Basic statistics for causal inference: visual and historical illustrations from the social, health, and life sciences

Teaching scientific literacy with a class on social science data analysis: a prologue for instructors.....Error! Bookmark not defined.

How the purpose of such a class aligns with the goals of STEM education Error! Bookmark not defined.

The substance of the class: an outline ..... Error! Bookmark not defined.

The importance of learning to create and critique causal claims from observational data: COVID-19 epidemiology as an illustration..... Error! Bookmark not defined.

The weakness of social science as the strength: the substance of a social science scientific literacy class.. Error! Bookmark not defined.

Other advantages of offering a social science statistics class, as part of the science curriculum ..... Error! Bookmark not defined.

The students can generate their own hypotheses..... Error! Bookmark not defined.

Making arguments and defending them..... Error! Bookmark not defined.

Using one's imagination..... Error! Bookmark not defined.

Learning about the role of ethics in science. ..... Error! Bookmark not defined.

Diversifying STEM education ..... Error! Bookmark not defined.

Our STEM deficit: we need more students to major (and stay) in STEM fields ..... Error! Bookmark not defined.

A caveat: not all social science statistics courses work for the science curriculum Error! Bookmark not defined.

Conclusion..... Error! Bookmark not defined.

How (and why) this book is different from other statistics books: a prologue for students .....Error! Bookmark not defined.

How this book differs from other statistics textbooks: more logic, less math... Error! Bookmark not defined.

This book serves as a guide to navigating causality in everyday life ..... Error! Bookmark not defined.

An historical guide to logical and inferential mistakes of even the smartest scientists ..... Error! Bookmark not defined.

Causal inference is necessary for progress and the reduction of human suffering..... Error! Bookmark not defined.

Chapter 1. A short overview of the history of philosophy: the ethical justification for turning our focus from ethics to causality.....Error! Bookmark not defined.

Socrates, Plato, and Aristotle: justice, virtue, and the good life... Error! Bookmark not defined.

Cicero, Augustine, and Aquinas: an example of a dialogue on the relative value of human liberty ..... Error! Bookmark not defined.

Hobbes and Machiavelli: the abandonment of virtue ethics (and the reaction)Error! Bookmark not defined.

Contemporary science and philosophy..... Error! Bookmark not defined.

Chapter 2. On the nature of statistical correlation: an introduction to the history of causality .....Error! Bookmark not defined.

A short history of causality: distinguishing "scientific" fact from causal inference ..... Error! Bookmark not defined.
The ancients and epistemology ..... Error! Bookmark not defined.
Intersubjectivity and falsifiability: Hume and Popper ..... Error! Bookmark not defined.
Kuhn and the fallible nature of science: the fight against overconfidence (or false positives) ... Error! Bookmark not defined.
Pearson and Fisher versus Wright and Pearl: managing the problem of under confidence (or false negatives) ..... Error! Bookmark not defined.
The epidemiology of AIDS: Managing overconfidence, Part I ..... Error! Bookmark not defined.
The epidemiology of COVID-19 as an airborne infection: Managing overconfidence, Part II ..... Error! Bookmark not defined.
There is no such thing as a "scientific fact," or managing under confidence .... Error! Bookmark not defined.
Science is a way of knowing, not a body of facts ..... Error! Bookmark not defined.
"When you say 'Science is Right,' You're Wrong": a note of warning from Naomi Oreskes Error! Bookmark not defined.
Summary of the history of philosophy and science (not the history of humanity) ..... Error! Bookmark not defined.

Chapter 3. On non-scientific inferences: why "non-scientific" does not mean "less valuable" ..... Error! Bookmark not defined.

The following are the introductory comments on the quiz..... Error! Bookmark not defined.

No category, (X): Declarations do not fit into the above: "I am mad and will not take it anymore" is a declaration. Interpretations of events: "Trump's election means that the U.S. is no longer the example of freedom in the world." Causal processes are also not in a category. ..... Error! Bookmark not defined.

