Exploratory Data Analysis

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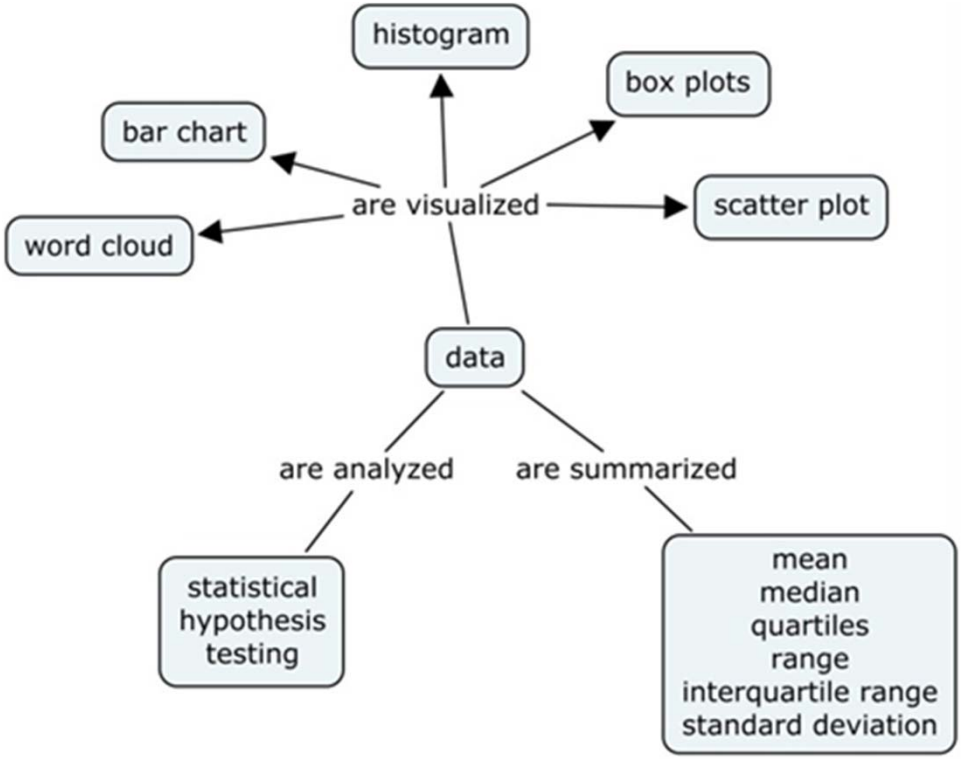
June 11, 2011

Concept Map



Created with Cmap: http://cmap.ihmc.us/

Learning Objectives

- After completion of this module, the student will be able to explore data graphically in Excel using
  - histogram
  - boxplot
  - bar chart
  - scatter plot
- After completion of this module, the student will be able to employ web-based tools for statistical hypothesis testing and determine significance levels under multiple testing using the Bonferroni correction.

Knowledge and Skills

- Graphing in Excel
- Functions in Excel
- Pivot tables in Excel
- Concepts: mean, standard deviation, bar chart, histogram, boxplot, quantiles, error bar, line graph, scatter plot

Prerequisites

- Statistical hypothesis testing
- Some basic familiarity with graphing in Excel
- Familiarity with
  - Cardiac events
  - Risk factors for cardiac events
  - Dobutamine stress echocardiography

