36-309/749
Experimental Design for Behavioral and Social Sciences

Sep. 1, 2015 Lecture 1: Intro

About the course

- Goals
  - Principles of statistics and experimental design
  - Common designs and analyses
  - Correct interpretation
- Organization

  Textbook→Lecture→Lab→HW
- Policies
  - Lectures, office hours, and email
  - Labs, homework, and collaboration vs. plagiarism
  - Exams and Grading

A Case Study

- A team of researchers from the Adelaide Institute for Sleep Research investigated the effects of low dose alcohol on driving among 21 sleep-deprived health young males (Sleep, 2007, 30:1327). They recruited subjects from University employment websites. The experiment involved a 70 minute driving simulator test taken after a 4-hours-of-sleep night. Participants are exposed to the placebo and ethanol conditions one week apart in random order. The ethanol condition is designed to achieve an approximate BAC of 0.025%. Today we look at (simulated) results for the outcome variable “braking reaction time”, which is the average time (in seconds) until braking for the five slow-moving trucks encountered in the simulator.

Quick Analysis of Case Study

Data

Subject	Sober Time	Drunk Time
1	1.33	1.84
…	…	…
21	0.85	0.82

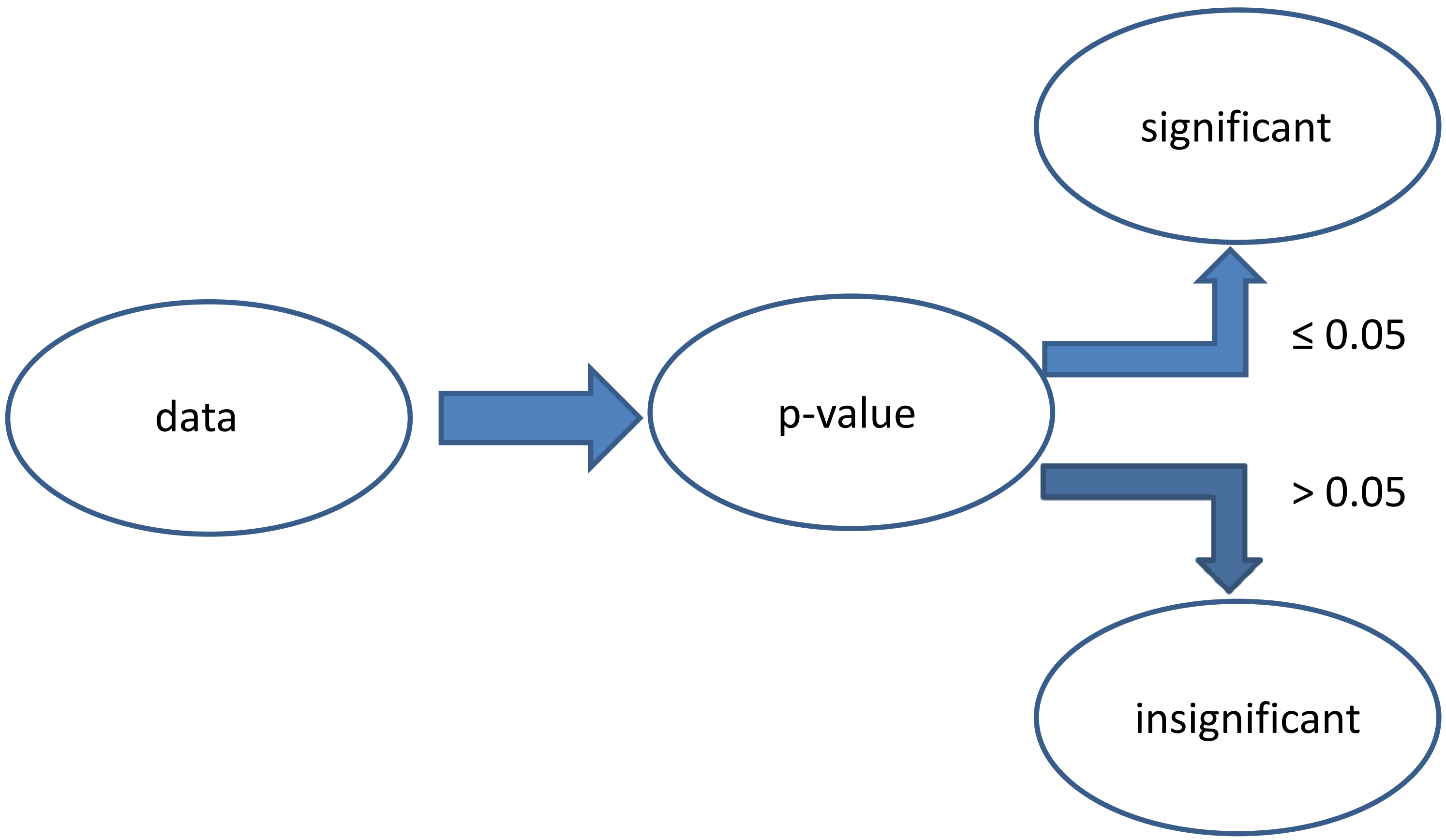
Group Statistics

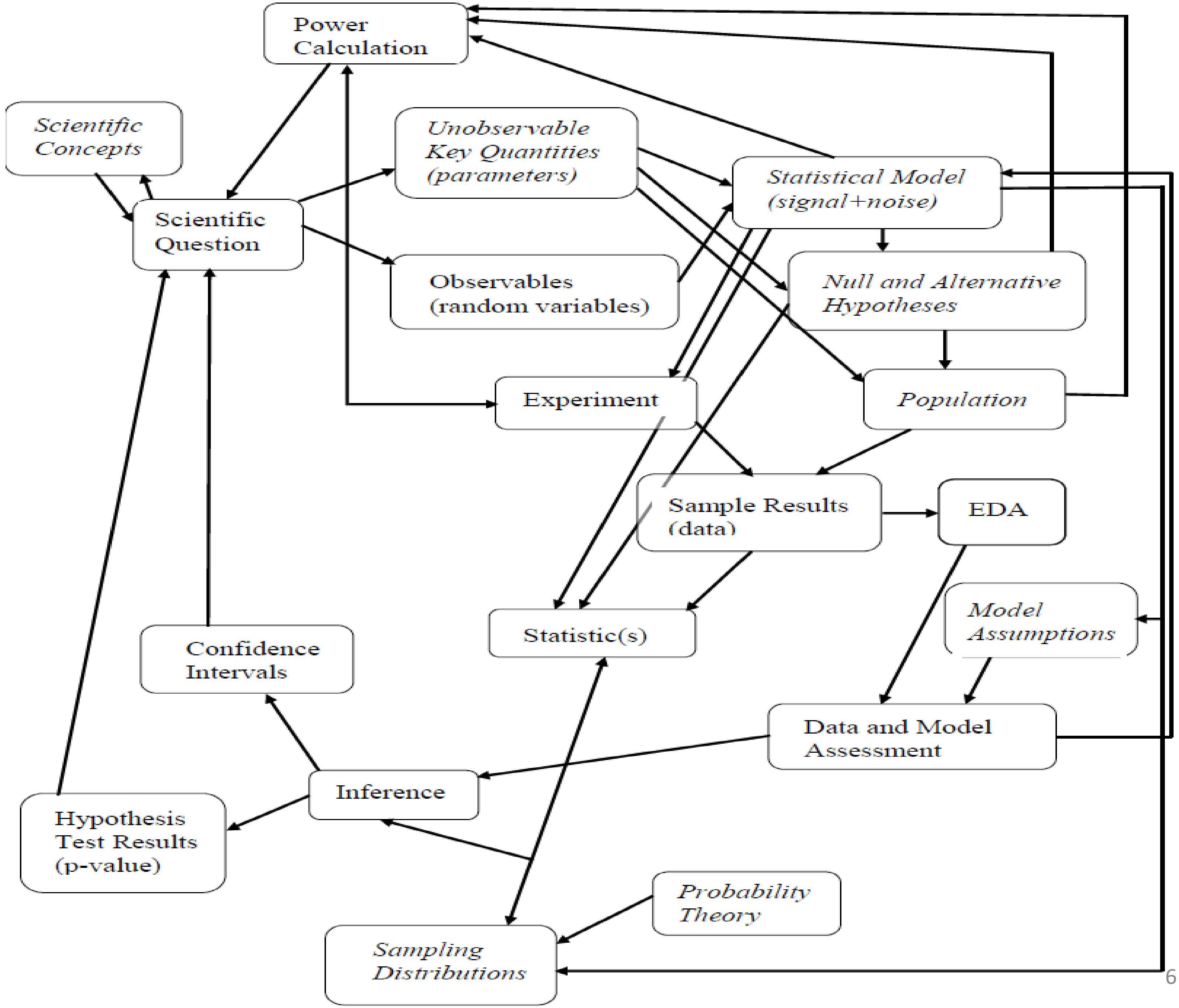
	Experimental Condition	N	Mean	Std. Deviation	Std. Error Mean
Braking Time	Sober	21	1.1619	0.4095	0.0893
	Drunk	21	1.3566	0.4058	0.0886

