

Everything Wrong with Statistics (and How to Fix It)

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Crisis!

Data science without statistics is possible, even desirable

Posted by Vincent Granville on December 8, 2014 at 5:00pm  View Blog

Essay

Why Most Published Research Findings Are False

John P. A. Ioannidis

A journal-level rejection of statistical inference

Richard Zink

Principal Research Statistician Developer for JMP Life Sciences

NATURE | NEWS



Science joins push to screen statistics in papers

New policy follows efforts by other journals to bolster standards of data analysis.

Richard Van Noorden

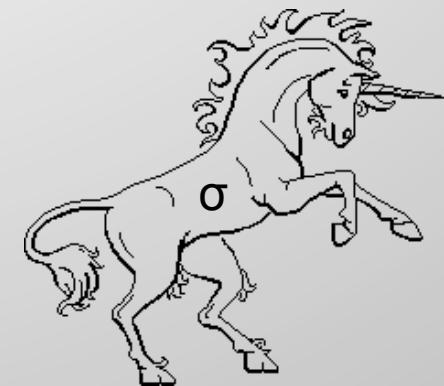
03 July 2014

What's going on?

Statistics is popular and important!

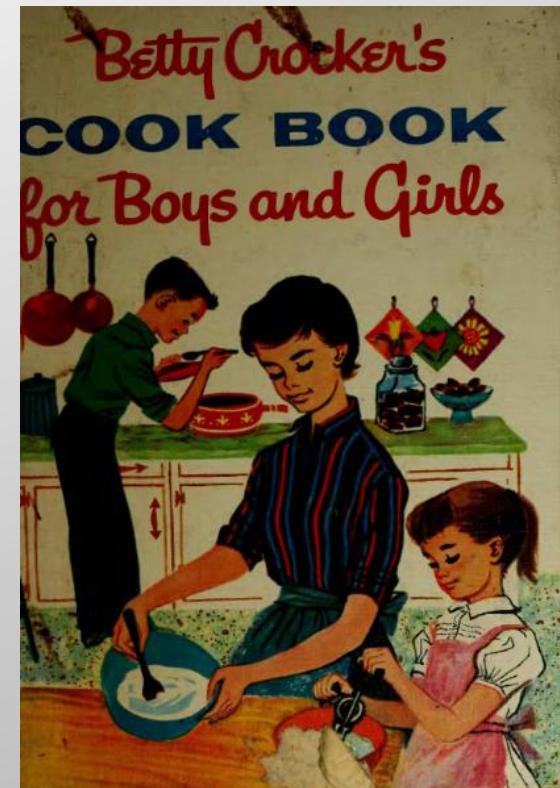
Statisticians are rare.

Statistics training isn't working.