People often talk about facts versus opinions. Normative, causal and interpretation statements are opinions; they are arguments. Facts are not better than opinions. Opinions can be dumb and still fit into their particular category. For example, "Nicholas Cage movie appearances causes deaths by drowning" is a dumb argument. But it is still causal. And those things are related, believe it or not: ..... Error! Bookmark not defined.

Some more study guides ..... Error! Bookmark not defined.
Causal versus normative ..... Error! Bookmark not defined.
Interpretation ..... Error! Bookmark not defined.
What to say about statements that interpret events as semantic expressions: e.g. "Parties are declining in importance." ..... Error! Bookmark not defined.
What to say about arguments that you do not intend to make ..... Error! Bookmark not defined.
When seeming logical fallacies are actually not: because they do what the author says they intend to do Error! Bookmark not defined.
Ethics and first principles ..... Error! Bookmark not defined.
Text interpretation ..... Error! Bookmark not defined.
Descriptive inference ..... Error! Bookmark not defined.
The less common logical fallacies ..... Error! Bookmark not defined.
The importance of all kinds of non-scientific inferences for (even scientific) progress ..... Error! Bookmark not defined.

Chapter 4. Overview of book and introduction to visual aids ..... Error! Bookmark not defined.

Statistical descriptive inferences ..... Error! Bookmark not defined.
Studying what matters: ethics, nonobviousness, and complexity Error! Bookmark not defined.
Causal theory and directed acyclical graphs ..... Error! Bookmark not defined.
Causal theory, statistical variation, and Venn Diagrams..... Error! Bookmark not defined.

Part II. The backbones of scientific inquiry: units and concepts..... Error! Bookmark not defined.

Chapter 5. Concepts: variables in theory ..... Error! Bookmark not defined.

Understanding conceptualization ..... Error! Bookmark not defined.
Temperature: when a variable is the concept ..... Error! Bookmark not defined.
Continuous and "interval level" variables ..... Error! Bookmark not defined.
Whether a variable is interval level depends on its use..... Error! Bookmark not defined.
Ordinal measurement: "feeling thermometers" ..... Error! Bookmark not defined.
Collapsing variables is (mostly) only for the purpose of illustration..... Error! Bookmark not defined.
A short digression: monotonicity..... Error! Bookmark not defined.
Tight conceptualization ..... Error! Bookmark not defined.
Loose conceptualizations ..... Error! Bookmark not defined.
Not every political or social phenomena are concepts..... Error! Bookmark not defined.

Chapter 6. The need for multiple counterfactuals: an introduction to "units of analysis". Error! Bookmark not defined.

Units of analysis as counterfactuals ..... Error! Bookmark not defined.
How we navigate units of analysis to estimate causality in our everyday life..... Error! Bookmark not defined.
The scientific testing new claims: replication as a form of a unit of analysis..... Error! Bookmark not defined.
Reasoning from events to multiple units ..... Error! Bookmark not defined.
Time as the unit of analysis: understanding changes in public opinion over time ..... Error! Bookmark not defined.
Individual variation does not necessarily imply change ..... Error! Bookmark not defined.
When to consider changing the units of analysis ..... Error! Bookmark not defined.
A note about Afghanistan, the price of opiates, and geographical regions versus time ..... Error! Bookmark not defined.

Chapter 7. Using the unit of time to explore public opinion ..... Error! Bookmark not defined.

Testing the "public as thermostat" theory of public opinion change ..... Error! Bookmark not defined.
Multiple studies as a way to increase the set of counterfactuals Error! Bookmark not defined.
Testing an exception to the "public as thermostat theory: the increase of egalitarianism. Error! Bookmark not defined.

Chapter 8. People as the units of analysis ..... Error! Bookmark not defined.

From frequency tables to crosstabulations (crosstabs)..... Error! Bookmark not defined.
Frequency tables..... Error! Bookmark not defined.
A short note about using survey weights ..... Error! Bookmark not defined.
Crosstabs that create confusion ..... Error! Bookmark not defined.
Moving from crosstabs to Venn diagrams and scatterplots..... Error! Bookmark not defined.
Venn diagram as an illustration of covariation..... Error! Bookmark not defined.

