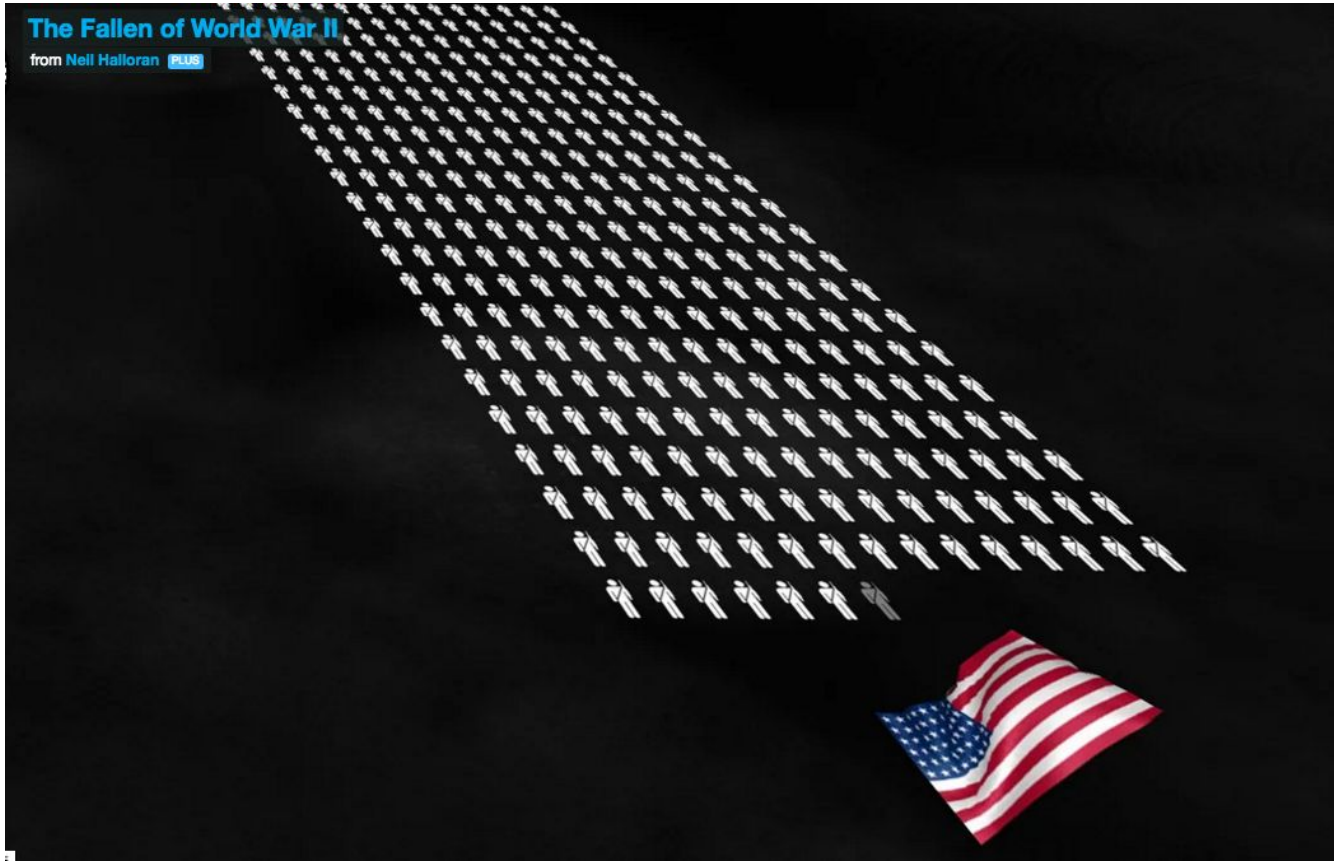
Multivariate Graphical EDA






BBC FOUR
lifespan
75 years
50 years
25 years
1927
income
$400
$4 000
$40 000

https://vimeo.com/128373915



Good Visualizations

- Present a visual interpretation of data and do so by improving comprehension, communication, and decision making
- Consider whom the visualization is targeting
- Set up a clear framework
- Tell a story

