The Cult of Statistical Significance

How the Standard Error Costs Us Jobs, Justice, and Lives

By Stephen T. Ziliak and Deirdre N. McCloskey

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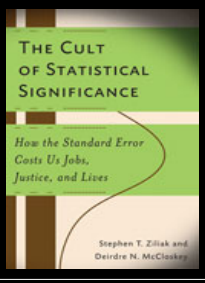
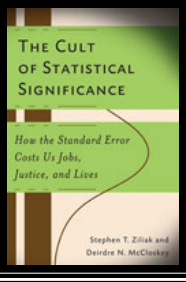
Mindless "Significance Testing" is Costing Us Jobs, Justice, & Lives –



The test of statistical significance is the most important technique in the empirical branches of the life and human sciences, economics to medicine
- and it is broken

The main problem?
80-to-90% of scientists don't "test for" or "estimate" what we want, which is:
Oomph and its odds
(but Oomph, especially)

Examples of Oomphless Science in Economics, Government, & Medicine



Two diet pills, Oomph vs. Precision
which pill for Mom?

Zero black unemployment rates for urban teens
why can't we find them?

The 4,953+ cases of Vioxx
why insist on 19-to-1 odds?

369 articles in the American Economic Review, 1980-1999

The "Significance" Mistake did not begin with "Student" – the inventor of *t*

A chemist by training,
William Sealy Gosset (1876-1937),
aka "Student"
Learned statistics on his own—
To solve inference problems
in the Main & Experimental
divisions of **Guinness's Brewery, Dublin**

"Student" was a Great Experimentalist
(and a business person, too)

He invented or inspired half of modern statistics

He co-invented 3 barley varieties grown (by the 1920s) on 5 million acres, feeding breakfast eaters, beer drinkers, & other wild beasts

And he served at Guinness's as:
Apprentice Brewer (1899-1906),
Head Experimental Brewer (1907-1935),
Head Statistician (c. 1922-35), and Head Brewer (Park Royal & Dublin, 1935-37)

"Student" took an Economic Approach to the Logic of Uncertainty, 1904 to 1937

"Results are only valuable when the amount by which they probably differ from the truth is so small as to be insignificant for the purposes of the experiment.

What the odds should be depends:

1. On the degree of accuracy the experiment allows
2. On the importance of the issues at stake" (W. S. Gosset, 1904)

"The Application of the Law of Error to the Work of the Brewery" (1904)

Gosset's report focused on MALT EXTRACT, measured in degrees saccharine per barrel of 168 lbs. malt

133° saccharine gave the targeted level of alcohol (excise tax was proportionate to alcohol level)

± .5° was an error that beer drinkers and tax payers could swallow

Source: Ziliak, "Guinnessometrics", 2008

"Student" in 1908

"It might be maintained that malt extract should be [estimated] within ± .5° of the true result with a probability of 10 to 1." He calculated extract means from a series of trials produced in the Main and Experimental Breweries.

Given the small samples he calculated the odds of observing the stipulated accuracy:

"Odds in favour of smaller error than .5

2 observations 4:1

3 " " 7:1

4 " " 12:1

5 " " 19:1

82 " " practically infinite"

CONCLUSION n =4 does the trick. Sort of. "How, in general, should one set the odds with small samples?"

"Student" in 1908

Fisher's campaign for a 5% Philosophy of Existence
Fisher's re-formulation of "Student's" test is causing more than headaches

Statistical Methods for Research Workers (1925)

Design of Experiments (1935)

Statistical Methods and Scientific Inference (1955/1956)

Statistical Tables for Bio., Agri., and Medical Res. (with Yates, 1938)

And in scores of articles, letters, and speeches

R.A. Fisher 1925 [1941], *Statistical Methods for Research Workers*, p. 42:

"The value for which P=.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 is to be considered significant or not. Deviations exceeding twice the standard deviation are thus formally regarded as significant."

R.A. Fisher 1926, "Arrangement of Field Experiments," p. 504

"Personally, the writer prefers to set a low standard of significance at the 5 per cent point, and *ignore entirely all results which fail to reach this level*."

R.A. Fisher 1935 [1960], *The Design of Experiments*, p. 13:

"It is usual and convenient for experimenters to take 5 per cent. as a standard level of significance, in the sense that they are prepared to *ignore all results which fail to reach this standard*, and, by this means, *to eliminate from further discussion* the greater part of the fluctuations which chance causes have introduced into their experimental results."

R.A. Fisher 1955, "Statistical Methods and Scientific Induction," p. 75

"Finally, in inductive inference we introduce no cost functions for faulty judgments . . .In fact, scientific research is not geared to maximize the profits of any particular organization . . .*We make no attempt to evaluate these consequences, and do not assume that they are capable of evaluation in any currency."*

Compare "Student's" "*Original question and its modified form*" (1905)

"When I first reported on the subject [of "The Application of the 'Law of Error' to the Work of the Brewery"], I thought that perhaps there might be some degree of probability which is conventionally treated as sufficient in such work as ours and I advised that some outside authority in mathematics [such as Karl Pearson] should be consulted as to what certainty is required to aim at in large scale work. However it would appear that in such work as ours the degree of certainty to be aimed at must depend on the *pecuniary advantage to be gained by following the result of the experiment, compared with the increased cost of the new method, if any, and the cost of each experiment.* This is one of the points on which I should like advice."

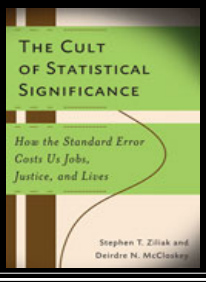
Source: W. S. Gosset to Karl Pearson, c. April 1905, in E. S. Pearson 1939, pp. 215-216; first italics in original

"Student" - as Head Brewer of Guinness – did not find "significance" to be profitable

"[O]bviously the important thing . . . is to have a low real error [said "Student" to Egon Pearson], not to have a "significant" result at a particular station. The latter ["Student" said] seems to me to be nearly valueless in itself. . . . Experiments at a single station [that is, tests of statistical significance on a single set of data] *are* almost valueless. . . . What you really want is a low real error. You want to be able to say not only "We have significant evidence that if farmers in general do this they will make money by it", but also "we have found it so in nineteen cases out of twenty and we are finding out why it doesn't work in the twentieth." To do that you have to be as sure as possible which is the 20th—your real error must be small."

Source: "Student" to E. S. Pearson 1937, in Pearson 1939, p. 244.
(Egon was the editor of *Biometrika*, in the era before David Cox)

If we stop doing 5% philosophy, what will we do?

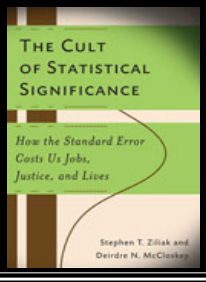


***Ask* to see the Oomph, loss function, and power** of a scientific model, variate or stimulus package

***Demand* to know the expected value** of a cancer treatment or diet pill, subject to "real error"

***Listen* to a Guinness brewer** & don't settle for small beer – **go for substantive significance –** not mere statistical significance!

And, of course, write more Haiku



Statistical fit:
epistemological
strangling, of *wit*!

Little *p*-value
What are you trying to say
of significance?

Copyright and References

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The contents of these slides—including the Gosset and Fisher quotes—are from S.T. Ziliak's and D.N. McCloskey's *The Cult of Statistical Significance: How the Standard Error Costs Us Jobs, Justice, and Lives (2008, University of Michigan Press) and from Ziliak's "Guinnessometrics: The Economic Foundation of 'Student's' t," Journal of Economic Perspectives (Fall 2008).*