Confounding and Cornfield: Back to the Future

Milo Schield, US
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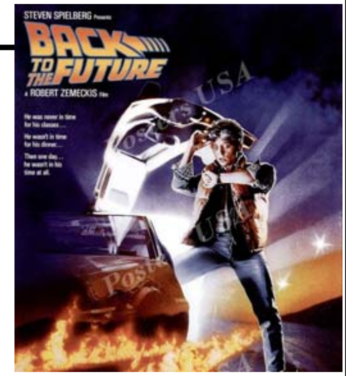
US Rep: International Statistical Literacy Project

2018
ICOTS-10 Kyoto, Japan

www.StatLit.org/pdf/2018-Schield-ICOTS-Slides.pdf
www.StatLit.org/pdf/2018-Schield-ICOTS.pdf
www.StatLit.org/pdf/2018-Schield-ICOTS1.pdf

Back to the Future: The Movie

Teenager Marty McFly travels **back** in time.



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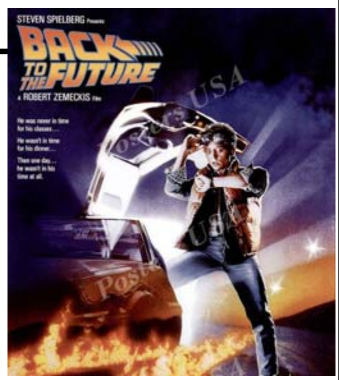
Statistical educators need to go back to the past to change the future.



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- More colleges offering statistics majors/minors.

Bad news: Satisfaction is down:

- Most students see **less value** in statistics **after** they take the course **than** they did **before**
- AP students don't take more stats

WHY???

#1 Teacher-Student Math Aptitude Gap

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551	61	Biological Sc.	482	38	Education
Business Insider (2014)			College Board (2015)		

#2: Student-Teacher Interest-Gap

	%	Major
Most students 80%	38%	Business or Economics
	19%	Social Science or History
	13%	Health
	10%	Psychology
Most teachers 20%	9%	Engineering
	9%	Biological Science
	2%	Math or Statistics
	100%	All students in these majors

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Most important statistics book: Teacher's Choice

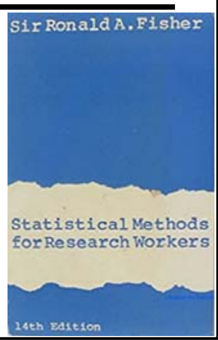
Fisher (1925)
Descriptive statistics

Sampling: Binomial distribution, sampling distribution & error.

Inference: hypothesis tests, statistical significance, p-values

Causation: random assignment

* Confidence Intervals



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"Teaching the wrong things" What's missing?

No [coherent] focus on any of the following:

- multi-variate thinking (modelling)
- studies: observational vs. quasi-experiments
- confounding [as a causal concept]
- causal statistics in observational studies

But these are the topics most of our students need.

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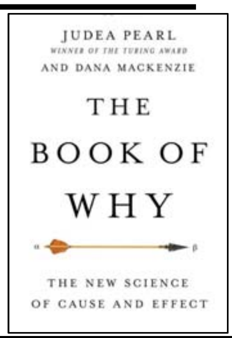

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To change our future, we must revisit our past

Our past: our triumphs and our failures.

What are the three biggest contributions of statistics to human knowledge?

What are the three biggest deficiencies of statistical educators in teaching intro statistics?

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Back to the Future: Three Biggest Contributions:

What are the three biggest contributions of statistics to human knowledge???

1. Association is not causation
2. Standard error in random sampling
3. Random assignment: controls for confounding

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Back to the Future: Three Biggest Deficiencies

What are three biggest deficiencies by statistical educators in teaching introductory statistics?
All three involve multivariate data.

1. Failure to focus on observational studies.
2. Failure to show that controlling for a confounder can change statistical significance.
3. Failure to connect effect size to confounder resistance. E.g., Smoking and lung cancer.

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Misuse of Confounding

We used confounding to show that "association is not causation." We then spend an entire semester on randomness (never mentioning confounding again). This is "Bait and Switch".

"Bait and switch" is unethical!
"Bait and switch" is professional negligence!

This is one reason why most students see less value in 'statistics' after taking the course than before.