Scatterplot as an illustration of covariation ..... Error! Bookmark not defined.

Chapter 9. Some logical fallacies regarding units and concepts ..... Error! Bookmark not defined.

Some concepts are not meant for some units ..... Error! Bookmark not defined.
Ecological fallacy ..... Error! Bookmark not defined.
Understanding how processes work at different levels of aggregation ..... Error! Bookmark not defined.
Modelling both individuals and the context simultaneously ..... Error! Bookmark not defined.
Individualistic fallacy ..... Error! Bookmark not defined.

Chapter 10. Validity, difficult concepts, and measurement error .. Error! Bookmark not defined.

Validity ..... Error! Bookmark not defined.
Measurement theory: matching the concept in theory to the measure .... Error! Bookmark not defined.
Conceptualizing life satisfaction ..... Error! Bookmark not defined.
Measuring life satisfaction: turning a concept into a variable ..... Error! Bookmark not defined.
The rules of concept naming ..... Error! Bookmark not defined.
Measurement error ..... Error! Bookmark not defined.
Measuring more difficult concepts ..... Error! Bookmark not defined.
Self esteem ..... Error! Bookmark not defined.
Another difficult concept: country level political liberty ..... Error! Bookmark not defined.
Moving from space to time: years as the units of analysis ..... Error! Bookmark not defined.
Other units of analysis ..... Error! Bookmark not defined.
Country (or other place), by year (or other unit of time) ..... Error! Bookmark not defined.

Part III. Reasoning about causal probabilities at the individual level ..... Error! Bookmark not defined.

Chapter 11. The logic of exogeneity (and endogeneity) ..... Error! Bookmark not defined.

Exogenous shocks ..... **Error! Bookmark not defined.**
One problem we cannot solve without fancy statistics and upgraded over time (longitudinal) models: reverse causality. ..... Error! Bookmark not defined.

Chapter 12. Clouds and clocks: case studies, comparative models, and mixed methods: an introduction ..... Error! Bookmark not defined.

Chapter 13. Experiments ..... Error! Bookmark not defined.

Chapter 14. Observation..... Error! Bookmark not defined.

Chapter 15. Epidemiology and medicine: An illustration of how observational correlations inform experimental designs and how experiments inform observational designs ..... Error! Bookmark not defined.

Chapter 16. Three (of the five) kinds of literature reviews ..... Error! Bookmark not defined.

How to read the literature..... Error! Bookmark not defined.
Literature review 1: Why the question is important ..... Error! Bookmark not defined.
Literature review 2: What we do not know shows what we should study . Error! Bookmark not defined.
Literature review 3: Evidence for causation: why your explanatory (independent) variable causes your (dependent) outcome variable ..... Error! Bookmark not defined.

How to write a review efficiently: taking notes organized by concept (or section in your paper), not by journal article..... Error! Bookmark not defined.
How to not read every word ..... Error! Bookmark not defined.
As a note about the other two literature reviews: Using the literature to understand measurement and implications..... Error! Bookmark not defined.
How to read a statistical table in a journal article ..... Error! Bookmark not defined.

Part IV: Some basic statistics ..... Error! Bookmark not defined.

Chapter 17. Some basic statistics for causal and descriptive inference..... Error! Bookmark not defined.

Measures of central tendency..... Error! Bookmark not defined.
Measures of variation: Standard deviation and Z scores..... Error! Bookmark not defined.
Covariation..... Error! Bookmark not defined.
Correlation ..... Error! Bookmark not defined.

Chapter 18. Testing linear hypotheses ..... Error! Bookmark not defined.

An introduction to Ordinary Least Squares and bivariate regression ..... Error! Bookmark not defined.
The magnitude of the impact: the line..... Error! Bookmark not defined.
Error: Least squares, residuals, R^2, and standard error ..... Error! Bookmark not defined.
Confidence: Statistical significance and its limits..... Error! Bookmark not defined.
The logic of causal and descriptive inference ..... Error! Bookmark not defined.