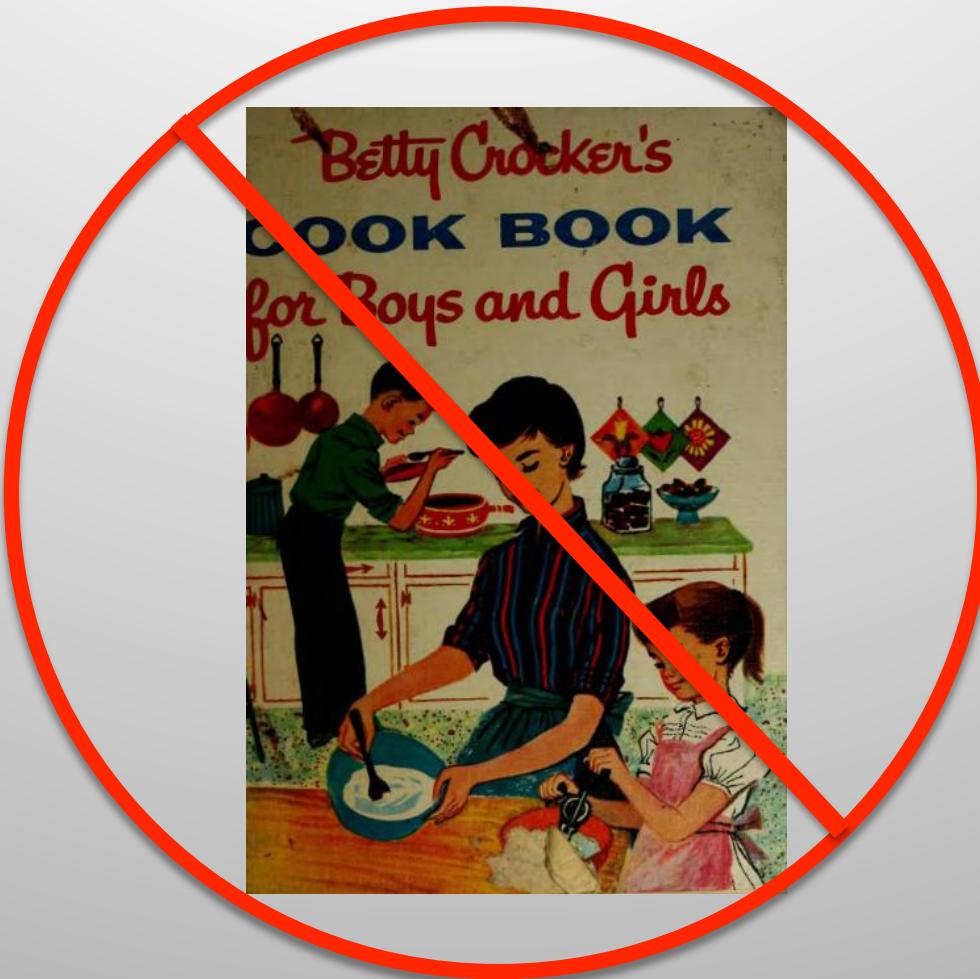


STAT 101 is Procedural

1. Check your data type
2. Select inference method
3. Calculate required sample statistics
4. Look up critical values
- ...
- N. Report result



Real Statistics Isn't



Comprehensive Plan for Reform of All Statistics

- 1) Show the problems with “cookbook statistics”
- 2) Demonstrate real statistical thinking
- 3) Help as needed

Golden Rules of Statistics

(What Statisticians REALLY Do)

- Know thy problem.
- Know thy tools.
- Know thy data.

Know Thy Problem

STAT 101: Determine the appropriate analysis by looking at the data.

E.g. two numeric variables = linear regression

Know Thy Problem

STAT 101: How to determine the appropriate analysis by looking at the data.

E.g. the presence of categorical variables -> use regression

Appropriate data AND appropriate analysis depend on the real world problem.

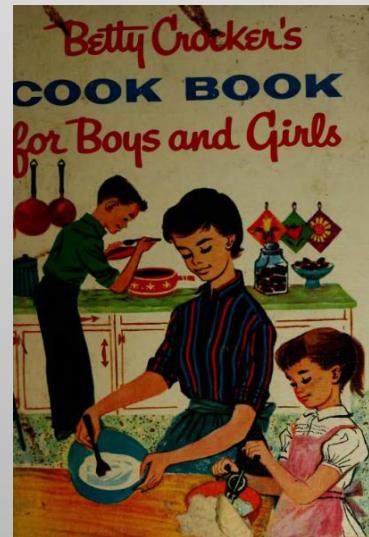
The Million Dollar Binomial Distribution



Know Thy Tools

STAT 101: Statistical methods are selected according to the appropriateness to the data and correctness of assumptions.

STAT 101: Statistical procedures, used correctly, yield unambiguous results.



Know Thy Tools

STAT 101: Statistical methods are selected according to the appropriate context, and the correctness of assumptions.

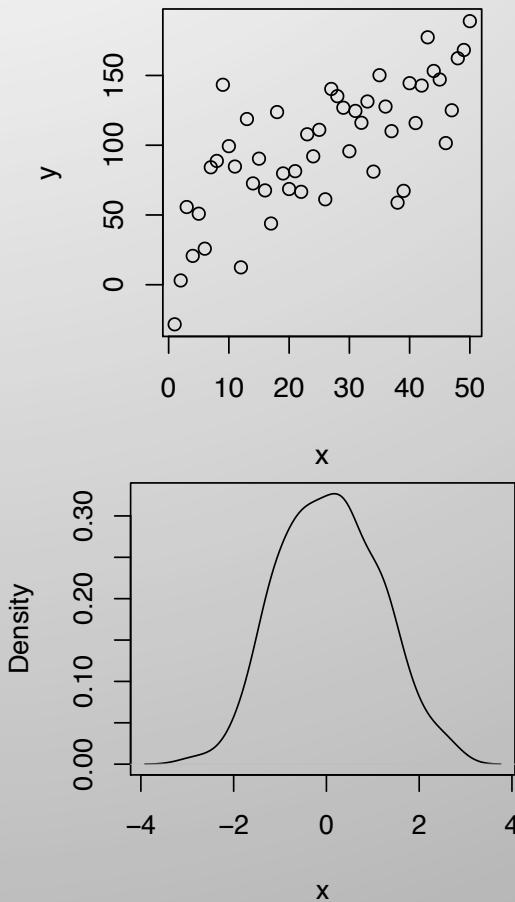
STAT 101: Statistical procedures, used correctly, yield unambiguous results.