Worksheet

- **Citation:** Neuhauser, C. Exploratory Data Analysis.
- **Created:** May 23, 2011
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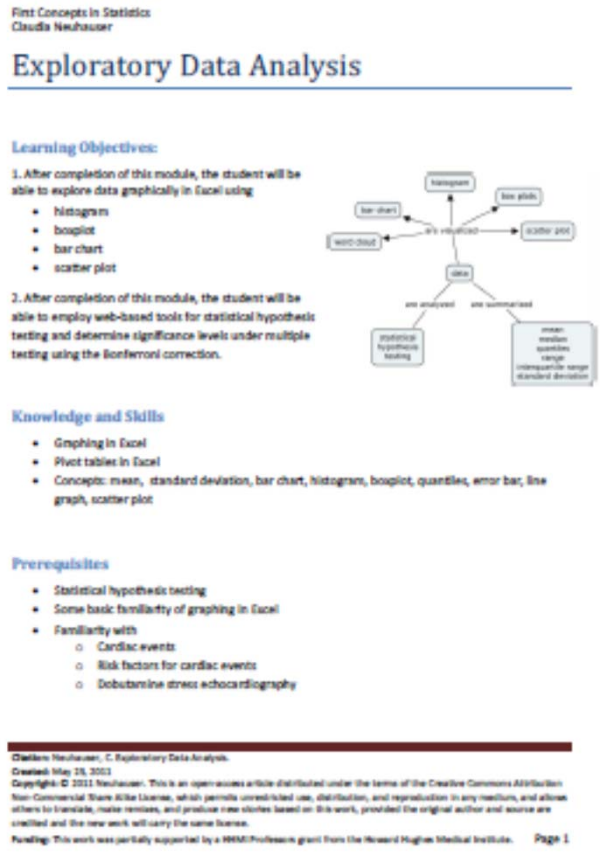

First Concepts in Statistics
Claudia Neuhauser

Exploratory Data Analysis

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Funding: This work was partially supported by a HHMI Professors grant from the Howard Hughes Medical Institute. Page 1

The Data

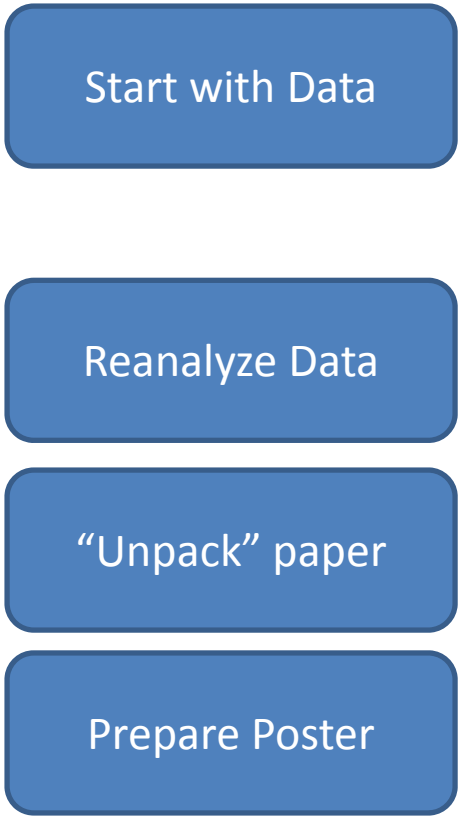
- Garfinkel Cardiac Data: http://bioquest.org/numberscount/data/
- Citation: Garfinkel, Alan, et. al. 1999. "Prognostic Value of Dobutamine Stress Echocardiography in Predicting Cardiac Events in Patients With Known or Suspected Coronary Artery Disease." Journal of the American College of Cardiology 33(3) (1999) 708-16

Background and Preparation

- The data set is a compilation of medical records of patients who underwent dobutamine stress echocardiography and were followed for twelve months afterwards for occurrences of cardiac events.
- The data set includes data on
  - patient characteristics
  - physiological data under rest and dobutamine conditions
  - the history of medical conditions relevant to cardiac events
  - outcome data during the subsequent twelve months.
- Preparation: review patient information on dobutamine stress echocardiography
  - http://stanfordhospital.org/healthLib/greystone/heartCenter/heartProcedures/dobutamineStressEchocardiogram.html