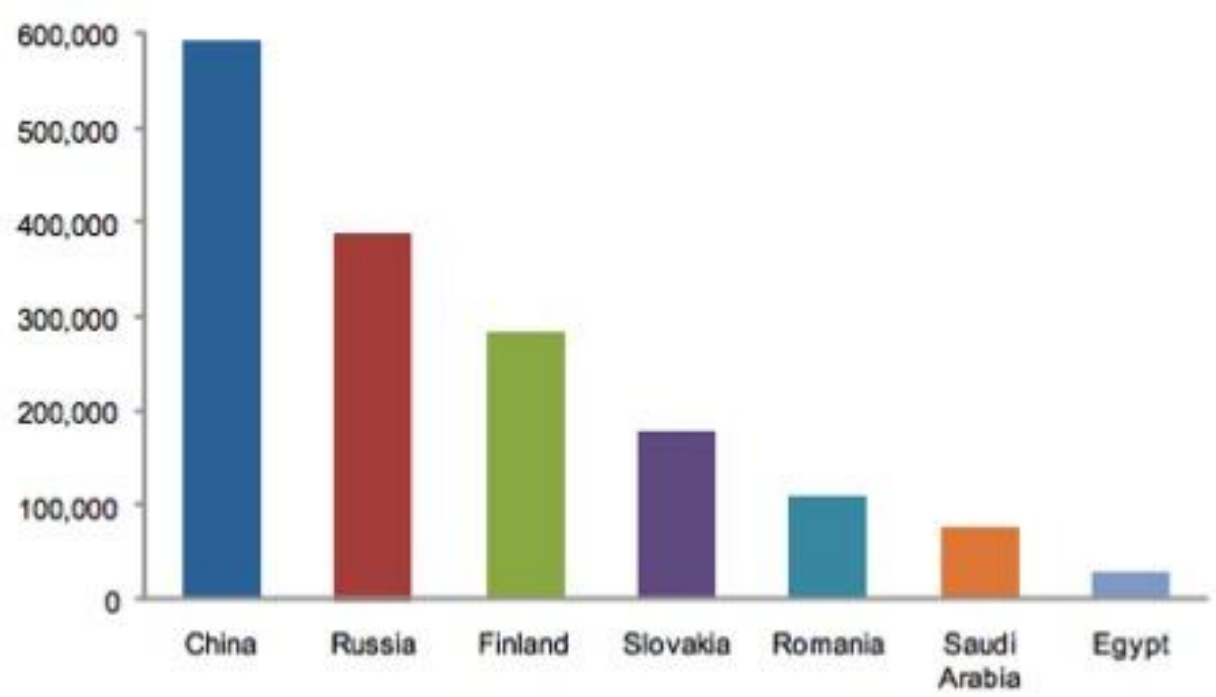
Principles of Good Visualizations

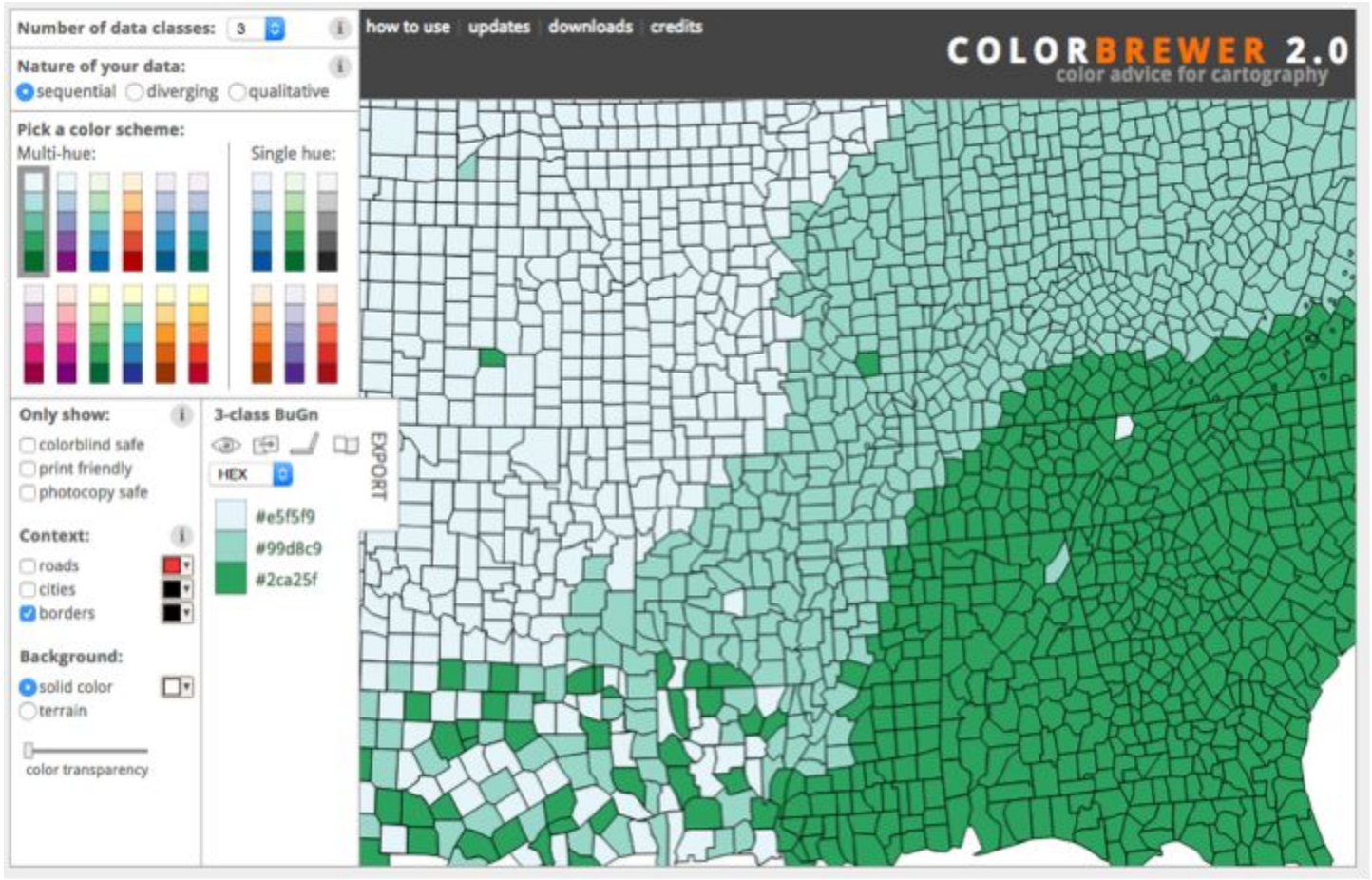
- “Above all else, show the data.”
- Help the audience think about the substance rather than about methodology (graphic design, the technology of graphic production, etc.), or something else.
- Avoid distorting what the data have to say.
- Present many numbers in a small space - but also emphasize the important values.
- Make large data sets coherent, and encourage the audience to compare different pieces of data.
- Reveal the data at several levels of detail, from a broad overview to the fine structure.

Design Principles

- Chart type
  - Select the appropriate chart type for your data and audience. Emphasize the data.
- Color
  - Use color sparingly. Use to highlight a data point.
  - Avoid decorative usage of color.
  - Only add color to an information display to communicate something in particular.
  - Use bright and/or dark colors to highlight information that requires greater attention.
  - Use lighter, soft, natural contrasting colors for the rest.
  - Consider using gray scale shading over color.
  - When encoding a sequential range of quantitative values:
    - Stick with a single hue (or a small set of closely related hues).
    - Vary intensity from pale colors for low values to increasingly darker and brighter colors for high values.

Design Principles - Color




Number of data classes: 3
how to use | updates | downloads | credits
COLORBREWER 2.0
color advice for cartography
Nature of your data:
sequential diverging qualitative
Pick a color scheme:
Multi-hue:
Single hue:
Only show:
colorblind safe
print friendly
photocopy safe
Context:
roads
cities
borders
Background:
solid color
terrain
color transparency
3-class BuGn
HEX
EXPORT
#e5f5f9
#99d8c9
#2ca25f

