Remembering Sir David Cox

Nancy Reid August 8 2022





SIGNIFICANCE

April 2022 volume 19 issue

In a sense, the only thing that matters is if you can look back when you reach a vast, vast, vast age and say, "Have I done something reasonably in accord with my capability?" If you can say yes, okay. My feeling is in one sense, I've done that...

Sir David Cox, statistician 15 July 1924 – 18 January 2022 A 12-page tribute

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ASAL AND

"In another sense I feel very dissatisfied: there are all sorts of problems that I nearly solved ... "

Statistical Theory and Foundations

- 1958. Some problems connected with statistical inference.
- 1967. Fieller's problem and a generalization.
- 1971. The choice between alternative ancillary statistics.
- 1977. The role of significance tests.
- 1978. Foundations of statistical inference: the case for eclecticism.
- 1980. Local ancillarity.
- 1981. Theory and general principle in statistics.
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- 1990. Role of models in statistical analysis.
- 1994. A note on the quadratic binary exponential distribution.
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- 1997. The nature of statistical inference.
- 2000. Likelihood-based inference with a singular information matrix
- 2006. Frequentist statistics as a theory of inductive inference.

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Theoretical Statistics D.R. Cox and D.V. Hinkley





$$X \sim N(\mu, 1000)$$

 $\mathbf{Y}\sim \mathbf{N}(\mu,\mathbf{1})$

$$Z = \begin{cases} X, \text{ w. p. } 1/2 \\ Y, \text{ w. p. } 1/2 \end{cases}$$





$$X \sim N(\mu, 1000) \qquad \qquad Y \sim N(\mu, 1) \qquad \qquad Z = \begin{cases} X, \text{ w. p. } 1/2 \\ Y, \text{ w. p. } 1/2 \end{cases}$$

choose a machine w.p. 1/2, take a single measurement Z = z

choice is known

(V up ala

 $\left(X \right) = a/a$





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choose a machine w.p. 1/2, take a single measurement Z = z choice is known what variance should be attached to the estimate $\hat{\mu} = z$? 1? 1000? (1/2) + 500? conditional variance clearly the correct choice what is the critical region for testing $H : \mu = 0$? either $z > q_{\alpha}$ or $z > q_{\alpha} \sqrt{1000}$

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the test that averages over the distribution of Z is more powerful unconditionally JSM August 2022 equivalently the unconditional confidence interval will be shorter on average

SOME PROBLEMS CONNECTED WITH STATISTICAL INFERENCE

By D. R. Cox

Birkbeck College, University of London¹

1. Introduction. This paper is based on an invited address given to a joint meeting of the Institute of Mathematical Statistics and the Biometric Society at Princeton, N. J., 20th April, 1956. It consists of some general comments, few of them new, about statistical inference.

Since the address was given publications by Fisher [11], [12], [13], have produced a spirited discussion [7], [21], [24], [31] on the general nature of statistical methods. I have not attempted to revise the paper so as to comment point by point on the specific issues raised in this controversy, although I have, of course, checked that the literature of the controversy does not lead me to change the opinions expressed in the final form of the paper. Parts of the paper are controversial; these are not put forward in any dogmatic spirit.

2. Inferences and decisions. A statistical inference will be defined for the

Cox 1958

- statistical inference vs. scientific inference
- statistical inference vs. decision theory
- "prior information that is not statistical cannot be included without abandoning the frequency theory of probability" Cox & Mayo, 2006

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- weighing-machine example designed to illustrate that "[the sample space] should be taken to consist, so far as is possible, of observations similar to the observed set"
- example is deliberately very stylized

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- "prior information that is not statistical cannot be included without abandoning the frequency theory of probability" Cox & Mayo, 2006
- weighing-machine example designed to illustrate that "[the sample space] should be taken to consist, so far as is possible, of observations similar to the observed set"
- example is deliberately very stylized
- linear regression $y = X\beta + \epsilon$

"fixed-X" vs "model-X", e.g. knock-offs

nonparametric or robust regression

de-biased Lasso

+ 2 \times 2 tables and their generalizations; Box-Cox transformations in regression; ...