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Intro statistics is silent on confounding

Most introductory statistics textbooks DO NOT list "confounding" in their index. Schield (2018)

Confounding was not listed in McKenzie's (2004) list of the top 30 intro-statistics topics

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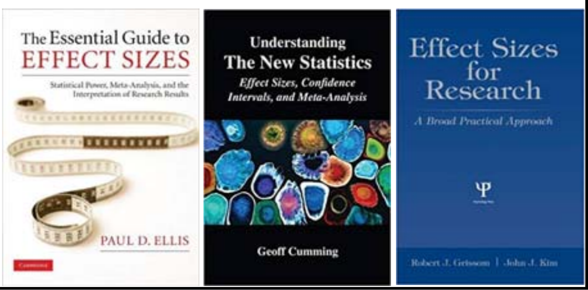
Books on Effect Sizes: Silent on Confounding

Why are we interested in effect sizes?



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Intro statistics is select on confounding

When confounding is mentioned, it is often in a very limited or specialized context.

- Wikipedia: under Design of experiments.

In 2016, SERJ published a special issue on Statistical Literacy. Of the 18 articles, only three mentioned confounding or lurking variable.

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Statistical Literacy and Confounding

Statistical literacy: the discipline that studies:
* all the influences on a statistic.

In observational studies, confounding is arguably a most common – a most important – influence.

The statistical literacy "debate" is ultimately between the 'pro' and the 'anti' confounders.

Schield is – and has always been – pro-confounder. See Schield (1998) for "confounding factors".

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Confounding Almost Absent in GAISE 2005

K-12 report: The first line: "The ultimate goal: statistical literacy". Confounding is mentioned twice: once to define and once to note it may create patterns that are not a "reliable basis for statistical inference".

College report: Confounding is mentioned only once. It is not defined; it appears in a sample problem in a list of words that may apply in analyzing data from an observational study.

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Confounding mentioned in GAISE 2016 Update

Plus: Confounding shown 20 times (big increase):

- Twice up front:
- Goal 9: Ethics: "with large data sets, … under-standing confounding … even more relevant." p 11
- Recommendation: Multivariable thinking. Examples "show how confounding plays an important role…" p.15
- Appendix B (9 times) 34, 38 (3), 40 (2), 41(3)
- Footnotes (7 times) 105; 113, 120, 122 (4).

Minus: Not in any one-line recommendations/goals

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Silence on Smoking and Lung Cancer

Extremely important observational studies.
Question: Is smoking a cause of cancer?
MINUS:

- Not in most statistics textbooks.
- Not mentioned in GAISE 2005 College.

PLUS:

- Discussed in detail in GAISE 2004 K-12.
  But *confounding* was never used in the discussion

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Why are we silent on confounding?

1. Confounding is not an issue in predicting.
2. There is no test for confounding. Judea Pearl
3. Using association as evidence for causation is a matter for subject-matter experts. Statisticians have no professional opinion on the subject.
4. Discussing confounding would bring disrepute on our discipline.

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How can we change the present?

We need to go back to the past.

We need to revisit the Fisher-Cornfield dialogue on whether smoking caused lung cancer.

We need to revisit Cornfield's conditions for a confounder to nullify or reverse an association.

We need to see how to change statistical education to include Cornfield's criteria for confounding.

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Back to the Future: Here we Go!

Back to 1958.

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Back to the Future: Jerome Cornfield: 1912-1979

Jerome Cornfield got his BA and MA in history.
He studied statistics at the US Dept of Agriculture.

He worked for USDA on sampling and study design

He created two common statistical measures:
Relative risk (RR) and the Odds Ratio (OR).

He carefully compared prospective (cohort) and retrospective (case control) studies.

He was President of the ASA in 1974.

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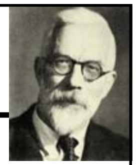
Does Smoking "Cause" Cancer?



Jerome Cornfield:
YES!
Strong evidence.

Ronald Fisher
NO!
Weak evidence

Fisher (a smoker) gave two arguments:
1. Association not causation (observational studies)
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Back to the Future: Cornfield Conditions

Cornfield

- knew there was no statistical test for confounding.
- derived necessary conditions for a confounder to nullify (or reverse) an observed association.

