PHIL 8670 (Fall, 2015): Philosophy of Statistics

Samuel C. Fletcher

September 12, 2015

Primary Email: scfletch@umn.edu

Office Phone: 612-625-4325

Office Hours: 754 Heller Hall, Tuesdays 3 pm – 4 pm, and by appointment

Class Period: 731 Heller Hall, Tuesdays 4 pm – 6 pm

Course Description

Statistical methods form a significant part of the methodology of every scientific discipline. This seminar will survey a number of central philosophical and conceptual issues in statistics. After a brief review of elementary probability theory and its interpretation, we will consider at length both the classical and Bayesian schools of statistics: their formulations, and arguments pro and con. We will then consider a third school, likelihoodism, that is sometimes considered a compromise between classical and Bayesian methodologies and has gained favor among some philosophers of science. This leads to the likelihood principle, a natural focal point in the debate between these schools on the nature of evidence. The remainder of the seminar will be split between topics on statistical modeling (model verification and model selection), connections between the philosophy of statistics and more traditional topics in the philosophy of science (simplicity, induction and confirmation) and the relation between statistics and causation (randomness, randomization and causal inference).

Evaluation

Each week, there will be a semi-formal presentation of that week's reading assignment aimed at stimulating a critical discussion. For the first meeting (or two) I will be responsible for presenting, and for each of the remaining meetings, one or two students will be responsible. Students not presenting during a given week are responsible instead for submitting a one-paragraph question about a philosophical/conceptual issue arising in that week's readings to those presenting (and me). There will be two options for term papers: either three short papers completed at roughly even intervals throughout the semester, or one longer research paper.

Here is how these requirements for the seminar will affect each student's grade (in percentage terms):

Attendance (10%) All students are expected to attend each seminar meeting, ready to discuss that week's reading.

Presentations (30%) Each student will decide at the beginning of the semester whether to give two or three presentations (each counting for 15% or 10%, respectively) to lead and initiate discussion, perhaps sometimes in collaboration with another student. This should include a concrete product: presentation slides or a handout (or both). Student presenters should try to incorporate into their presentations the discussion questions of their peers (for which, see below).

Discussion Questions (20%) For each week beginning with the second, students not presenting will, before the Monday preceding the seminar meeting, submit to me and those presenting a long(-ish) paragraph introducing a discussion question arising from that week's reading. Only a student's best ten discussion questions will count (at 2% each) toward their grade.

Term Paper(s) (40%) Each student will decide at the beginning of the semester whether to write three short ($\sim$6–7 pages) papers on focused questions arising from the readings at roughly even intervals throughout the semester, or one longer ($\sim$18–21 pages) research paper due at the end. Research papers should aspire to make an original contribution to the literature.

Students auditing the seminar are required only to attend and give two or three presentations, but contributing discussion questions as well is encouraged.

Class Policies

Absences If you foresee being absent for any class meeting, it is your responsibility to notify me during the first week of classes. Unplanned but justified absences (e.g., medical emergencies) require proper documentation.

Students with Disabilities The University of Minnesota is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

- If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact the DRC at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

- If you are registered with the DRC and have a current letter requesting reasonable accommodations, we encourage you to contact your instructor early in the semester to review how the accommodations will be applied in the course.

Additional information is available on the DRC website: `https://diversity.umn.edu/disability/`.

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety. alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily activities. University of Minnesota services are available to assist you with addressing these and other concerns you may be experiencing. You can learn more about the broad range of confidential mental health services available on campus via `http://www.mentalhealth.umn.edu`.

Academic Integrity Academic integrity is essential to a positive teaching and learning environment. All students enrolled in University courses are expected to complete coursework responsibilities with fairness and honesty. Failure to do so by seeking unfair advantage over others or misrepresenting someone else's work as your own, can result in disciplinary action. The University Student Conduct Code defines scholastic dishonesty as follows:

> Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis.

Within this course, a student responsible for scholastic dishonesty can be assigned a penalty up to and including an "F" or "N" for the course. If you have any questions regarding the expectations for a specific assignment or exam, ask.

Inclusiveness Diversity and inclusion are critical to the institutional and academic mission of the University. In this class, we strive to maintain a safe learning environment for students that is respectful of all despite differences in age, citizenship, disability, ethnicity, gender identity or expression, geographic origin, marital status, nationality, primary language, race, religion, sexual orientation, or socioeconomic or veteran status.

Accordingly, if you have a preferred name or pronoun, please contact me so that I can do my best to follow your preferences.

Readings and Course Schedule

Many of the readings will be drawn from the recent (2011) Elsevier handbook, *Philosophy of Statistics* (*PS*) edited by Prasanta S. Bandyopadhyay and Malcolm R. Forster, and the (even more) recent (2014) *Stanford Encyclopedia of Philosophy* (*SEP*) article, "Philosophy

of Statistics," by Jan-Willem Romeijn. Readings within square brackets are *optional* for that week.

1. Elementary Probability and Statistics

   - "§2: Foundations and interpretations," *SEP*.
   - §1–5.3 of Prasanta S. Bandyopadhyay and Steve Cherry. "Elementary Probability and Statistics: A Primer," *PS*, 53–98.