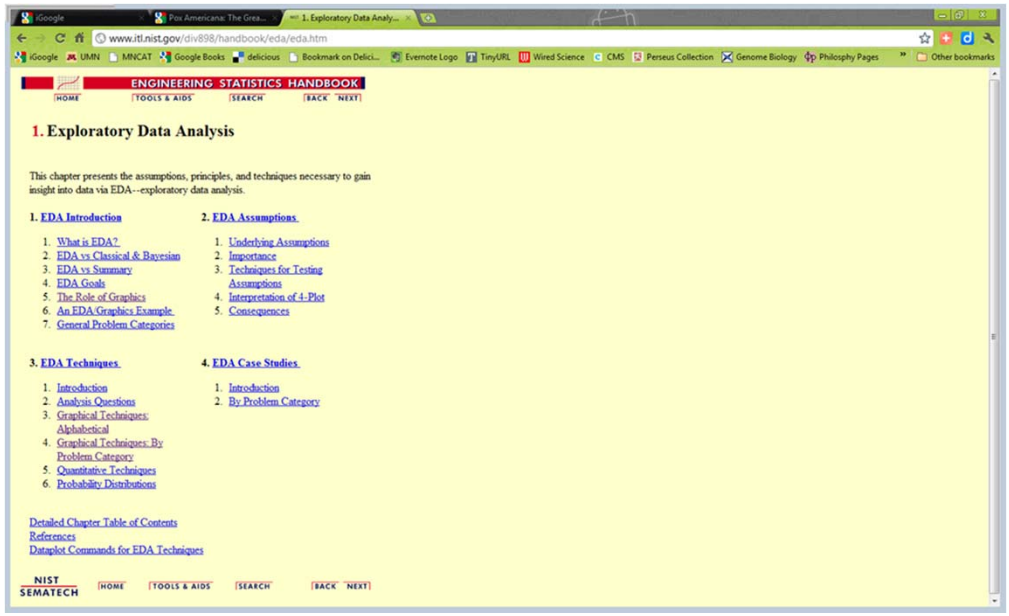
Classroom Use

- If students are already familiar with statistical methods, they can start with the data set and explore the data on their own or with some guidance. Both a hypothesis-based or a discovery-based approach are appropriate: based on prior knowledge, students can formulate hypotheses and test them subsequently; or students can explore the data and discover patterns.
- Students can reanalyze the data based on results from the accompanying paper to deepen their grasp of statistical analysis.
- Students can "unpack" the paper to learn how a scientific paper in this discipline is written and how results can be succinctly communicated.
- The paper relies almost exclusively on tables to convey results. A student could focus on a specific aspect of the paper and develop a poster where the results are visually displayed.



Exploratory Data Analysis (EDA)

- NIST Engineering Statistics Handbook
  - http://www.itl.nist.gov/div898/handbook/eda/eda.htm

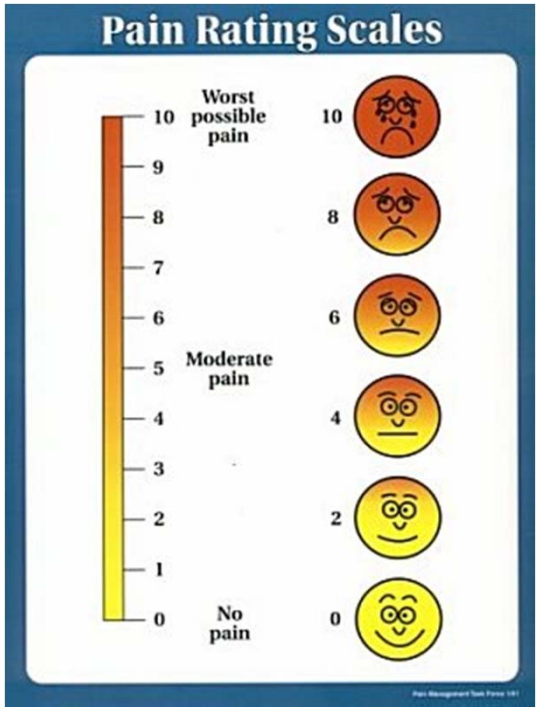


Data I

- Free text
  - Word clouds: http://www.tagxedo.com/

Data II

- Categorical data
  - Nominal (unranked)
    - Yes/No
  - Ordinal (ranked)
- Numerical data
  - Discrete
    - Heart rate
  - Continuous
    - Glucose or cholesterol levels in blood