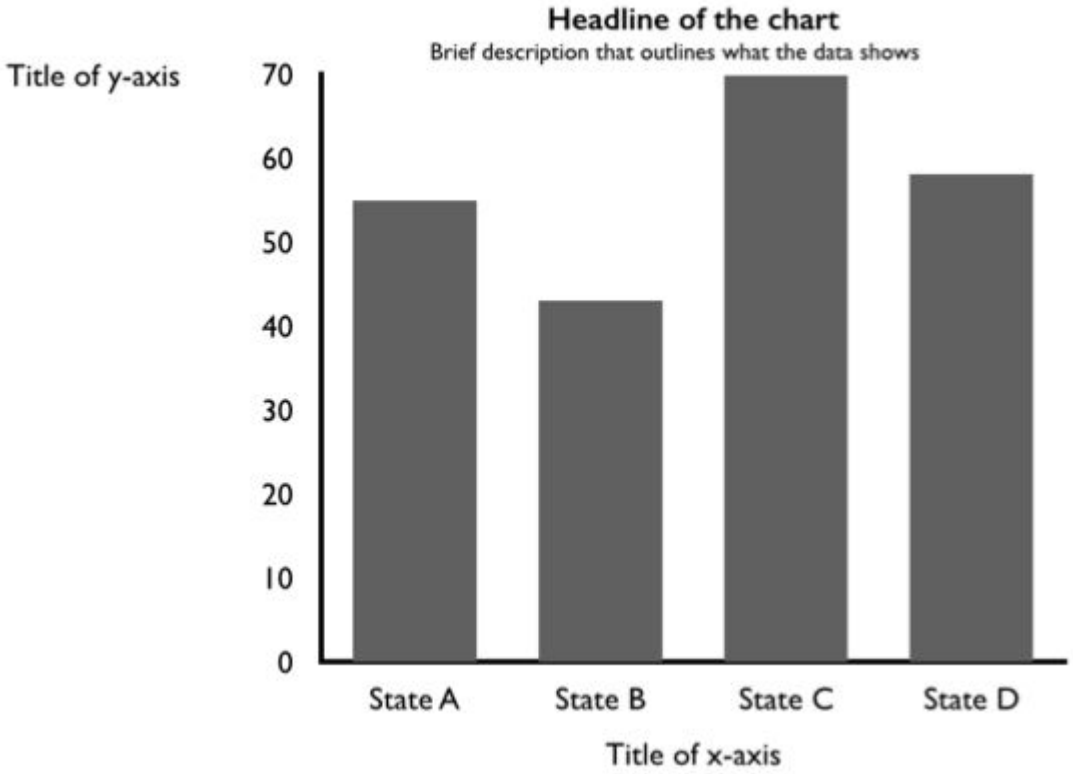
Design Principles - Labeling

- Use descriptive text and labels.
- Place label directly on the data.
- Use a legend when the chart encodings are too small to label and/or if they would impede readability.
- Add a description to guide readers in interpreting your visualization.
- Cite your data sources.

Design Principles - Text

- Readability - Font face, size, direction, and color affect the legibility.
  - Don’t set type too small or condensed.
  - Avoid all CAPS.
  - Avoid **bold** and *italic* at the same time.
  - Don’t use highly stylized fonts.
  - Do not set text at an angle or vertically.