2. Classical Statistical Methods

   - "§3.1: Basics of classical statistics," *SEP*.
   - §5.4–6 of Prasanta S. Bandyopadhyay and Steve Cherry. "Elementary Probability and Statistics: A Primer," *PS*, 53–98.

3. Classical Statistics: Pro

   - Ronald N. Giere. "Empirical Probability, Objective Statistical Methods, and Scientific Inquiry," *Foundations of Probability Theory, Statistical Inference and Statistical Theories of Science*, vol. 2. Eds. W.L. Harper and C.A. Hooker. Dordrecht: D. Reidel, 63–101 (1976).
   - Deborah G. Mayo and Aris Spanos. "Error Statistics," *PS*, 153–198.
   - [D. R. Cox. "Some Problems Connected with Statistical Inference," *The Annals of Mathematical Statistics* 29.2, 357–372 (1958).]

4. Classical Statistics: Con

   - "§3.2: Problems for Classical Statistics," *SEP*.
   - Richard Royall. "Ch. 2: Neyman-Pearson theory" and "Ch. 3: Fisherian theory," *Statistical Evidence: A likelihood paradigm*. New York: Chapman and Hall, 1997.
   - Michael Dickson and Davis Baird, "Significance Testing," *PS*, 199–232.

5. Subjective and Objective Bayesian Methods

   - "§4.1: Basic pattern of inference," *SEP*.
   - I. J. Good. "46656 Varieties of Bayesians," *The American Statistician* 25.5, 62–63 (1971).
   - John Earman. "Ch. 2: The Machinery of Modern Bayesianism," *Bayes or Bust?* Boston: MIT Press, 1992.
   - I. J. Good. "Rational Decisions," *Journal of the Royal Statistical Society, Series B (Methodological)* 14.1, 107–114 (1952).
   - José M. Bernardo. "Modern Bayesian Inference: Foundations and Objective Methods," *PS*, 263–306.
   - [Paul Weirich. "The Bayesian Decision-Theoretic Approach to Statistics," *PS*, 233–263.]

- [Ward Edwards, Harold Lindman, and Leonard J. Savage. "Bayesian Statistical Inference for Psychological Research," *Psychological Review* 70.3, 193–242 (1963).]

6. Bayesian Statistics: Pro

  - Dennis V. Lindley. "The Philosophy of Statistics", *Journal of the Royal Statistical Society D (The Statistician)* 49.3, 293–337 (2000).
  - Colin Howson and Peter Urbach. "Ch. 8: Bayesian Induction: Statistical Theories," *Scientific Reasoning: The Bayesian Approach.* 3rd ed. Chicago: Open Court, 2006.
  - Andrew Gelman and Cosma Rohilla Shalizi. "Philosophy and the practice of Bayesian statistics," *British Journal of Mathematical and Statistical Psychology* 66, 8–38 (2013).
  - [I. J. Good. "The Interface Between Statistics and Philosophy of Science," *Statistical Science* 3.4, 386–397 (1988).]

7. Bayesian Statistics: Con

  - "§4.2: Problems with the Bayesian Approach," *SEP.*
  - John Earman. "Ch. 6: The Rationality and Objectivity of Scientific Inference," *Bayes or Bust?* Boston: MIT Press, 1992.
  - D. G. Mayo and M. Kruse. "Principles of Inference and Their Consequences," in D. Cornfield and J. Williamson (eds.) *Foundations of Bayesianism.* Dordrecht: Kluwer, 381–403 (2001).
  - Richard Royall. "Ch. 8: Bayesian statistical inference" *Statistical Evidence: A likelihood paradigm.* New York: Chapman and Hall, 1997.
  - Brad Efron. "Why Isn't Everyone a Bayesian?" *The American Statistician* 40.1, 1–5 (1986).
  - Andrew Gelman. "Objections to Bayesian statistics," *Bayesian Analysis* 3.3, 445–449 (2008).
  - Stephen Senn. "Comment on Article by Gelman," *Bayesian Analysis* 3.3, 460–462 (2008).
  - Larry Wasserman. "Comment on Article by Gelman," *Bayesian Analysis* 3.3, 463–466 (2008).
  - [Robert E. Kass and Larry Wasserman. "The Selection of Prior Distributions by Formal Rules," *Journal of the American Statistical Association* 91.435, 1343–1370 (1996).]

8. Likelihoodism

  - Richard Royall. §1.1–1.6 in "Ch. 1: The first principle," and "Ch. 4: Paradigms for statistics," *Statistical Evidence: A likelihood paradigm.* New York: Chapman and Hall, 1997.

- Jeffrey D. Blume. "Likelihood and its Evidential Framework," *PS*, 493–512.
- Malcolm R. Forster. "Counterexamples to a Likelihood Theory of Evidence," *Minds and Machines* 16.3, 319–338 (2006).
- [Mark L. Taper and Subhash R. Lele. "Evidence, Evidence Functions, and Error Probabilities," *PS*, 513–532.]