Fisher's twinship data had a relative risk (RR) of 3.

Fisher's RR was inadequate to nullify Cornfield's RR of 10. Fisher never replied.

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Back to the Future: Cornfield

Statisticians subdued in talking about Cornfield.

Cornfield is …

1. not listed in the RSS statistical timeline.
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3. not listed in Stigler's 2013 list of twenty ASA members who have strongly influenced the development of statistics.

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Back to the Future: Cornfield Conditions

Statisticians are silent on the Cornfield conditions.

Nothing on the Cornfield conditions

1. in the Wikipedia entry for Jerome Cornfield.
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Why are We Silent on Confounding?

Because we don't know Cornfield's conditions!

#3: Cornfield conditions: Minimum confounder size needed to nullify an observed association.

Impact: Allowed statisticians to say that "Smoking causes cancer" using data from an observational study.

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Summary Need Cornfield Conditions

With Cornfield conditions, we can

1. Show that the larger the effect size, the more resistance an association has to causation. (Schield and Burnham, 1998)
2. Show how to use Cornfield's conditions as necessary conditions. Schield (2012).
3. Show how to work problems controlling for a binary confounder. Schield ().

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Can we talk about Confounder Significance?

Confounders have no single analytical distribution. There is no way to say that a given effect size will resist X% of all relevant confounders.

But we can postulate a standard (S) distribution of confounders: say an exponential distribution of relative risks with a mean of 2 (median of 1.7).

RR=4 will resist 95% of these S-confounders. RR=1.5 resists less than half.

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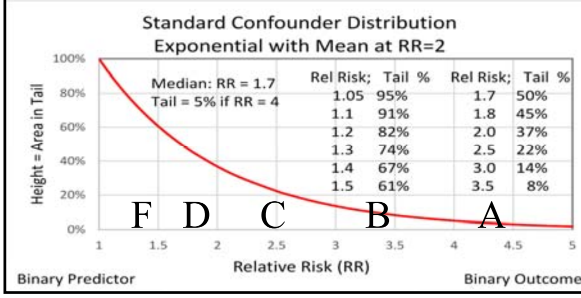
Confounder Distriution: A Proposed Standard

Arbitrary, but simple and fits existing data.



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Conclusion

Statistical education is at a fork in the road. Which path will we take? Will we stay steadfast in our allegiance to Fisher? Or will we include confounding and Cornfield? Our choice will determine the statistics that most college graduates study in decades to come.

By featuring confounding in introductory statistics we can change our destiny. Instead of being “the worst course I took”, most students will agree that “statistical literacy should be taken by all college students.”