Independent Samples Test

		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Braking Time	Equal variances assumed	-1.548	40	0.130	-0.195	0.126	-0.449	0.060

Simple concept map




Power Calculation
Scientific Concepts
Unobservable Key Quantities (parameters)
Statistical Model (signal+noise)
Scientific Question
Observables (random variables)
Null and Alternative Hypotheses
Experiment
Population
Sample Results (data)
EDA
Model Assumptions
Statistic(s)
Confidence Intervals
Data and Model Assessment
Inference
Hypothesis Test Results (p-value)
Probability Theory
Sampling Distributions

Data Analysis Steps

- Preliminary steps: what’s what?
- EDA
- Formal statistical analysis (may be iterative)
- Presentation and statistical interpretation
- Subject matter conclusions

Preliminary Steps

- Data format and id of **experimental units**
- Variable **roles** (§2.2):
  - DV (dependent or outcome variable)
  - IVs (independent or explanatory variables)
- Variable **types** (§2.3):
  - Quantitative (subtracted values indep. of originals)
    - Discrete (counts; must be recorded as whole numbers)
    - Continuous (true measurements; fractions make sense)
  - Categorical
    - Nominal (numbers arbitrary; no meaningful order)
    - Ordinal (≥3 levels; with a meaningful order)

Details of Exploratory Data Analysis (EDA) and Basic Statistics

What are we are looking for?

- <u>Single quantitative variable</u>: central location, spread, shape, outliers (§4.2, 4.3)
- <u>Single categorical variable</u>: distribution of categories
- <u>DV vs IVs</u>: ***How does the distribution of the DV vary as the IVs change?*** (§4.4, 4.5)

Non-graphical EDA (§4.2, 4.4)

- For univariate (one variable at a time) quantitative data
  - standard statistics: mean, standard deviation, variance
  - robust statistics: median, inter-quartile range (IQR)
  - also: Q1, Q3, skewness, kurtosis
- For univariate categorical data: frequency table, % of total
- For bivariate (two at a time) quantitative data: correlation (§4.4.4-4.4.5).
- For quantitative outcome and categorical explanatory variables: statistics by category
- For multiple categorical variables: two (or higher) way frequency tables (aka contingency tables or cross-tabs).

Graphical EDA (§4.3, 4.5)

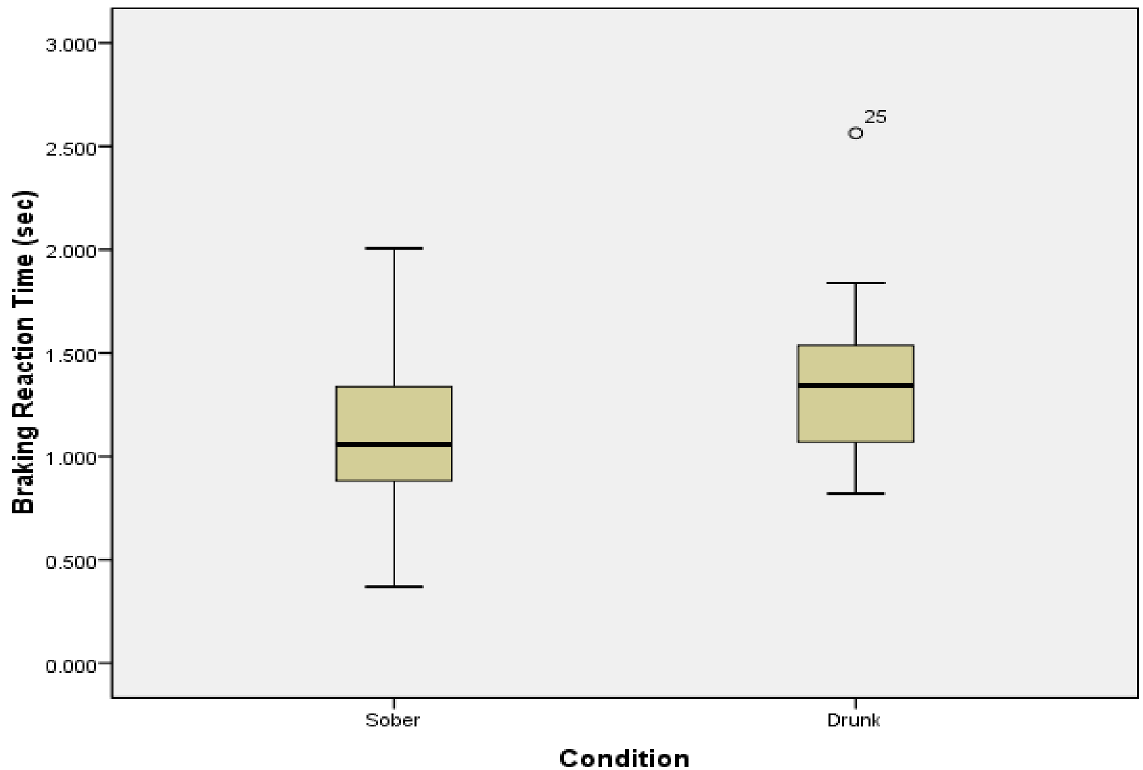
- For quantitative univariate data
  - Stem and leaf plot:

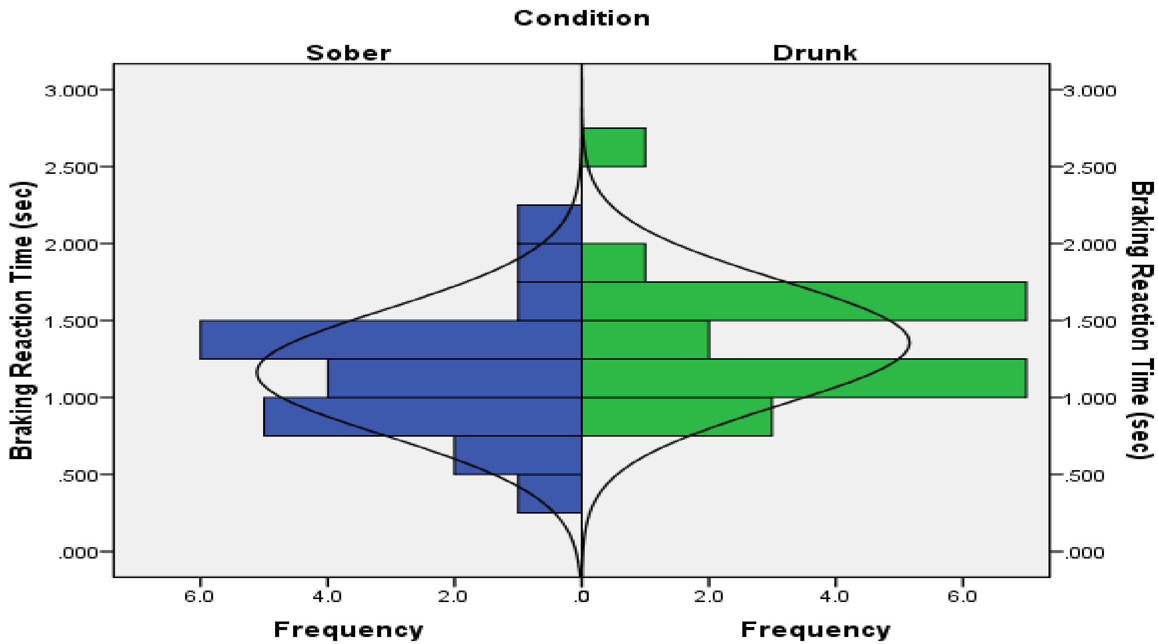
    2: 64
    4: 335901588
    6: 51688
    8: 4456
  - Frequency histogram (a distribution estimate)
  - Boxplot
  - Quantile-Normal plot (Gaussian check; mostly for residuals)
- For categorical univariate data, use bar graph or pie chart.
- For quantitative outcomes with categorical explanatory variables, use side-by-side stem and leaf plots, boxplots, or histograms.
- For multiple categorical variables, perhaps use bar charts of one category for each level of the other category. (Newer plots: fourfold, sieve.)
- For bivariate quantitative data, make a scatterplot with the outcome variable (DV) on vertical (y) axis.