Pain rating scales are an example of ranked categorical data

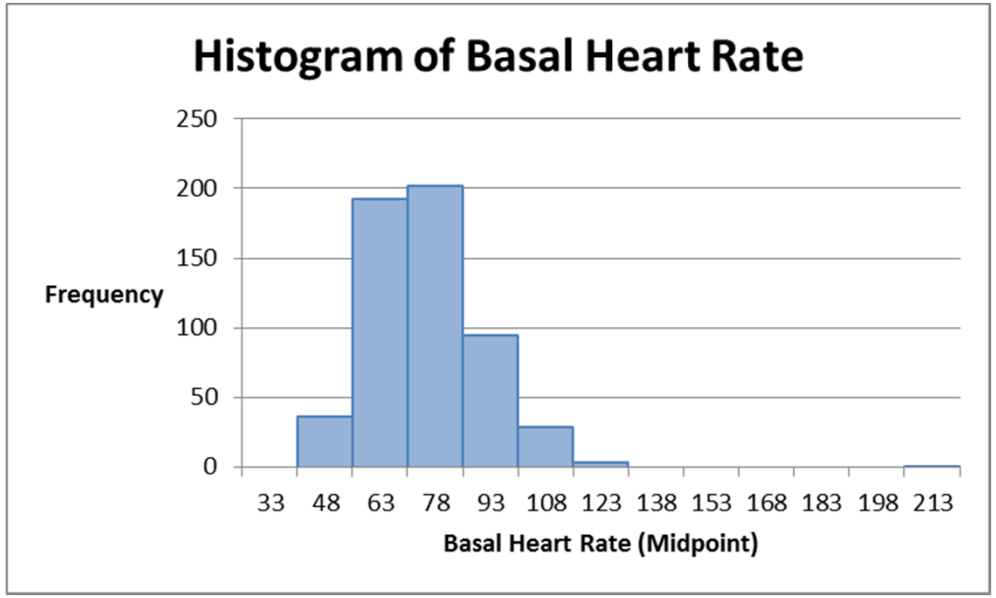
Garfinkel's Cardiac Data

Column	Variable
A	Basal Heart Rate
B	Basal Blood Pressure
C	Basal Double Product BHR*BBP
D	Peak Heart Rate
E	Systolic Blood Pressure
F	Double Product PKR*SBP
G	Dobutamine Dose
H	Maximum Heart Rate
I	% Maximun Predicted Heart Rate Achieved by Patient
J	Maximum Blood Pressure
K	Double Product of Maximum on Dobutamine
L	Double Product Maximum on this Dobutamine Dose
M	Age
N	Gender (male=0)
O	Baseline Cardiac Ejection Fraction
P	Baseline Cardiac Ejection Fraction on Dobutamine

Column	Variable
O	Baseline Cardiac Ejection Fraction
P	Baseline Cardiac Ejection Fraction on Dobutamine
Q	Chest Pain (yes=0)
R	Sign of Heart Attack on ECG (yes=0)
S	Equivocal ECG (yes=0)
T	Heart Wall Motion Anomaly Observed (yes=0)
U	Stress ECG Positive (yes=0)
V	New Heart Attack (yes=0)
W	New Angioplasty (yes=0)
X	New Bypass Surgery (yes=0)
Y	Death (yes=0)
Z	History of Hypertension (yes=0)
AA	History of Diabetes (yes=0)
AB	History of Smoking (yes=0)
AC	History of Heart Attack (yes=0)
AD	History of Angioplasty (yes=0)
AE	History of Bypass Surgery (yes=0)
AF	Any New Cardiac Event (yes=0)

Histograms

- http://www.itl.nist.gov/div898/handbook/eda/section3/histogra.htm



The histogram graphically shows the following:

- center (i.e., the location) of the data;
- spread (i.e., the scale) of the data;
- skewness of the data;
- presence of outliers; and
- presence of multiple modes in the data.

