

Applied Statistics

Anne Boomsma & Marijtje van Duijn

Faculty of Behavioural and Social Sciences
University of Groningen

October 2008

apstat09.tex

Introduction

Participants

The Applied Statistics course is offered to students of the Research Master Human Behaviour in Social Contexts.

Time schedule and locations

First semester, period two, week 45–51, 2008, Tuesdays from 13.00–15.00 hours in room M.027 of the Munting Building, and from 15.00–17.00 hours in room H.0406 of the Heymans Building. The first meeting is on Tuesday, November 4.

On Fridays from 12.00–13.00 (room M.0140 of the Munting Building) individual or small group meetings with the instructors will be planned to discuss student's research projects.

Purpose

To apply principles of statistical design and analysis to real data sets from both experimental and observational studies. The objectives of the course include reporting on scientific research in writing and oral presentation of its results.

Global content

The theoretical part of this course offers an in-depth review of some major themes of quantitative research.

- a. From research questions to data analyses.
- b. Experimental and observational studies.
- c. The measurement of variables and looking at sample data.
- d. The general linear model for the analysis of data.
- e. Estimation and null hypothesis significance testing.
- f. Aspects of internal and external validity.

Lectures and literature

There will be seven lectures of two hours a week, immediately followed by two hours of practical work. A reader with selected articles and other material, and the *R tutorial for Applied Statistics*, can be obtained at the Reproduction Service of the Faculty. Additional course material will be made available through Nestor.

The practice of statistical analysis

In the practical part of the course, participants will work on an individual research project (possibly in cooperation with a fellow-student).

During the lab classes students will be working on these projects using so-called R software, for which a tutorial is provided. The analyses and results of the individual projects are discussed and elaborated, if necessary, during the course. At the end of the course, each student will give an oral presentation on the research project and the results obtained. The presentation includes a discussion of all aspects of the topics listed above, and beyond, for short: problem under study, research design, measurement and description of data, statistical data analysis, and making valid inferences from the results. A written report of the research project completes the practical part of Applied Statistics.

Exercises

The exercises are meant to introduce R software, and applied to the research question and the (individual or common) data set provided by each student.

Evaluation and exams

Weekly assignments and an oral presentation are part of the course. The final result of the course is a concise written report of the individual research project, as practiced during the course. In addition, students have to take a multiple-choice examination on the course material. The weights of the written report and the literature part are $2/3$ and $1/3$, respectively. For each part the score must be at least a 6.0.

The first exam is on Tuesday, January 13, 2009, from 09.00–11.00 hours in room M.061 of the Munting Building. A second opportunity is offered on Tuesday, February 3, 2009, from 09.00–11.00 hours in room M.0127 of the Munting Building.

Credit points

The number of credit points to be obtained equals five ECTS.

Website

General course information can be found at website www.gmw.rug.nl/~boomsma/apstat.htm. This site also covers additional information on applied statistics literature, software, data files, and related websites.

Questions and remarks

For questions and remarks feel free to contact the lecturers at Grote Rozenstraat 15: Marijtje van Duijn, room 227, telephone (363)6195, e-mail address m.a.j.van.duijn@rug.nl, and Anne Boomsma, room 221, telephone (363)6187, e-mail a.boomsma@rug.nl.

Software

In the lectures and during practical work, R software will be used — an open source environment for statistical computing and graphics. The following references to this software may be useful.

- A general introduction is provided by *The R Project for Statistical Computing* as described at <http://www.r-project.org>, where links to downloadable R manuals can be found too.
See also the link to **Contributed Documentation** under **The R Manuals** at this site, some of its contents are listed below.
- Baron, J., & Li, Y. (2004). *Notes on the use of R for psychology experiments and questionnaires*. Department of Psychology, University of Pennsylvania; Center of Outcomes Research, Children's Hospital of Philadelphia. The full text can be found at <http://www.psych.upenn.edu/~baron/rpsych/rpsych.html>.
- Faraway, J.J. (2005). *Linear models with R*. Boca Raton, FL: Chapman & Hall/CRC. The main part of the book can be found in PDF and postscript format at <http://www.stat.lsa.umich.edu/~faraway/book/> under the title *Practical regression and Anova in R*. [recommended]
- Venables, W.N., Smith, D.M., & R Development Core Team (2005). *An introduction to R*. An elementary introduction. To be found at <http://cran.r-project.org/doc/manuals>.
- Verzani, J. (2005). *Using R for introductory statistics*. Boca Raton, FL: Chapman & Hall/CRC. See the corresponding website <http://wiener.math.csi.cuny.edu/UsingR/>. Applications of R corresponding to this book can be found at website <http://cran.r-project.org/doc/contrib/Verzani-SimpleR.pdf>, under the title *SimpleR: Using R for introductory statistics*. [recommended]
- Everitt, B.E., & Hothorn, T. (2006). *A handbook of statistical analyses using R*. Boca Raton, FL: Chapman & Hall/CRC.
- Crawley, M.J. (2007). *The R book*. Chichester: Wiley. [recommended]
- Dalgaard, P. (2008). *Introductory statistics with R* (2nd ed.). New York: Springer. [recommended]

