Stockholm University

Department of Statistics
(Gebrenegus Ghilagaber) 5 Nov 2019

Course Description for Statistical Philosophy/Theory of Science (ST742A), 7.5 ECTS (Statistisk vetenskapsteori, AN, 7.5 hp) – autumn term 2019.

The course consists of one course-module: "Statistical Theory of Science"

The course covers some basic epistemological views on empirically based knowledge and statistical problem solving and modelling from an applied point of view. A pervading theme in the course is the role models play in empirical science. The course takes as a starting point some basic epistemological views on knowledge, for example, how scientific knowledge is generated and how it changes. Different classic epistemological approaches are related to different statistical methods (e.g. hypothesis testing, Bayesian statistics, likelihood models) in order to highlight the relationship between philosophical questions about science, statistical inference, and proofs/results.

The course also treats ethical aspects.

The course also gives a deeper understanding of experimental and non-experimental research methods, especially with respect to validity, causal conclusions, control of sources of error and handling of confounders.

The course also provides tools to be able to independently examine the epistemological assumptions behind different statistical methods.

Learning outcomes
After the course, the student is expected to be able to

- give an account of some important epistemological viewpoints and their relationship to statistical methods,
- discuss the advantages and disadvantages of some experimental and non-experimental methods in specific situations, especially with respect to validity, causal conclusions, control of sources of error and handling of confounders.

Course Contents
The contents of the course can roughly be divided into following subparts (with reservation for minor changes):

1. Statistical philosophy (L1 - L4)
2. Experimental and non-experimental research methods (L5 – L8)
3. Multiplicity and some further topics from a philosophical perspective (L8 – L10)

Teaching Format
10 lectures (see schedule on the course site). In some of the lectures, mandatory home assignments will be handed out (and posted on Athena). Students are expected to have read through the corresponding chapters according to the last column in the table below. The course is equivalent to 7.5 credits, which in turn corresponds to 5 full-time weeks or 200 hours workload for: participation at instructor-led teaching, home assignments, reading literature, and training of methods.

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Teaching Schedule

Schedule is available at the course website. Please check regularly as the schedule can be updated when the need arises. With reservation for changes, the following topics (see table) will be covered during the lectures:

Lecture	Content	Reading assignments and home assignments*
1	Review of Basic Procedures and Principles in Statistical Inference	Extra material (exercises and/or assignments). **Home assignment 1 (return by 13 December)**
2	The scientific approach, basic epistemological views on knowledge, hypothetico-deductive method, significance and hypothesis testing	Read SOH Sections 1-5 and 9
3	Hypothesis testing: Fisher vs Neyman-Pearson; The Likelihood Principle; estimation	Read SOH Section 6& Lehmann (1993)
4	Ockham's razor; Models	
5	Probabilities; Bayesian Statistics; Prior Probabilities	Extra material. **Home assignment 2 (return by 20 December)**
6	Experiments	Read Montgomery (2013) Section 1 and SOH Section 7-8
7	Causality; Ethical demands for statisticians	Read Pearl et al (2016), Section 1 (except 1.3); Rosenbaum (2010) Section 7-8
8	Observational studies; Methods to allow for causal conclusions	Read Pawitan & Sjölander (2014) and Bretz et al (2010) chapter 1 and 2.1. **Home assignment 3 (return by 7 January)**
9	Methods to allow for causal conclusions Multiple comparisons, their philosophy and statistical concepts and methods	
10	Sequential Methods, their philosophy and statistical concepts and methods, Summary	Read Pawitan (2001) Section 7.5-7.7
Exam	16 January 2020, 10:00 – 15:00	Uggleviksalen (see course site for any changes)
Re-Exan	13 February 2020, 16:00 – 21:00	Värtasalaen (see course site for any changes)

*: further reading assignments and training homework may be announced during the course.

All lectures are scheduled in Room B705 (Bldg. B, 7th floor).

Examination
To pass the course the student should be able to:

- give an account of some important epistemological viewpoints and their relationship to statistical methods
- discuss the advantages and disadvantages of some experimental and non-experimental methods in specific situations, especially with respect to validity, causal conclusions, control of sources of error and handling of confounders.

Grading Criteria
There are three home assignments (see table above for deadlines) which will be handed out approximately one week before. One written exam concludes the course.

The home assignments should be performed individually. On each home assignment, a maximum of 20 points can be achieved. Problems will be both pure discussion problems and problems for data analysis plus discussion. For the data analysis, one of the program packages SAS or R should be used.