Chapter 19. An introduction to "omitted variable bias" and the types of statistical relationships ..... Error! Bookmark not defined.

This part of the book explores various illustrations of the kinds of relationships that help us answer the question: what could this correlation be, if not causation?..... Error! Bookmark not defined.
It relies on basic statistics (crosstabs and correlations), visualizations (scatterplots, Venn diagrams, and DAGs), and illustrations from the history of science and social science scholarship as the foundation for understanding multiple regression. ..... Error! Bookmark not defined.
Multiple alternative causes..... Error! Bookmark not defined.
Confounding..... Error! Bookmark not defined.
Mediating (intervening) ..... Error! Bookmark not defined.
Moderating (interactions)..... Error! Bookmark not defined.
Suppression (Simpson's or Lord's paradox) ..... Error! Bookmark not defined.
Curves and other nonlinearities ..... Error! Bookmark not defined.

Chapter 20. Evaluating multiple alternative explanations ..... Error! Bookmark not defined.

Chapter 21. Confounding..... Error! Bookmark not defined.

Chapter 22. Mediating (intervening)..... Error! Bookmark not defined.

Chapter 23. Moderating (interactions)..... Error! Bookmark not defined.

Chapter 24. Causation without correlation, part I: Suppression (Simpson's or Lord's paradox) ..... Error! Bookmark not defined.

Chapter 25. Causation without correlation, part II: Curves and other nonlinearities ..... Error! Bookmark not defined.

Part V. Measurement ..... Error! Bookmark not defined.

Chapter 26. Validity..... Error! Bookmark not defined.

Chapter 27. Scaling..... Error! Bookmark not defined.

Chapter 28. Reliability ..... Error! Bookmark not defined.

Chapter 29. The types of measurement error and how they affect inferences . Error! Bookmark not defined.

Part VI. Multiple regression..... Error! Bookmark not defined.

Chapter 30. From basic statistics to multiple regression ..... Error! Bookmark not defined.

Chapter 31. Interpreting multiple regression models with two variables ... Error! Bookmark not defined.

Multiple alternative causes..... Error! Bookmark not defined.
Confounding..... Error! Bookmark not defined.
Mediating (intervening) ..... Error! Bookmark not defined.
Moderating (interactions)..... Error! Bookmark not defined.
Suppression (Simpson's or Lord's paradox) ..... Error! Bookmark not defined.
Curves and other nonlinearities ..... Error! Bookmark not defined.

Chapter 32. The logic of nested models ..... Error! Bookmark not defined.

Chapter 33. Interpreting models with more than two independent variables .. Error! Bookmark not defined.

Chapter 34. Interpretating models with dummy variables ..... Error! Bookmark not defined.

Chapter 35. Interactions: reviewing the logic of moderation compared with a control (mediation and confounding) ..... Error! Bookmark not defined.

Chapter 36. Interactions with dummy variables ..... Error! Bookmark not defined.

Chapter 37. Interactions with continuous variables ..... Error! Bookmark not defined.

Chapter 38. Interactions with continuous variables ..... Error! Bookmark not defined.

Chapter 39. Interpreting complex models..... Error! Bookmark not defined.

Part VII. Critiques and caveats: unmeasured confounders ..... Error! Bookmark not defined.

Chapter 40. Wait, what? The art of bouncing back ..... Error! Bookmark not defined.

Chapter 41. Selection bias and generalizability..... Error! Bookmark not defined.

Chapter 42. Missing data..... Error! Bookmark not defined.

Chapter 43. Assessing the impact of missing data and measurement error Error! Bookmark not defined.

Chapter 44. Conclusions: going back to the literature ..... Error! Bookmark not defined.

Chapter 41. Implications: going back to the literature ..... Error! Bookmark not defined.

References ..... Error! Bookmark not defined.