Instructions

- **Basal Heart Rate** tab
- Excel functions
  - MIN(*range*)
  - MAX(*range*)
  - COUNTIF(*range*, “<=“&E4)
- Determine bins and their midpoints
- Correct use of bar charts to create histograms
  - Area is proportional to counts
- Detailed instructions are on pp. 6-8

Boxplots

- http://www.itl.nist.gov/div898/handbook/eda/section3/boxplot.htm

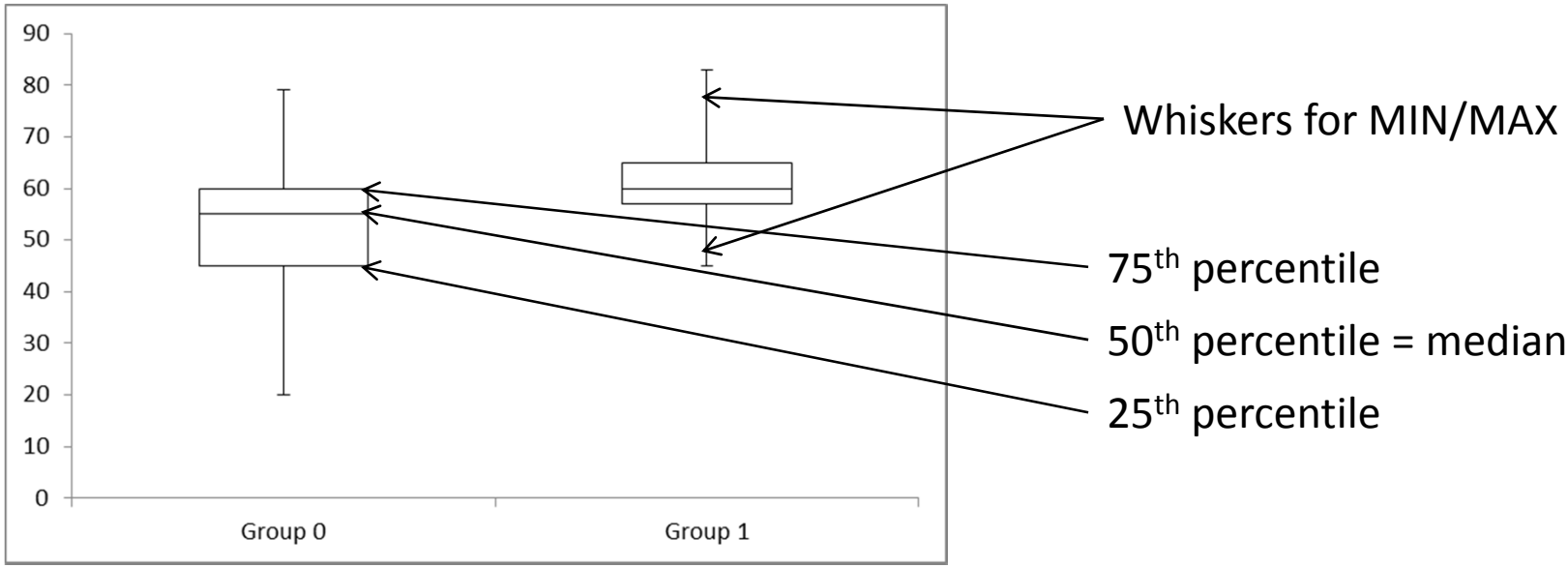


Figure 3: Boxplot for Baseline Cardiac Ejection Fraction for two groups: Group 0 has heart wall motion anomaly observed, whereas Group 1 does not have heart wall motion anomaly observed.