Statistical models work the same way that other scientific and engineering models work. Their validity depends on context, and they may be open to interpretation.

Statistical Methods are Based on Models

$$y_i = b_0 + b_1 x_i + \varepsilon_i$$

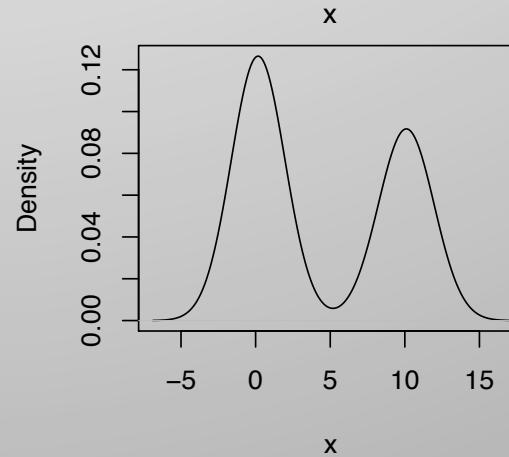
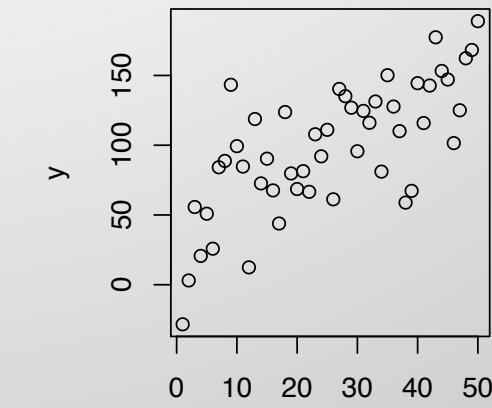
\bar{x}



Statistical Methods are Based on Models

$$y_i = b_0 + b_1 x_i + \varepsilon_i$$

\bar{x}



A Wise Man Once Said...