- Ugarte, M.D., Militino, A.F., & Arnholt, A.T. (2008). *Probability and statistics with R*. Boca Raton, FL: Chapman & Hall/CRC.
- A general Help for R site is at <http://finzi.psych.upenn.edu/>.
- On-line tutorials are also available, for example at <http://www.cyclismo.org/tutorial/R/> and <http://www.math.ilstu.edu/dhkim/Rstuff/Rtutor.html>.

Warning

This relatively new course, with participants from ill-known populations, is both an experiment and an observational study. It may fail to attain its objectives. The null hypothesis is that students learn nothing from this course. The one-sided alternative hypothesis is obvious. The power of the statistical test that there is no lecture and no practice effect, however, is assumed to be high, even with as few as twenty students.

Preliminary Overview and Literature

Lecture 1. Data Analysis and Statistics

- Wilkinson, L., & The Task Force on Statistical Inference (1999). Statistical methods in psychology journals: Guidelines and explanations. *The American Psychologist*, **54**, 594–604. 11
- Maxwell, S.E., & Delaney, H.D. (2004). *Designing experiments and analyzing data: A model comparison perspective* (2nd ed.). The logic of experimental design (pp. 3–22). Mahwah, NJ: Erlbaum. 20
- Christensen, R. (2005). Testing Fisher, Neyman, Pearson, and Bayes. *The American Statistician*, **59**, 121–126. 6
- Boomsma, A. (2006). *Bayesian statistics*. Unpublished lecture sheets. University of Groningen, Department of Statistics & Measurement Theory. [to be available online] 16

Lecture 2. Observational Studies and Experiments

- Freedman, D., Pisani, R., & Purves, R. (1998). *Statistics* (3rd ed.). Controlled experiments and observational studies (pp. 3–28). New York: Norton. 26
- Cochran, W.G. (1983). *Planning and analysis of observational studies*. Variation, control, and bias (pp. 1–14). New York: Wiley. 14
- Rosenbaum, P.R. (2005). Observational study. In B.S. Everitt & D.C. Howell (Eds.), *Encyclopedia of statistics in behavioral science* (pp. 1451–1462). Chichester, UK: Wiley. 12

Lecture 3. Measurement and Data Inspection

- Stevens, S.S. (1946). On the theory of scales of measurement. *Science*, **103**, 677–680. 4
- Wilcox, R.R. (2003). *Applying contemporary statistical techniques*. Summarizing data (pp. 55–79). Amsterdam: Academic Press. 25

**Lecture 4. Estimation and Null Hypothesis Significance Testing:
The General Linear Model**

- Snijders, T.A.B. (2001). Hypothesis testing: Methodology and limitations. In N.J. Smelser & P.B. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (Vol. 10, pp. 7121–7127). Amsterdam: Elsevier. 7
- Crawley, M.J. (2005). *Statistics: An introduction using R* (pp. 103–124). Chichester: Wiley. 22
- Hutcheson, G.D., & Sofroniou, N. (1999). *The multivariate social scientist: Introductory statistics using generalized linear models* (pp. 1–14). London: Sage. 14

Lecture 5. The Practice of Statistical Design and Modeling

- Cohen, J. (1992). A power primer. *Psychological Bulletin*, **112**, 155–159. 5
- Kirk, R.E. (1996). Practical significance: A concept whose time has come. *Educational and Psychological Measurement*, **56**, 746–759. 14
- Boomsma, A. (2006). *An overview of regression diagnostics*. Unpublished manuscript. University of Groningen, Department of Statistics & Measurement Theory. 14