Instructions

- **BCEF** tab
- Excel functions
  - PERCENTILE(*range*, *p*)
  - MIN(*range*)
  - MAX(*range*)
- Determine 25^{th}, 50^{th}, and 75^{th} percentiles and the minimum and maximum of the data
- Use of “Stacked Columns” and “Error Bars” to create box plots
- Detailed instructions are on pp. 8-11

Online Tools for Hypothesis Testing

- To compare the two groups, we perform a *t*-test
  - http://studentsttest.com/
  - http://www.dimensionresearch.com/resources/calculators/ttest.html
- Excel functions
  - AVERAGE(*range*)
  - STDEV(*range*)
- Bonferroni correction (see p. 5)

Pivot Tables and Bar Charts

- “Patients with a positive SE had a 34% cardiac event rate within the ensuing 12 months (Table 3) versus an event rate of only 10% in patients with a negative SE ($p<0.001$).”
  - Use a pivot table to confirm these figures and bar charts to illustrate the difference.
- Detailed instructions on pp. 11-12

Online Tools for Hypothesis Testing

- To test for associations, we use a chi-square test
  - http://people.ku.edu/~preacher/chisq/chisq.htm
  - http://faculty.vassar.edu/lowry/tab2x2.html
  - http://statpages.org/ctab2x2.html