“Essentially, all models are wrong, but some are useful. ”
– George E. P. Box

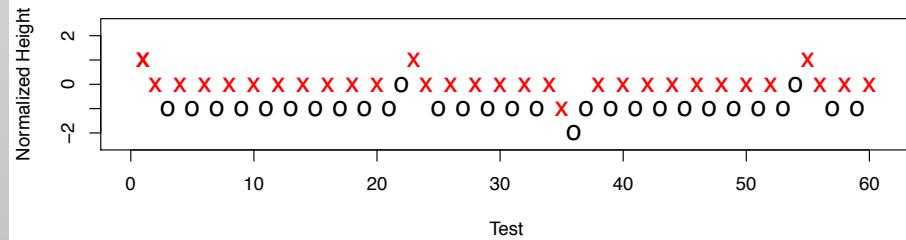
How to Evaluate Explosives Safety

A METHOD FOR OBTAINING AND ANALYZING SENSITIVITY DATA*

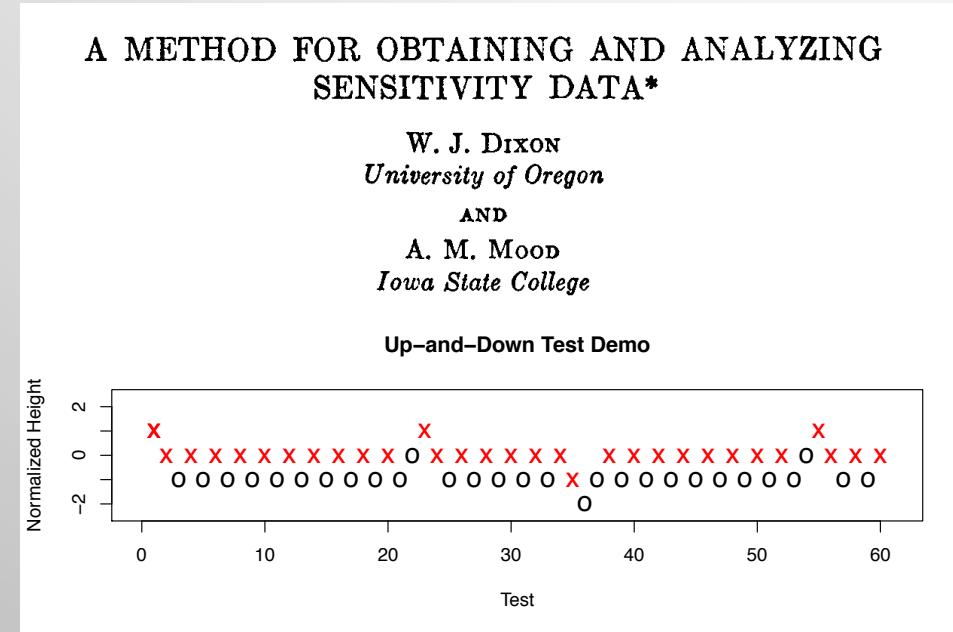
W. J. DIXON
University of Oregon

AND
A. M. MOOD
Iowa State College

Up-and-Down Test Demo



How NOT to Evaluate Explosives Safety



“...the up and down method is particularly effective for estimating the mean. It is not a good method for estimating small or large percentage points (for example, the height at which 99 per cent of specimens explode) unless normality of the distribution is assured.” – Dixon and Mood



A Note on Statistical Significance

(the following statements reflect only the author's opinion, and should not be construed to reflect those of LLNL, the Applied Statistics Group, or any other person, statistician or not, living or dead)

- There isn't anything wrong with p-values
...but $p=0.0501$ is the same as $p=0.0499$
- There isn't anything wrong with statistical hypothesis testing
... but it isn't the right tool for making all decisions.

These procedures aren't broken. They are misused.

This does not mean that you should keep using them.

Know Thy Data

Parametric models are (of course) sensitive to assumptions, but purely data driven approaches are far more robust to “cookbook” approaches.

Know Thy Data

Parameters are (of course) sensitive to assumptions, but even approaches are far from “cookbook” approaches.

There are multiple cautions and caveats when using “big data” approaches. The most important is that you have to start with the right data.

Jackie's Improbable Sister

Jackie is a girl in a family with two children. What is the probability that Jackie has a sister?

- A. 1/2
- B. 1/3
- C. 0 or 1, but we don't know which

Jackie's Improbable Sister

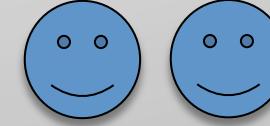
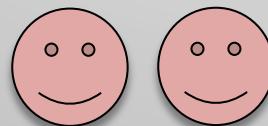
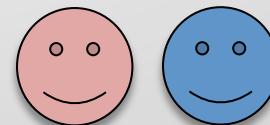
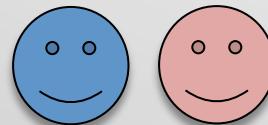
Jackie is a girl in a family with two children. What is the probability that Jackie has a sister?

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How did we find Jackie?

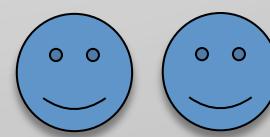
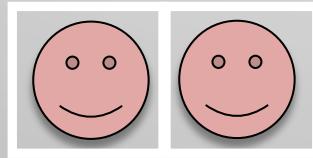
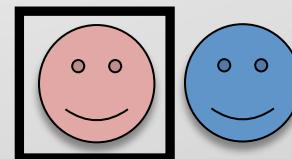
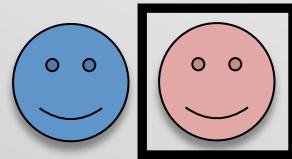
Option A: 1/2

- 1) Pick a two child family at random.
- 2) Pick a child from the family at random.