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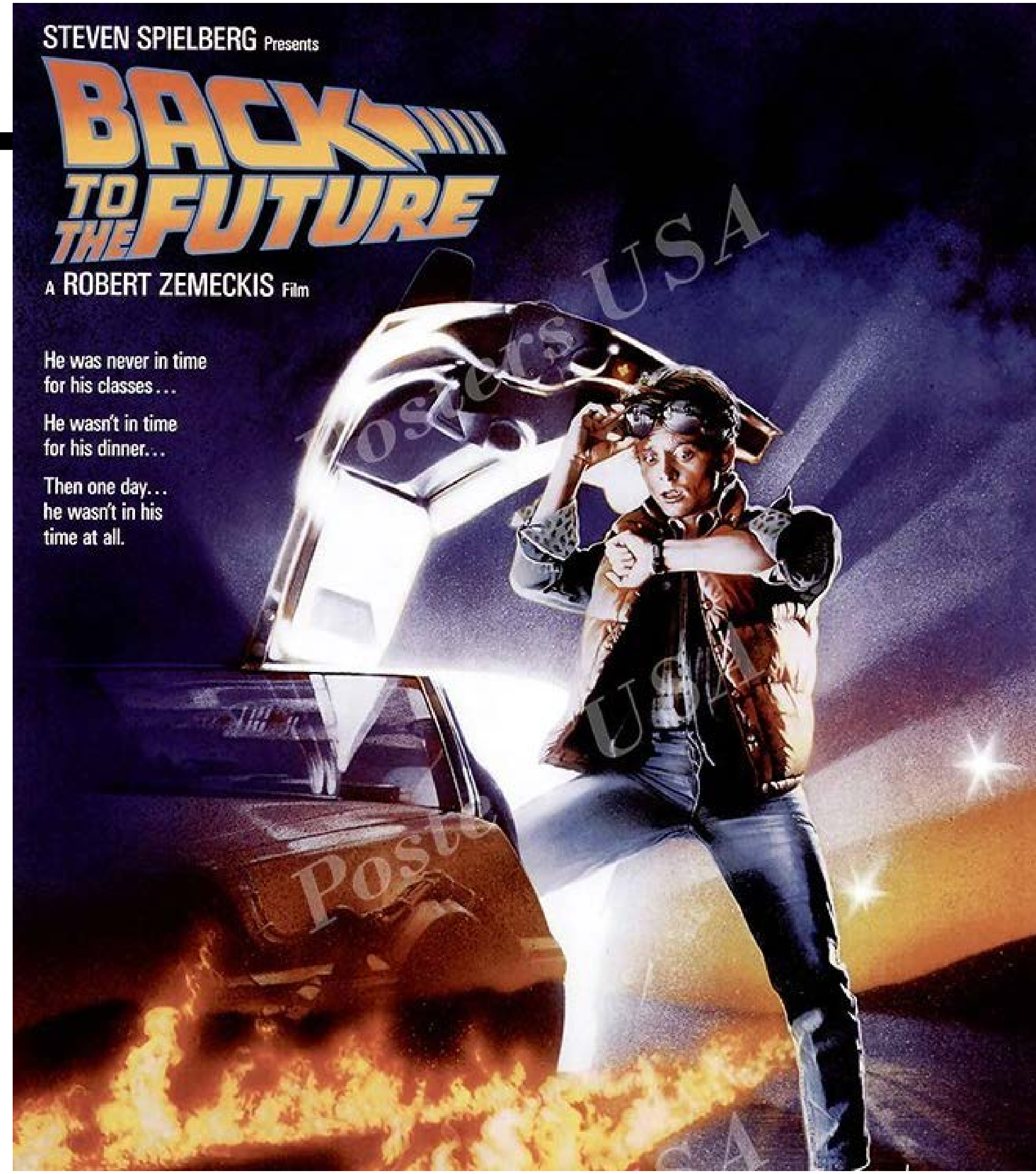