Design Principles - Labeling & Text



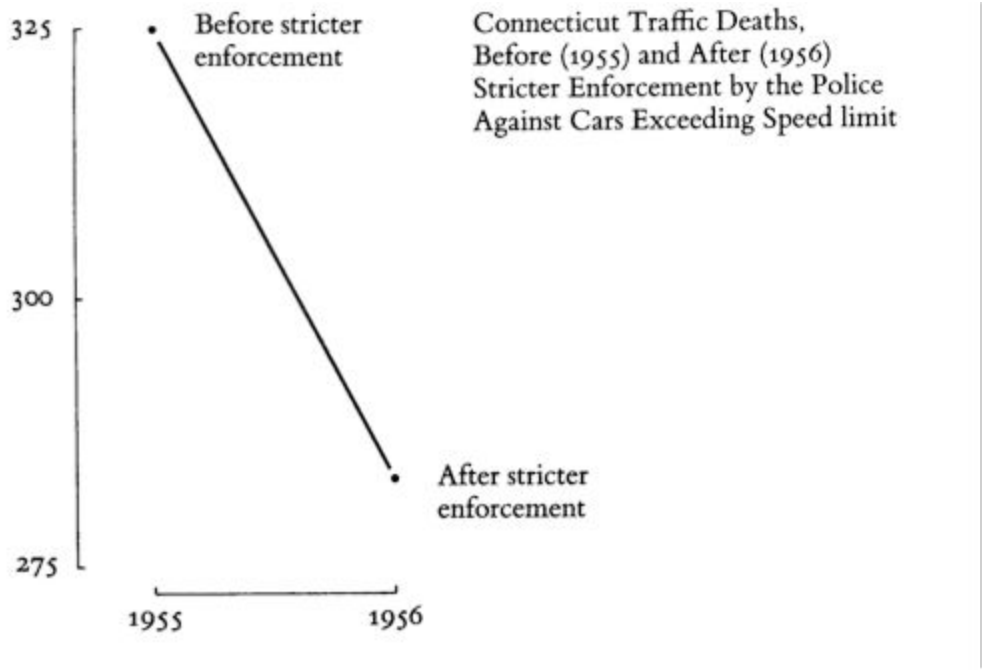
Design Principles - Scale

- Use natural increments for scales
  - 0,1, 2, 3, 4, 5
  - 0, 2, 4, 6, 8, 10
  - 0, 5, 10, 15, 20
  - 0, 10, 20, 30, 40, 50
  - 0, 25, 50, 75, 100
  - 0, 0.25, 0.50, 0.75, 1.00
- Avoid awkward scale increments
  - 0, 3, 6, 9, 12, 15
  - 0, 4, 8, 12, 16, 20
  - 0, 6, 12, 18, 24, 30
  - 0, 12, 24, 36, 28
  - 0, 0.4, 0.8, 1.2, 1.6

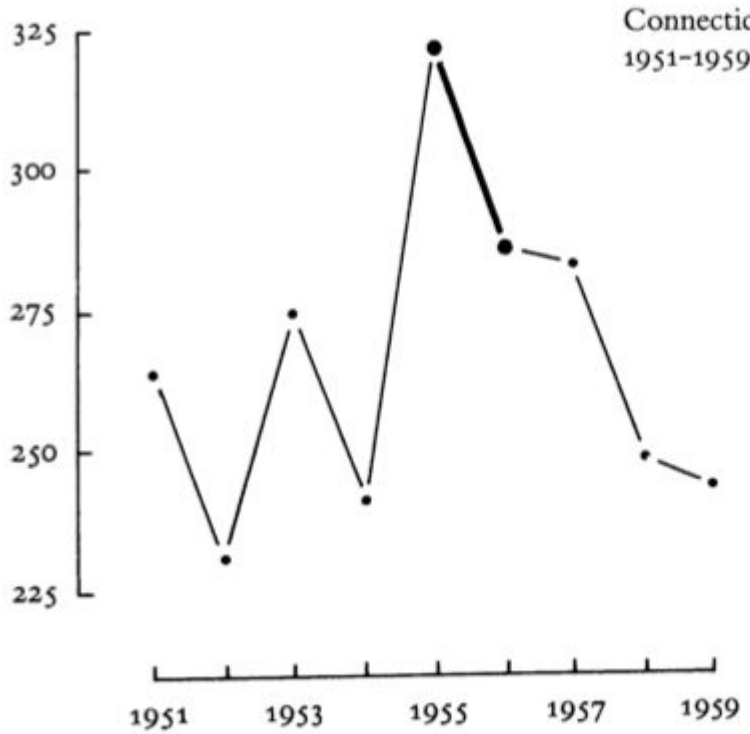
Design Principles - Data Integrity

- Show your data accurately and avoid distortions.
- Avoid fake perspectives, such as 3D.
- The graphics should bear the question “compared to what?” – presented within the right context.

Design Principles - Data Integrity



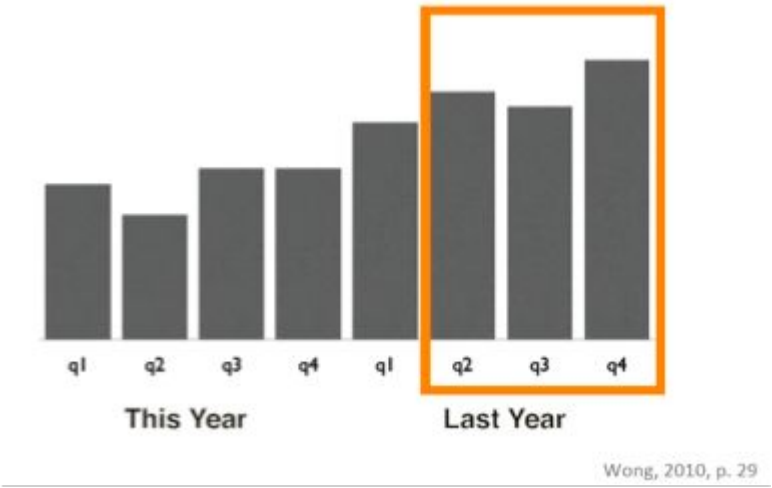
Design Principles - Data Integrity



Context is essential for data integrity.