Option A: 1/2

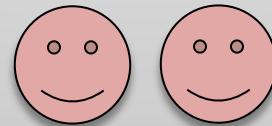
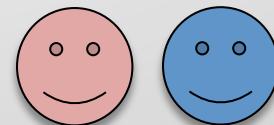
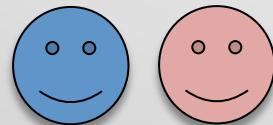
- 1) Pick a two child family at random.
- 2) Pick a child from the family at random.



Two girls have sisters and two girls have brothers.

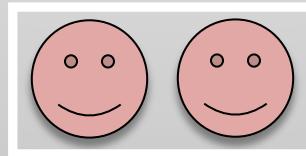
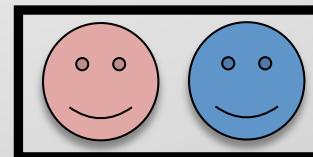
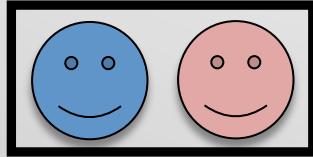
Option B: 1/3

- 1) Pick a two child family with *at least one girl* at random.
- 2) Report one girl's name for each family.



Option B: 1/3

- 1) Pick a two child family with *at least one girl* at random.
- 2) Report one girl's name for each family.



Of three possible families, only one has girls with sisters.

Real (and Expensive) Problem

1948



1954



2013

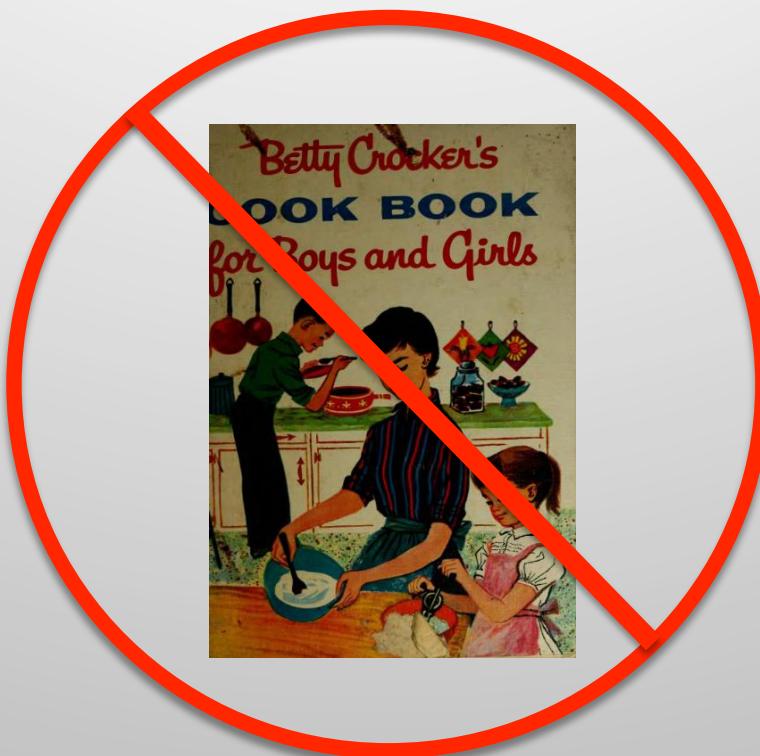
EPIDEMIOLOGY

When Google got flu wrong

US outbreak foxes a leading web-based method for tracking seasonal flu.

To summarize...

Don't:



Do:

- Know thy problem.
- Know thy tools.
- Know thy data.

Do:

- Know thy problem.
- Know thy tools.
- Know thy data.

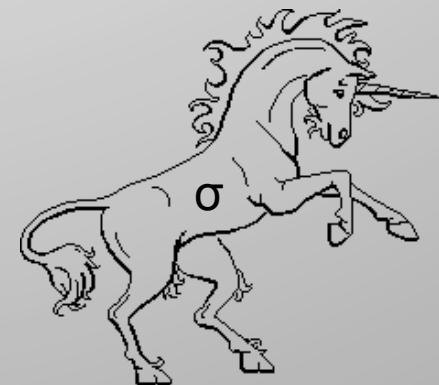
When in doubt:

The LLNL Statistical Consulting Service provides up to 4 hours of assistance *free of charge* for LLNL projects.

stats-consulting@llnl.gov

https://data-analytics.llnl.gov/statistical_consultants

Thank you!





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Image sources:

Wikipedia: Betty Crocker Cookbook, Salk Polio Vaccine

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