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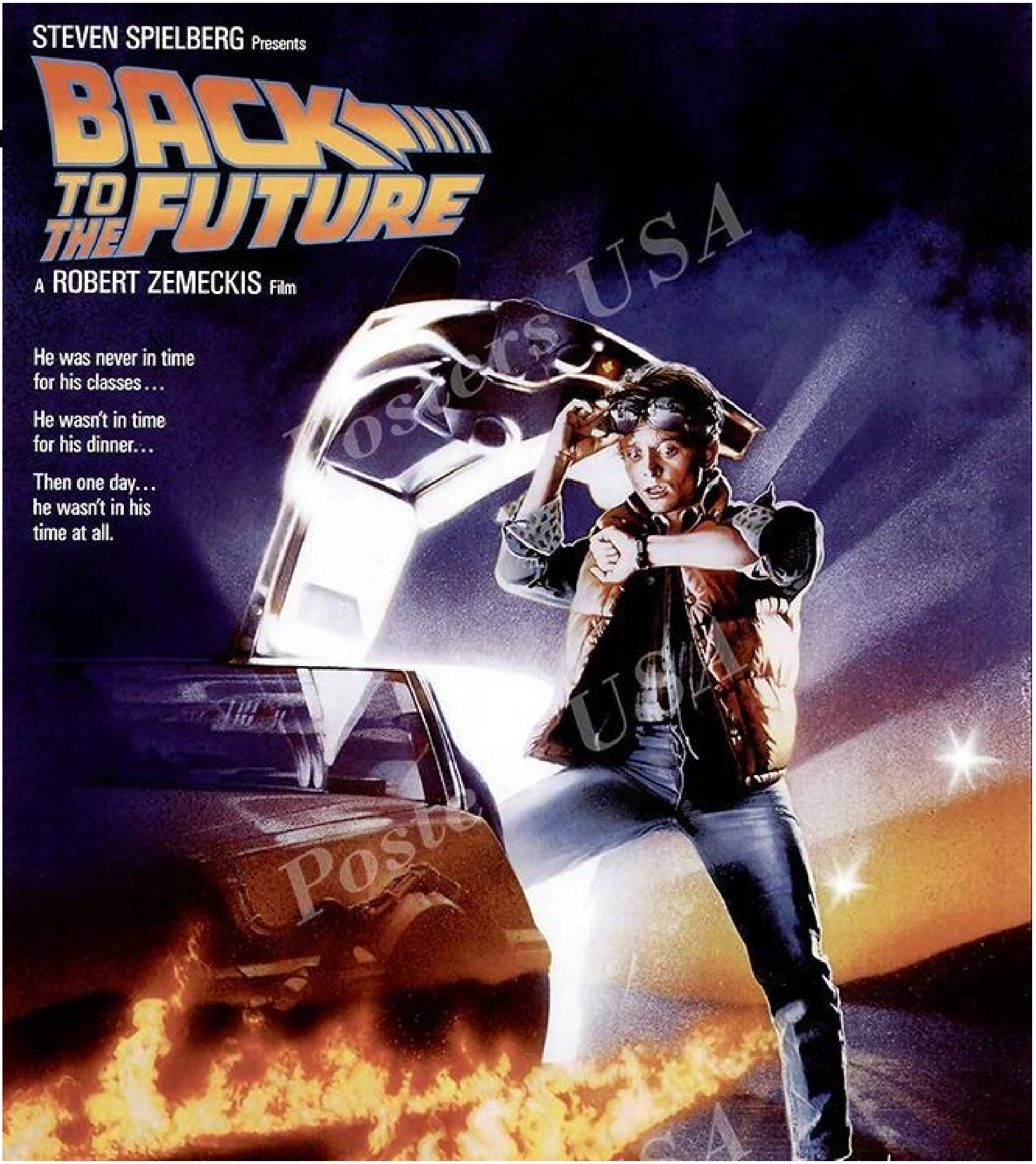

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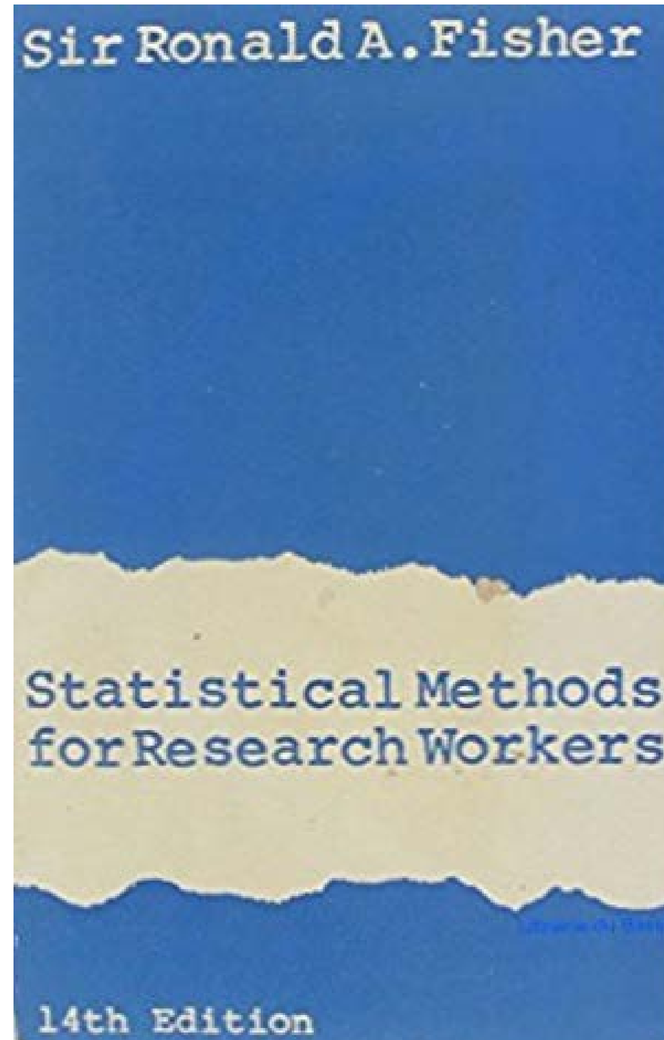