- extensive discussion of Fisher's fiducial argument
- proposes the notion of a confidence distribution Xie & Singh, 2013; Schweder & Hjort, 2016
- "Statements made on the basis of this distribution, provided we are careful about their form, have a direct frequency distribution"

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Cox 1958

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JSM August 2022

- significance tests as distinct from hypothesis testing
- *p*-value as a measure of consistency with the null hypothesis

Cox 1958

• significance tests as distinct from hypothesis testing

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• *p*-value as a measure of consistency with the null hypothesis



This paper motivates the call for the end of significance. A 25% mortality reduction, but because P=0.06 (two-sided), they declare it 'did not reduce' mortality. Appalling, jamanetwork.com/journals/jama/...

significance tests as distinct from hypothesis testing

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AMERICAN STATISTICAL ASSOCIATION RELEASES STATEMENT ON STATISTICAL SIGNIFICANCE AND *P*-VALUES

Provides Principles to Improve the Conduct and Interpretation of Quantitative Science March 7, 2016

- significance tests as distinct from hypothesis testing
- *p*-value as a measure of consistency with the null hypothesis



David Spiegelhalter @d spiegel

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COMMENT



by Deborah Mayo

7



Figure 1: A photo of David Firth's bookshelf, featuring a selection of David Cox's many books.

Significance V19 #2

Hand & Herzberg (eds.) (2006). Selected Statistical Papers of Sir David Cox

Design of Investigations (10) Statistical Methods (25) Applications (6)

Foundations of Statistical Inference (8) Theoretical Statistics (22) Time Series and Stochastic Processes (15)



D. R. COX CHRISTLA. DONNELLY Principles of Applied Statistics

CAMPRING





- arose from a collaboration with medical researchers studying cystic fibrosis
- standard errors provided by conventional models were too small
- "essentially because of strong explicit or implicit assumptions of at most weak dependence"
- impact of long-range dependence on estimation of the variance of the mean, and of a regression coefficient five pages, three references ISM August 2022

J. R. Statist. Soc. B (2004) 66, Part 2, pp. 395-400

A simple procedure for the selection of significant effects

D. R. Cox

Nuffield College, Oxford, UK

and Man Yu Wong

Hong Kong University of Science and Technology, People's Republic of China

[Received August 2003. Final revision December 2003]

Summary. Given a large number of test statistics, a small proportion of which represent departures from the relevant null hypothesis, a simple rule is given for choosing those statistics that are indicative of departure. It is based on fitting by moments a mixture model to the set of test statistics and then deriving an estimated likelihood ratio. Simulation suggests that the procedure has good properties when the departure from an overall null hypothesis is not too small.

Keywords: Bayes factor; Discrimination; Empirical Bayes; False discovery rate; Mixture of distributions; Multiple testing

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A simple procedure for the selection of significant effects

simplest possible parametric formulation

D. R. Cox

Nuffield College, Oxford, UK

and Man Yu Wong

likelihood ratio interpreted as a Bayes factor

Hong Kong University of Science and Technology, People's Republic of China

[Received August 2003. Final revision December 2003]

Summary. Given a large number of test statistics, a small proportion of which represent departures from the relevant null hypothesis, a simple rule is given for choosing those statistics that are indicative of departure. It is based on fitting by moments a mixture model to the set of test statistics and then deriving an estimated likelihood ratio. Simulation suggests that the procedure has good properties when the departure from an overall null hypothesis is not too small.

Keywords: Bayes factor; Discrimination; Empirical Bayes; False discovery rate; Mixture of distributions; Multiple testing

two-paragraph discussion of the need for multiple testing

likelihood analysis.

six pages, three references

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