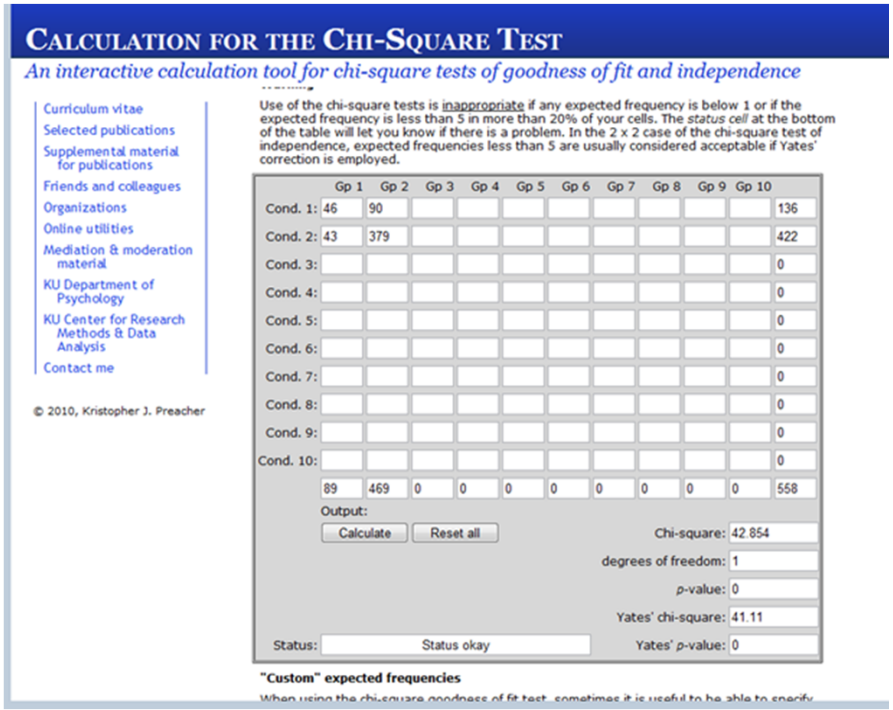


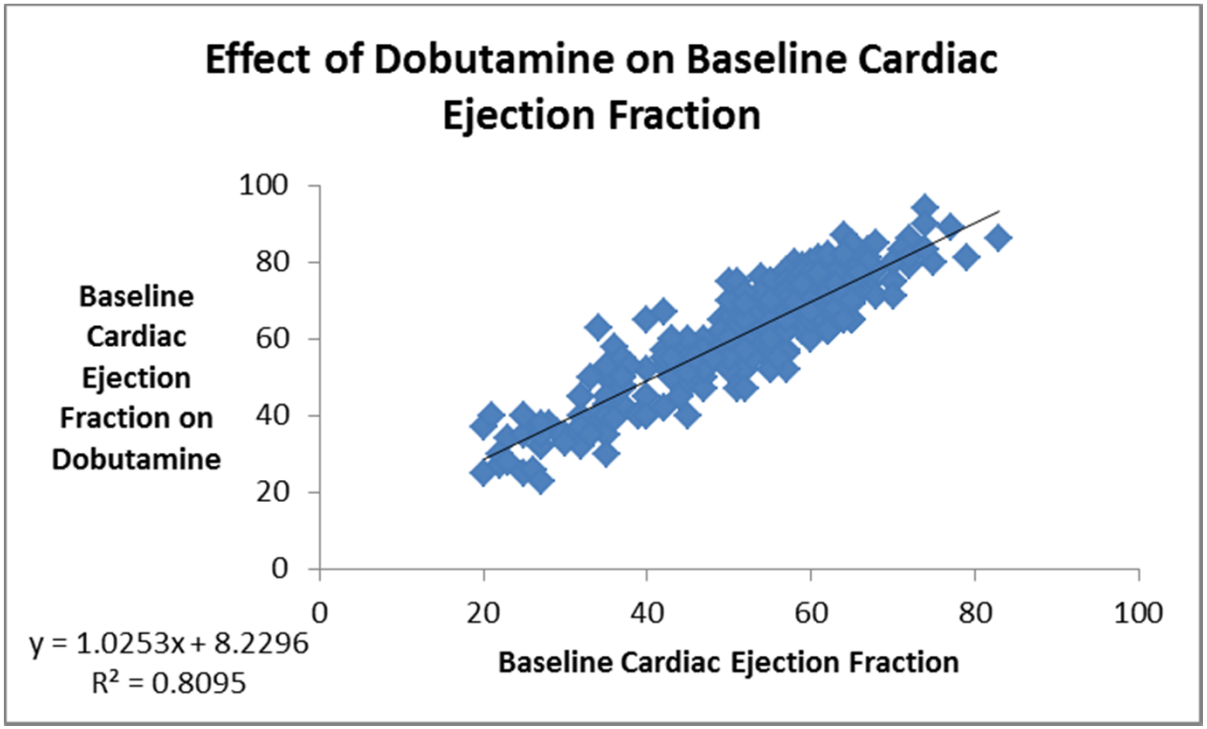
Figure 5: Screenshot of Chi-square calculator (http://people.ku.edu/~preacher/chisq/chisq.htm)

Multiple Testing

- Bonferroni Correction
  - http://en.wikipedia.org/wiki/Bonferroni_correction
- Every time you perform a statistical hypothesis test with significance level 5%, there is a 5% chance that you reject the null hypothesis even though it is true.
  - If you have a coin that comes up tails 5% of the time, then if you toss the coin often enough you will eventually see tails. In fact, we expect to see tails about every twenty coin tosses since 5% is 1 in 20.
- One solution to the multiple comparison problem is provided by the **Bonferroni correction**, which says that you need to **divide the desired significance level across all tests by the number of tests and apply this new level to each of the individual tests**.

Scatterplots

- You Tube videos
  - http://youtu.be/-SeCPLC30_g



A scatterplot can convey visually whether two numeric variables are related. We added a regression line and the R^2 value, both are readily available in Excel.

Effective Graphing

- Take the Graph Design IQ test: http://www.perceptualedge.com/files/GraphDesignIQ.html and record your score.
  - Go to http://www.perceptualedge.com/examples.php
  - A graph and a table: http://www.perceptualedge.com/example2.php
  - Pie chart versus bar graph : http://www.perceptualedge.com/example12.php
  - Using line markers: http://www.perceptualedge.com/example14.php
  - Multiple solutions: http://www.perceptualedge.com/example10.php