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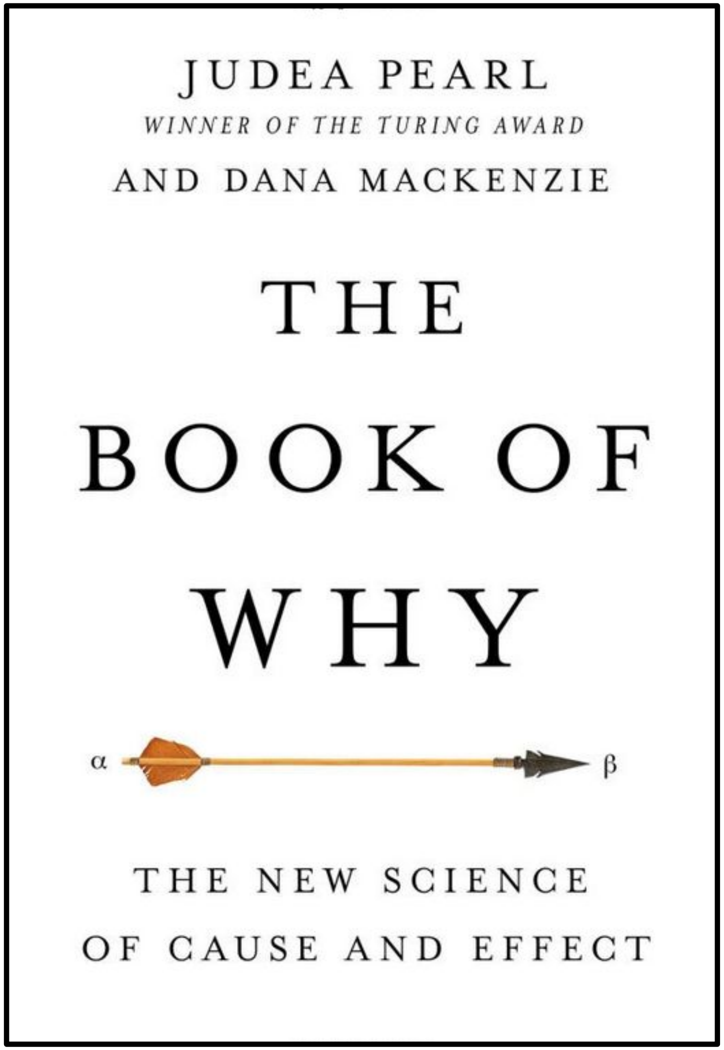

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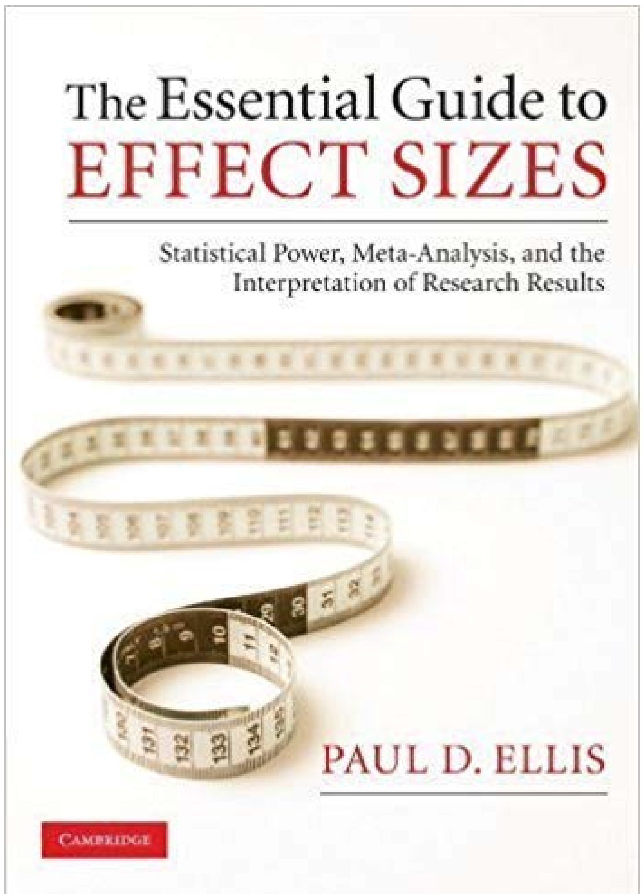