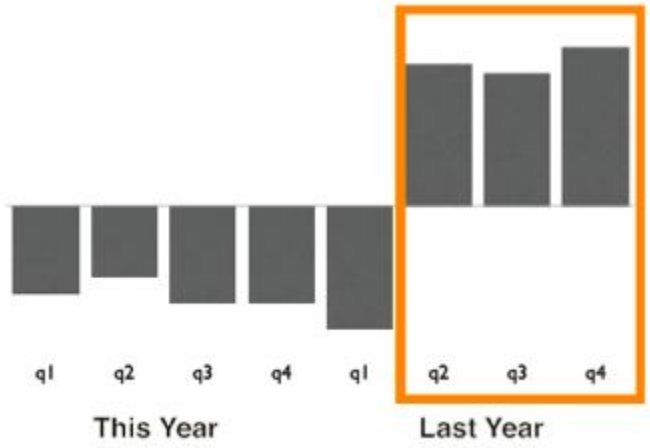
Design Principles - Data Integrity

It is acceptable to extract a few numbers out of a series if these data points tell a story without misleading the reader.



Design Principles - Data Integrity

It would be misleading to extract the last three quarters in the case below.



Wong, 2010, p. 29

Design Principles - Data Integrity

Provide context for your visualizations.

Design Principles - Chart Junk

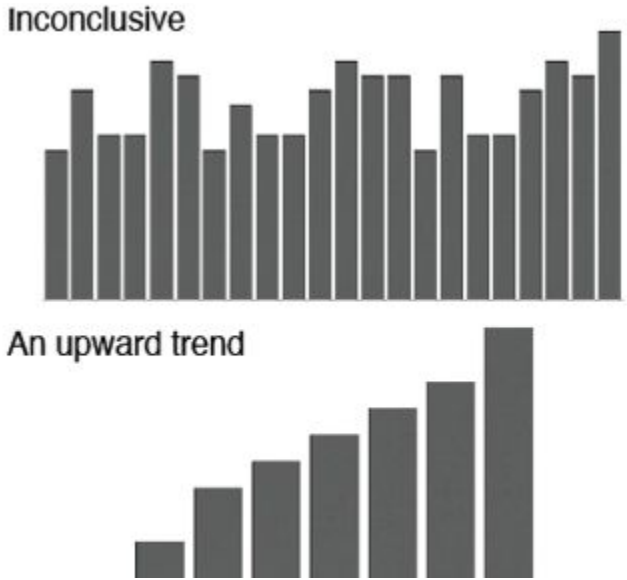
- Avoid chart junk.
- Useless, non-informative, or information-obscuring elements of quantitative information displays.

  --Edward Tufte

- Reduce non-data graphic elements (e.g. reduce the thickness of the bars in a bar chart).
- Remove the grid (or use a light gray grid) and non-essential elements.
- Avoid using shadows.
- Stick to white or match the chart background.

Design Principles - Data Richness

Accurate data and effective filtering of your data based on audience.



Process of creating and selecting appropriate visual displays

Identify the following:

1. Audience: Who will be viewing and/or interacting with your visual displays?
2. Task: What is the message of your display? Is there something you want the reader to take away from your visual?
3. Data: Do you have the data to achieve the task? What are the tables/fields? Does the data need to be aggregated, transformed, etc?
4. Display: What is the best display type for my task, data, and audience? Do I want to show a pattern, relationship, proportions, comparisons, or distributions?

In-Class Activity

DOHMH New York City Restaurant Inspection data

Questions for exploration:

1) How are restaurant inspections in all of NYC distributed?
2) How does Manhattan restaurants compare to Brooklyn?
3) What is the most common type of cuisine for restaurants in Staten Island? How does this compare to Queens?
4) Are inspection grades for certain types of restaurants better than others?
    a. What type of restaurants has the worst ratings?
5) Is the quality/cleanness of restaurants improving or worsening over time?
6) What are the top 3 causes for violations?