Lecture 6. Generalizability and Meta-Analysis

- Maxwell, S.E., & Delaney, H.D. (2004). *Designing experiments and analyzing data: A model comparison perspective* (2nd ed.). Threats to the validity of inferences from experiments (pp. 22–32). Mahwah, NJ: Erlbaum. 11
- Huisman, M. (2008) *Missing data analysis*. Workshop facilitated at the European Health Psychology Conference, University of Bath, September 9. [also available at <http://www.gmw.rug.nl/~huisman/bath2008.pdf>] 70
- Curran, D., Molenberghs, G, Fayers, P.M., & Machin, D. (1998). Incomplete quality of life data in randomized trial: Missing forms. *Statistics in Medicine*, 17, 697–709. 13
- Boomsma, A. (2008). *Literature review and meta-analysis*. Unpublished lecture sheets. University of Groningen, Department of Statistics & Measurement Theory. [to be available online] 30

Lecture 7. What Have We Learned?

- Cohen, J. (1990). Things I have learned (so far). *The American Psychologist*, 45, 1304–1312. 9
- Students will give final presentations of their applied statistics research project, provisionally scheduled on January 6 and 8, 2009.

Applied Statistics

Copyright © 2009 by Anne Boomsma, Vakgroep Statistiek & Meettheorie, Rijksuniversiteit Groningen

Alle rechten voorbehouden. Niets in deze uitgave mag worden verveelvoudigd, opgeslagen in een geautomatiseerd gegevensbestand, en/of openbaar gemaakt, in enige vorm of op enige wijze, hetzij elektronisch, mechanisch, door fotocopie, microfilm of op enige andere manier, zonder voorafgaande schriftelijke toestemming van de auteur.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the author.

Applied Statistics

A. Boomsma, M.A.J. van Duijn & W.J. Post

Department of Statistics & Measurement Theory
University of Groningen

October 12, 2008

`apstat07.tex`

Maxwell, S.E., & Delaney, H.D. (2004). *Designing experiments and analyzing data: A model comparison perspective* (2nd ed.). The logic of experimental design (pp. 3–22). Mahwah, NJ: Erlbaum.

a.

Wilkinson, L., & The Task Force on Statistical Inference (1999). Statistical methods in psychology journals: Guidelines and explanations. *The American Psychologist*, **54**, 594–604.

b.

Christensen, R. (2005). Testing Fisher, Neyman, Pearson, and Bayes. *The American Statistician*, **59**, 121–126.

c.

Lehmann, E.L. (1990). Model specification: The views of Fisher and Neyman, and later developments. *Statistical Science*, **5**, 160–168.

d.

Efron, B. (1986). Why isn't everyone a Bayesian? (with discussion). *The American Statistician*, **40**, 1–11.

e.

Moore, D.S. (1997). Bayes for beginners? Some reasons to hesitate. *The American Statistician*, **51**, 254–261.

f.

Freedman, D., Pisani, R., & Purves, R. (1998). *Statistics* (3rd ed., pp. 3–28). New York: Norton.

g.

Freedman, D.A. (1999). From association to causation: Some remarks on the history of statistics. *Statistical Science*, **14**, 243–258.

h.

Cochran, W.G. (1983). *Planning and analysis of observational studies*. Variation, control, and bias (pp. 1–14). New York: Wiley.

i.

Rosenbaum, P.R. (2005). Observational study. In B.S. Everitt & D.C. Howell (Eds.), *Encyclopedia of statistics in behavioral science* (pp. 1451–1462). Chichester, UK: Wiley.

j.

Cox, D.R., & Wermuth, N. (2001). Some statistical aspects of causality. *European Sociological Review*, **17**, 65–74.

k.

Campbell, S.K. (2004). *Flaws and fallacies in statistical thinking*. Relationships: Causal and casual (pp. 152–177). Mineola, NY: Dover.

l.

Stevens, S.S. (1946). On the theory of scales of measurement. *Science*, **103**, 677–680.

m.

Wilcox, R.R. (2003). *Applying contemporary statistical techniques*. Summarizing data (pp. 55–79). Amsterdam: Academic Press.

n.

Tukey, J.W. (1969). Analyzing data: Sanctification or detective work? *The American Psychologist*, **24**, 83–91.

o.