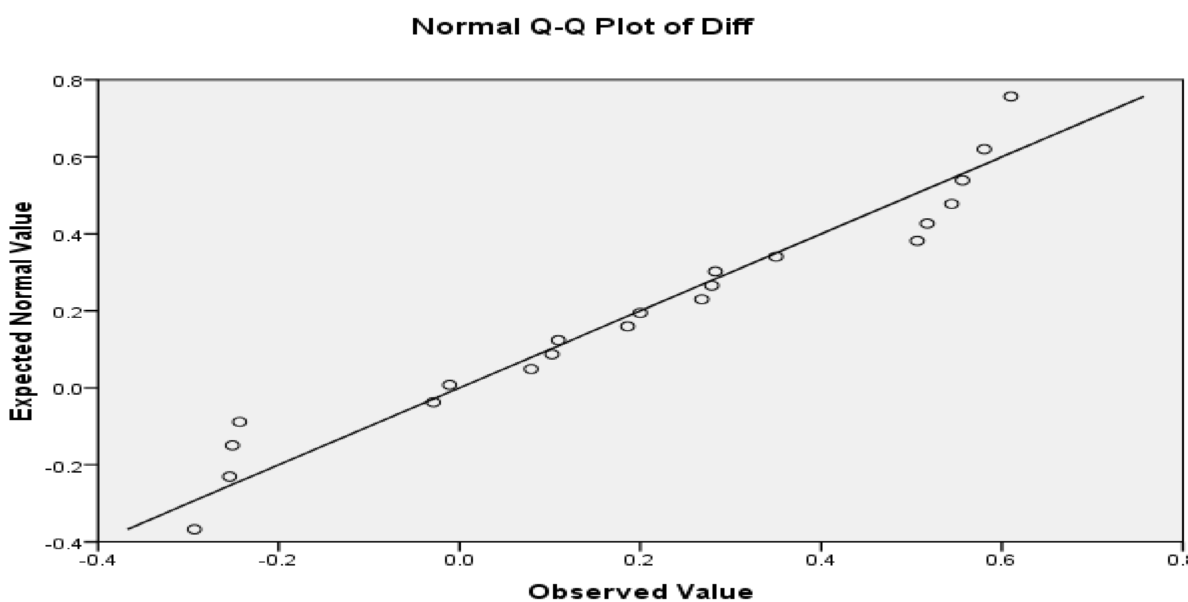
EDA for Driving Study

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sober	21	0.370	2.007	1.162	0.409
Drunk	21	0.819	2.563	1.356	0.406
Valid N (listwise)	21				




Condition
Sober
Drunk
3.000
2.500
2.000
1.500
1.000
.500
.000
Braking Reaction Time (sec)
6.0
4.0
2.0
.0
Frequency
Frequency


Normal Q-Q Plot of Diff
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Expected Normal Value
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
Observed Value

Correct Formal Statistical Analysis of Driving Experiment

Paired Samples Test

		Paired Differences					t	Df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
	Drunk-Sober	0.195	0.297	0.065	0.059	0.330	2.999	20	0.007

Presentation and Statistical Interpretation

- "p=0.000" is WRONG!!
- Generally use 3 significant figures.
- Use leading zeros to avoid misreads (although APA style says to drop zeros in front of numbers that cannot be greater that 1.0).
- Conclusions here: Reject "H_0: mean difference equals 0.0". 95% confidence interval for the difference is 59 to 330 milliseconds.

Subject Matter Conclusions

This study supports the conclusion that the true mean braking time is likely to be 0.06 to 0.33 seconds longer for subjects consuming low dose alcohol (at least for healthy, young males). Most individuals have braking times within about 0.8 seconds of their group's mean braking time. At 60 mph, 0.06 seconds is about 5 feet, but 0.33 seconds is about 29 feet, so it is likely to be associated with more serious accidents.

A few class conclusions

- Identification of the experimental unit and variable classification are important first steps that help you choose the right analysis.
- EDA helps you understand your data and choose the right analysis.
- **Computers are stupid**, and are happy to perform the wrong analysis for you.
- P-values can be useful for testing specific null hypotheses, but confidence intervals are often more useful.