9. The Likelihood Principle

- Jason Grossman. "The Likelihood Principle," *PS*, 553–582.
- Deborah G. Mayo. "On the Birnbaum Argument for the Strong Likelihood Principle," (with discussion and rejoinder) *Statistical Science* 29.2, 227–266 (2014).

10. Model Verification

- Deborah G. Mayo. and Aris Spanos. "Methodology in Practice: Statistical Misspecification Testing," *Philosophy of Science* 71: 1007–1025 (2004).
- Kent W. Staley. "Strategies for securing evidence through model criticism," *European Journal for Philosophy of Science* 2.1, 21–43 (2012).
- David Freedman. "Some issues in the foundation of statistics," (with discussion and rejoinder) *Foundations of Science* 1.1, 19–83 (1995).
- SCF. "Model Verification and the Likelihood Principle."

11. Model Selection: Statistical Methods

- "§5.1: Model comparisons," *SEP*.
- Malcolm R. Forster. "Key Concepts in Model Selection: Performance and Generalizability," *Journal of Mathematical Psychology* 44.1, 205–231 (2000).
- Arijit Chakrabarti and Jayanta K. Ghosh. "AIC, BIC and Recent Advances in Model Selection," *PS*, 583–606.
- A. Philip Dawid. "Posterior Model Probabilities," *PS*, 607–632.

12. Model Selection: Simplicity and Underdetermination

- Malcolm R. Forster and Elliott Sober. "How to Tell When Simpler, More Unified, or Less Ad Hoc Theories Will Provide More Accurate Predictions," *British Journal for the Philosophy of Science* 45, 1–35 (1994).
- I. A. Kieseppä. "Akaike Information Criterion, Curve-fitting, and the Philosophical Problem of Simplicity," *British Journal for the Philosophy of Science* 48, 21–48 (1997).
- I. A. Kieseppä. "Statistical Model Selection Criteria and the Philosophical Problem of Underdetermination," *British Journal for the Philosophy of Science* 52, 761–794 (2001).
- Elliott Sober. "Likelihood, Model Selection, and the Duhem-Quine Problem," *The Journal of Philosophy* 101.5, 221–241 (2004).

- [Kevin T. Kelly. "Simplicity, Truth and Probability," *PS*, 983–1026.]

13. Confirmation and Induction

- James Hawthorne. "Confirmation Theory," *PS*, 333–390.
- Jan-Willem Romeijn. "Statistics as Inductive Inference," *PS*, 751–776.
- [John D. Norton. "Challenges to Bayesian Confirmation Theory," *PS*, 391–440.]
- [Colin Howson. "Bayesianism as a Pure Logic of Inference," *PS*, 441–472.]
- [Roberto Festa. "Bayesian Inductive Logic, Verisimilitude, and Statistics," *PS*, 473–492.]

14. Randomization

- Patrick Suppes. "Arguments for Randomizing," *Proceedings of the Biennial Meeting of the Philosophy of Science Association 1982, Volume Two: Symposia and Invited Papers.* Chicago: University of Chicago Press, 464–475 (1983).
- Peter Urbach. "Randomization and the Design of Experiments," *Philosophy of Science* 52.2, 256–273 (1985).
- Deborah Mayo. "Comments on 'Randomization and the Design of Experiments' by P. Urbach," *Philosophy of Science* 54.4, 592–596 (1987).
- Peter Urbach. "A Reply to Mayo's Criticisms of Urbach's 'Randomization and the Design of Experiments'," *Philosophy of Science* 58.1, 125–128 (1991).
- David Papineau. "The Virtues of Randomization," *British Journal for the Philosophy of Science* 45.2, 437–450 (1994).
- Peter Urbach. "Reply to David Papineau," *British Journal for the Philosophy of Science* 45.2, 712–715 (1994).
- John Worrall. "Why There's No Cause to Randomize," *British Journal for the Philosophy of Science* 58.3, 451–488 (2007).
- [Joseph B. Kadane and Teddy Seidenfeld. "Randomization in a Bayesian Perspective," *Journal of Statistical Planning and Inference* 25, 329–345 (1990).]
- [Zeno G. Swijtink. "A Bayesian Argument in Favor of Randomization," *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association 1982, Volume One: Contributed Papers.* Chicago: University of Chicago Press, 159–168 (1982).]
- [Dennis V. Lindley. "'The Role of Randomization in Inference," *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association 1982, Volume Two: Symposia and Invited Papers.* Chicago: University of Chicago Press, 431–446 (1983).]
- [Isaac Levi. "Direct Inference and Randomization," *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association 1982, Volume Two: Symposia and Invited Papers.* Chicago: University of Chicago Press, 447–463 (1983).]

15. Causation and Causal Inference

- Sander Greenland. "The Logic and Philosophy of Causal Inference: A Statistical Perspective," *PS*, 813–833.
- Judea Pearl. "Casual inference in statistics: An overview," *Statistics Surveys* 3, 96–146 (2009).
- [Jim Woodward. "Causal Interpretation in Systems of Equations," *Synthese* 121, 199–247 (1999).]