Finney, D.J. (1975). Numbers and data. *Biometrics*, **31**, 375–386.

p.

Mosteller, F., & Tukey, J.W. (1977). *Data analysis and regression: A second course in statistics*. Approaching data analysis (pp. 1–24). Reading, MA: Addison-Wesley.

q.

Micceri, T. (1989). The unicorn, the normal curve, and other improbable creatures. *Psychological Bulletin*, **105**, 156–166.

r.

Hardy, M. (2004). Summarizing distributions. In M. Hardy & A. Bryman (Eds.), *Handbook of data analysis* (pp. 36–64). London: Sage.

s.

Cox, D.R. (1977). The role of significance tests (with discussion). *Scandinavian Journal of Statistics*, **4**, 49–70.

t.

Moore, D.S. (2001). *Statistics: Concepts and controversies* (5th ed.). Use and abuse of tests of significance (pp. 451–461). New York: Freeman.

u.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, **112**, 155–159.

v.

Kramer, S.H., & Rosenthal, R. (1999). Effect sizes and significance levels in small-sample research. In R.H. Hoyle (Ed.), *Statistical strategies for small sample research* (pp. 59–79). Thousand Oaks, CA: Sage.

w.

Kirk, R.E. (1996). Practical significance: A concept whose time has come. *Educational and Psychological Measurement*, **56**, 746–759.

x.

Cohen, J. (1994). The earth is round ($p < .05$). *The American Psychologist*, **49**, 997–1003.

a.

Snijders, T.A.B. (2001). Hypothesis testing: Methodology and limitations. In N.J. Smelser & P.B. Baltes (Eds.), *International encyclopedia of the social & behavioral sciences* (Vol. 10, pp. 7121–7127). Amsterdam: Elsevier.

b.

Glass, G.V. (2000). *Meta-analysis at 25*. [Online]. Available at <http://glass.ed.asu.edu/gene/papers/meta25.html>. College of Education, Arizona State University.

c.

Maxwell, S.E., & Delaney, H.D. (2004). *Designing experiments and analyzing data: A model comparison perspective* (2nd ed.). Threats to the validity of inferences from experiments (pp. 22–32). Mahwah, NJ: Erlbaum.

d.

Curran, D., Molenberghs, G, Fayers, P.M., & Machin, D. (1998). Incomplete quality of life data in randomized trial: Missing forms. *Statistics in Medicine*, **17**, 697–709.

e.

Schafer, J.L. & Graham, J.W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, **7**, 147–177.

f.

Cochran, W.G. (1983). *Planning and analysis of observational studies*. Statistical introduction (pp. 15–31). New York: Wiley.

g.

Kline, R.B. (2004). *Beyond significance testing: Reforming data analysis methods in behavioral research*. Replication and meta-analysis (pp. 247–271). Washington, DC: American Psychological Association.

h.

Hedges, L.V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. Tests of statistical significance of combined results (pp. 27–46). San Diego, CA: Academic Press.

i.

Cohen, J. (1990). Things I have learned (so far). *The American Psychologist*, **45**, 1304–1312.

j.

Kirk, R.E. (2001). Promoting good statistical practices: Some suggestions. *Educational and Psychological Measurement*, **61**, 213–218.

k.

Preece, D.A. (1987). Good statistical practice. *The Statistician. Journal of the Royal Statistical Society, Series D*, **36**, 397–408.

l.

Chatfield, C. (2002). Confessions of a pragmatic statistician. *The Statistician. Journal of the Royal Statistical Society, Series D*, **51**, 1–20.

m.

Wright, D.B. (2003). Making friends with your data: Improving how statistics are conducted and reported. *British Journal of Educational Psychology*, **73**, 123–136.

n.

Crawley, M.J. (2005). *Statistics: An introduction using R*. Statistical modelling (pp. 103–124). Chichester: Wiley.

o.

Hutcheson, G.D., & Sofroniou, N. (1999). *The multivariate social scientist: Introductory statistics using generalized linear models*. Introduction (pp. 1–14). London: Sage.

p.

Huisman, M. (2008) *Missing data analysis*. Workshop facilitated at the European Health Psychology Conference, University of Bath, September 9. [also available at <http://www.gmw.rug.nl/~huisman/bath2008.pdf>]

q.