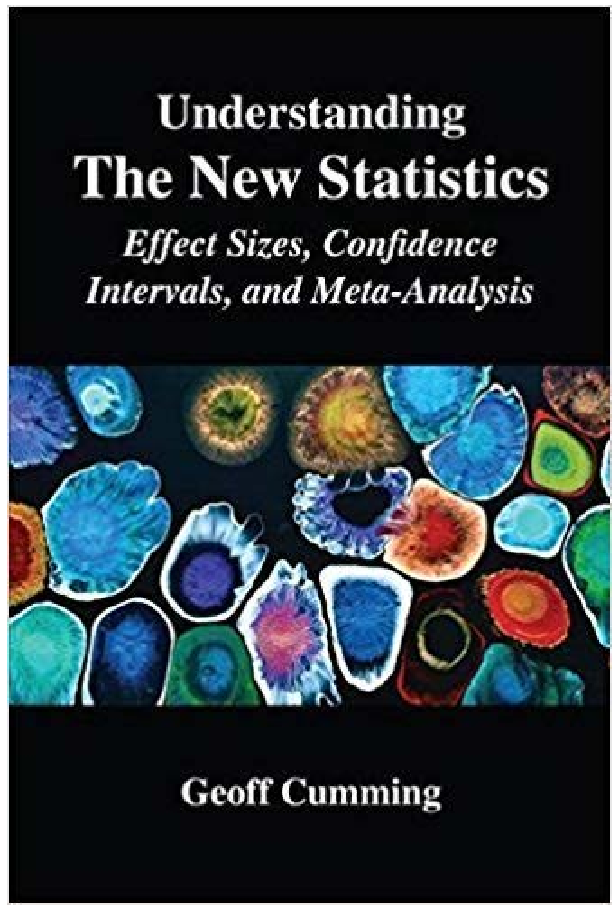

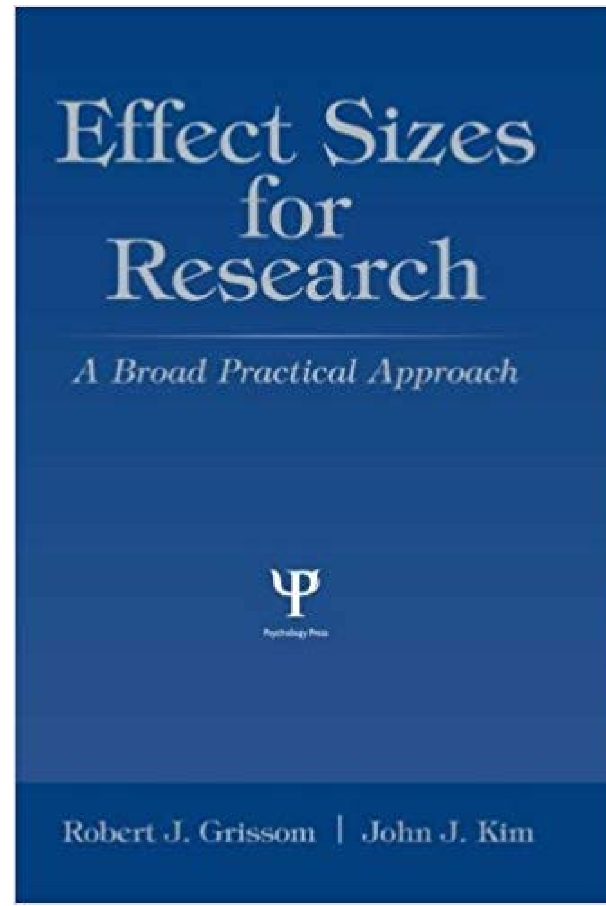

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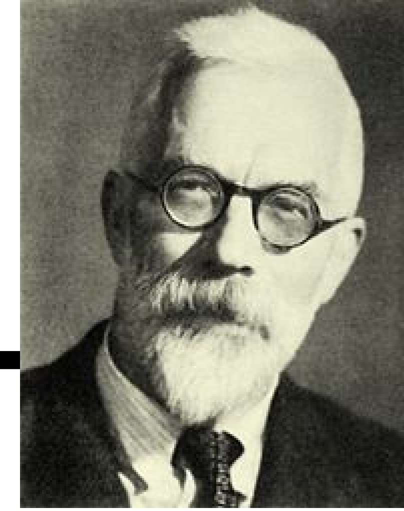