In the written exam, a maximum of 40 points can be achieved. Problems in the exam can be discussion problems, discussion of case studies and some interpretation of statistical results. No literature or other facilities are allowed to be used during the exam.

See the course schedule above for the dates for submission of home assignments.
To pass the course, a minimum of 10 points need to be achieved on each home assignment and a minimum of 20 points need to be achieved on the written exam. The sum of credit points from the three home assignments and from the written exam define the grade (possible maximum 100 points).

Grades are given on a seven-point rating scale:

A	Excellent	85-100 points*
B	Very good	77-84 points*
C	Good	69-76 points*
D	Satisfactory	61-68 points*
E	Adequate	50-60 points*
Fx	Inadequate	None of the criteria for A-E but at least 40 points
F	Totally Inadequate	Anything less than 40 points

*: and additionally the minimum requirements for the home assignments and the written exam

All the credit points from the assignments need to be achieved at this period of teaching.

No credit points from the assignments achieved at this semester can be transferred to the next time the course will be given.

Students who get less than 10 points on an assignment or who fail to submit it are given one opportunity to re-submit it until a second hand-in date but can then get a maximum of only 15 points for this assignment. These later second hand-in dates are **December 20 Home Assignment 1, January 7 for Home Assignment 2, and January 15 for Home Assignment 3**. The examiner will advise the student about the need to re-submit such that there are at least 7 days to perform the re-submission.

Course literature

As central starting point, we use:

- **SOH: Hansson S. O. (2007). The Art of doing science.** Department of Philosophy and the History of Technology, Royal College of Stockholm. Will be available in Athena; the original Swedish version, "Konsten att vara vetenskaplig", can be found here: http://home.abe.kth.se/~soh/downloads.htm.

Further important literature:

- Gelman A, Shalizi CR (2013). Philosophy and the practice of Bayesian statistics. *British Journal of Mathematical and Statistical Psychology* **66**, 8–38.
- Häggström O (2016). The need for nuance in the null hypothesis significance testing debate. *Educational and Psychological Measurement* to appear (online available). Author version at: http://www.math.chalmers.se/~olleh/NHST-nuance-revision.pdf.
- Lehmann EL (1993). The Fisher, Neyman-Pearson theories of testing hypotheses: one theory or two? *J Am Stat Assoc* **88**, 1242-1249.
- Pawitan Y (2001). *In all likelihood. Statistical modelling and inference using likelihood.* Clarendon press, Oxford.
- Romeijn JW (2014). *Philosophy of Statistics.* The Stanford Encyclopedia of Philosophy, Edward N. Zalta (ed.): http://plato.stanford.edu/archives/fall2014/entries/statistics/.
- Royall R (1997). *Statistical evidence – a likelihood paradigm.* Monographs on Statistics and Applied Probability 71. Chapman & Hall.
- Stigler S (2008). Fisher and the 5% level. *Chance* **21** (4), 12.
- Wasserstein RL, Lazar NA (2016). The ASA's statement on p-values: context, process, and purpose. *The American Statistician* **70**, 129-133.
- American Statistical Association (1999). "Ethical guidelines for statistical practice". http://www.amstat.org/about/ethicalguidelines.cfm.
- Bretz F, Hothorn T, Westfall P (2010). *Multiple Comparisons Using R*. CRC Press.
- Fisher RA (1949). *Design of experiments. 5th ed.* Oliver and Boyd, Edingburgh.
- Jackson M, Cox DR (2013). The principles of experimental design and their application in sociology. *Annu Rev Sociol* **39**, 27-49.
- Montgomery DC (2013). *Design and analysis of experiments*. 8th ed. Wiley. Chapter 1.

- Pawitan Y, Sjölander A (2014). Dealing with multiple comparisons: To adjust or not to adjust. *Qvintensen* **2/2014**, 11-14.
- Pearl J, Glymour M, Jewell NP (2016). *Causal Inference in Statistics: A Primer*. Wiley, Chichester, UK.
- Rosenbaum PR (2010). *Design of Observational Studies*. Springer Series in Statistics.
- Rothman KJ (1990). No Adjustments Are Needed for Multiple Comparisons. *Epidemiology* **1**, 43–46.

The literature list can be updated during the course. Note that some of the literature above can be accessed via SUs library (free of charge for SU students).

Lecturer, course coordinator and examiner:
Gebrenegus Ghilagaber, Room B727, Tel. 08-162983, Gebre@stat.su.se

Information
Further information and updates will be posted on Athena. Also, Athena will be used during the course for communication. Please do not hesitate to write an email (Gebre@stat.su.se) or come to my office (B727) for questions.