Using the Historical Development of Statistical Techniques to Teach the Value of Evidence from Data

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Goals of the TRIUMPHS Project

- To write, disseminate, and evaluate Primary Source Projects (PSPs) that cover undergraduate mathematical content and are based on primary historical sources.
- Teaching with a PSP allows students to work in groups during class or individually outside of class to complete a series of tasks based on a primary source.

Outline of Seeing and Understanding Data PSP

1. **"Ancient" Visualization:** introduction to the earliest data visualization

2. **Communicating Data Visually:** graphical displays of Michael Florent van Langren and William Playfair

3. **Making an Argument by Telling a Data Story:** works of Florence Nightingale and Charles Joseph Minard

4. **Beyond Paper and Ink:** data visualizations of Edward Tufte and Hans Rosling

Learning Objectives:
- Understand how to read and interpret printed graphical displays and interactive data visualizations
- Apply their knowledge of graphical displays to visualizations that students may not be familiar with

Outline of Quantifying Certainty: the p-value PSP

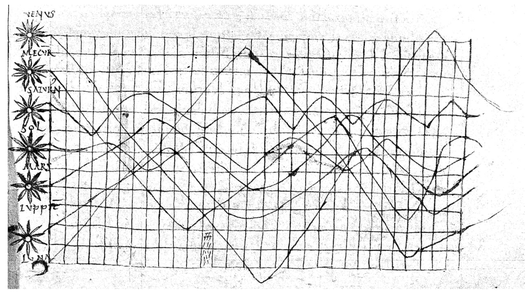
1. Proof by Contradiction and Proof by the Highly Improbable

2. Use of the p-value before formal definition by Ronald Fisher

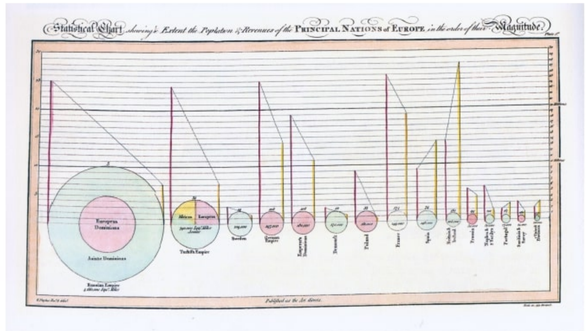
3. Reasoning for why the null hypothesis is rejected if $p < 0.05$

Learning Objectives:
- Provide students with an intuitive introduction to hypothesis testing and p-values through reading the works of 18th century thinkers
- Having students wrestle with what it means to reject a hypothesis and with the question of what the threshold value should be

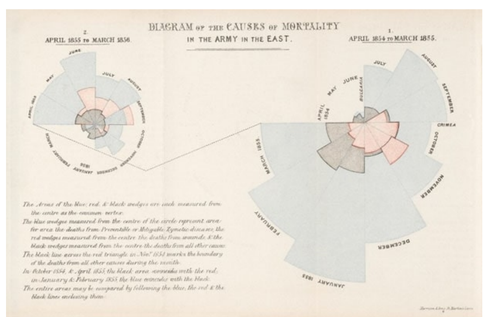
Seeing and Understanding Data PSP



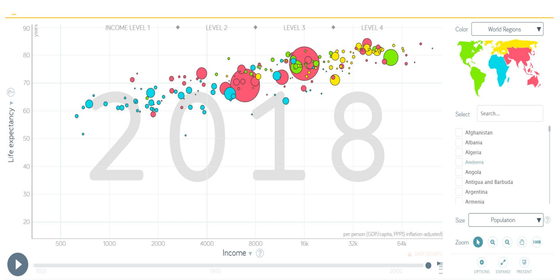
Time-series graph from the 10th or possibly 11th century



Resources of Principal States and Kingdoms in Europe, Circle Graph by William Playfair



Causes of mortality in the Army in the East, Coxcomb Diagram by Florence Nightingale



Hans Rosling's interactive data visualization on Gapminder's website

Developed under NSF Grant 1524098

Quantifying Certainty: the p-value PSP

Greek philosopher Chrysippus and the Proof by Contradiction:

1. If A is true, then B is true.
2. B is not true.
3. Therefore "A" is not true.

Proof by the Highly Improbable:

1. If A is true, then B almost certainly is true.
2. B is not true.
3. Therefore A is almost certainly not true.

Boys and girls, births and baptisms an activity using work by John Arbuthnot in 1710:

We must observe that the external Accidents to which Males are subject (who must seek their Food with danger) make a great havock of them, and that this loss exceeds far that of the other Sex occasioned by Diseases incident to it, as Experience convinces us. To repair that Loss, provident Nature, by the Disposal of its wise Creator, brings forth more Males than Females; and that in almost a constant proportion.

One of two statements by Sir Ronald Fisher:

The value for which P = 0.05, or 1 in 20, is 1.96 or nearly 2; it is convenient to take this point as a limit in judging whether a deviation ought to be considered significant or not. Deviations exceeding twice the standard deviation are thus formally regarded as significant. Using this criterion we should be led to follow up a false indication only once in 22 trials, even if the statistics were the only guide available. Small effects will still escape notice if the data are insufficiently numerous to bring them out, but no lowering of the standard of significance would meet this difficulty.