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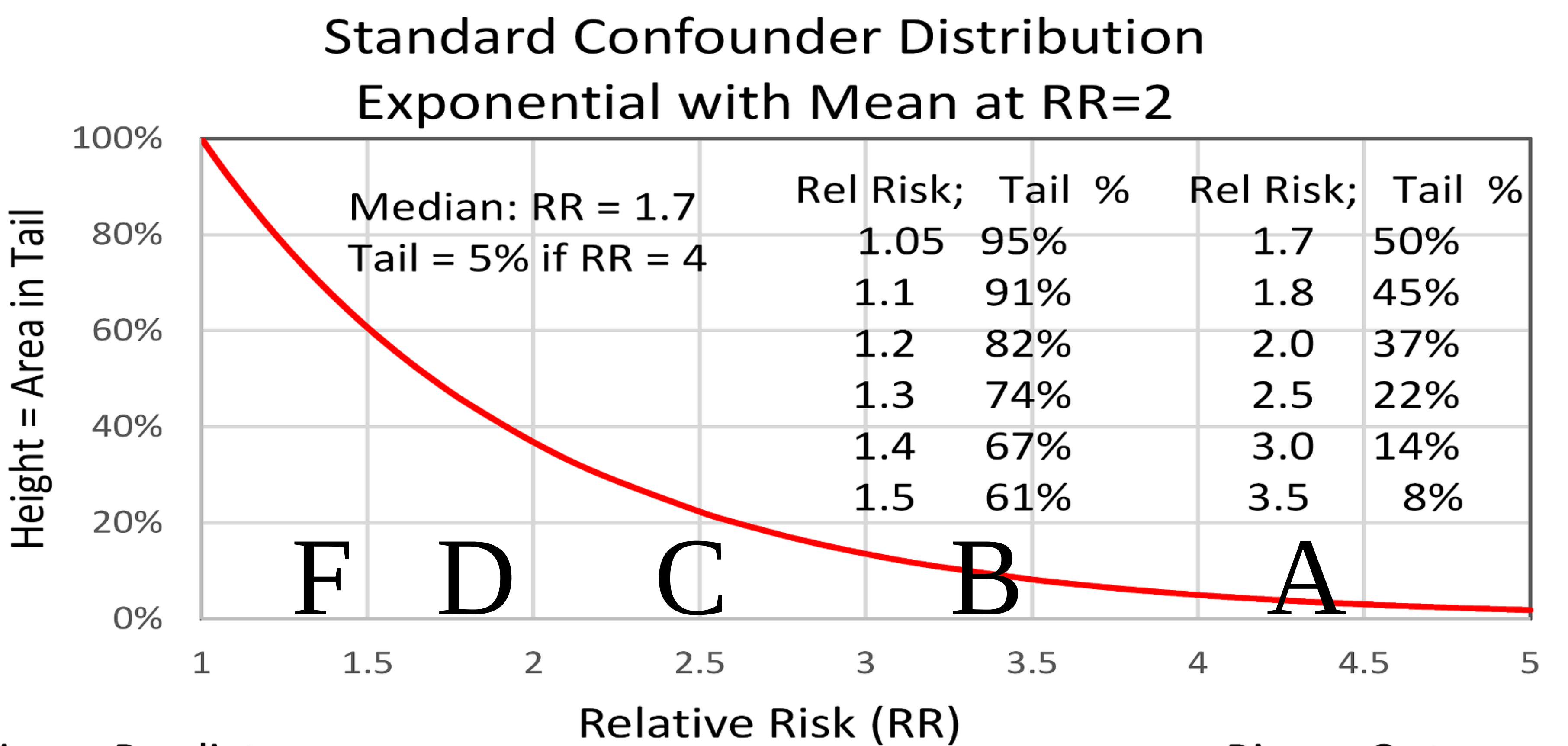

Binary Predictor

Binary Outcome

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