Many fields of science are transitioning from null hypothesis significance testing (NHST) to Bayesian data analysis. Bayesian analysis provides complete information about the relative credibilities of all candidate parameter values for any descriptive model of the data. Bayesian analysis applies flexibly and seamlessly to complex hierarchical models and realistic data structures, including small samples, large samples, unbalanced designs, missing data, censored data, outliers, etc. Bayesian analysis software is flexible and can be used for a wide variety of data-analytic models. This course shows you how to do Bayesian data analysis, hands on (with free software called R and JAGS). The course will use new programs and examples.

The intended audience is advanced students, faculty, and other researchers, from all disciplines, who want a ground-floor introduction to doing Bayesian data analysis. No specific mathematical expertise is presumed. In particular, no matrix algebra is used in the course. Some previous familiarity with statistical methods such as a t-test or linear regression can be helpful, as is some previous experience with programming in any computer language, but these are not critical.

This course is offered through the Interuniversity Consortium for Political and Social Research (ICPSR) Summer Program. Registration is required and links are provided below.

Course Topics include the following. There will be updated software and examples for 2014!

**Day 1:**
- Overview / Preview:
  - Bayesian reasoning generally.
  - Robust Bayesian estimation of difference of means. Software: R, JAGS, etc.
  - NHST t test: Perfidious p values and the con game of confidence intervals.
- Bayes' rule, grid approximation, and R. Example: Estimating the bias of a coin.
- Markov Chain Monte Carlo and JAGS. Example: Estimating parameters of a normal distribution.
- HDI, ROPE, decision rules, and null values.

**Day 2:**
- Hierarchical models: Example of means at individual and group levels. Shrinkage.
- Examples with beta distributions: therapeutic touch, baseball, meta-analysis of extrasensory perception.
- The generalized linear model.
- Simple linear regression. Exponential regression. Sinusoidal regression, with autoregression.
A posterior probability distribution for parameters that describe two groups, showing complete distributions of the difference of means (right middle), the difference of standard deviations, the effect size (right bottom), and posterior predictive check (right upper).

- How to modify a program in JAGS & rjags for a different model.
- Robust regression for accommodating outliers, for all the models above and below.
- Multiple linear regression.
- Hierarchical regression models: Estimating regression parameters at multiple levels simultaneously.
- Hierarchical model for shrinkage or regression coefficients in multiple regression.

**Day 3:**
- Bayesian hierarchical one-way ANOVA.
- Multiple comparisons and shrinkage.
- Example with unequal variances (“heteroscedasticity”).
- Bayesian hierarchical two-way ANOVA with interaction. Interaction contrasts.
- Split plot design.
- Log-linear models and chi-square test.

**Day 4:**
- Model comparison as hierarchical model. The Bayes factor. Doing it in JAGS.
- Two Bayesian ways to assess null values: Estimation vs model comparison.
- Power: Probability of achieving the goals of research. Applied to Bayesian estimation of two groups.
- Sequential testing.
- The goal of achieving precision, instead of rejecting/accepting a null value.
- How to report a Bayesian analysis.
- Advanced topics as time permits: Censored data in JAGS. Mixture of normals. Other data distributions in JAGS using beta 1's trick. Stan an Hamiltonian Monte Carlo.

For more information about Bayesian data analysis, with links to articles and videos, and for information about the instructor, scroll to the bottom of this page, or click here!

---

**Register with the ICPSR summer program.**

This course is offered as part of the ICPSR Summer Program in Quantitative Methods of Social Research, so you must register to attend. People who are not on the official roster will not be admitted to the classroom. Registration information is at this link. Registration fees are the standard amounts set by ICPSR. The instructor has no control.
over fees. Please check this ICPSR web page for information about whether your institution is a member of ICPSR.

---

**Install software before arriving.**

You are encouraged to bring a notebook computer to the course, but it is not required. If you bring a computer, then you will need to install some free software to run the data analyses. Please install the software before arriving at the course. The programs are being updated, so please check here a week before the course to be sure you have the most recent programs. For complete installation instructions, please refer to this blog entry.

---

**Why go Bayesian?**

Sciences from astronomy to zoology are changing from null-hypothesis significance testing to Bayesian data analysis, because Bayesian analysis provides complete information with flexible application to numerous models. Read more:

- An article that shows the rich information provided by Bayesian estimation in the context of analyzing data from two groups: Kruschke, J. K. (2013). Bayesian estimation supersedes the t test. *Journal of Experimental Psychology: General, 142*(2), 573-603. More info, including links to videos, is here.
- An article that provides an overview of Bayesian analysis aimed at organizational researchers: Kruschke, J. K., Aguinis, H., & Joo, H. (2012). The time has come: Bayesian methods for data analysis in the

**Above:** A brief video that describes Bayesian estimation for comparing two groups, and how Bayesian estimation supersedes the t test.


- An article that emphasizes that Bayesian data analysis is appropriate regardless of the status of Bayesian models of cognition: Kruschke, J. K. (2010). What to believe: Bayesian methods for data analysis. * Trends in Cognitive Sciences, 14(7), 293-300.

- An article that explains two Bayesian methods to assess null values, and which one is typically more informative: Kruschke, J. K. (2011). Bayesian assessment of null values via parameter estimation and model comparison. * Perspectives on Psychological Science, 6(3), 299-312.

*Your click on this link constitutes your request to the author for a personal copy of the article exclusively for individual research.

Who is the instructor? John Kruschke is eight-time winner of Teaching Excellence Recognition Awards from Indiana University, where he is Professor of Psychological and Brain Sciences, and Adjunct Professor of Statistics. He has written an introductory textbook on Bayesian data analysis; see also the articles linked above. His research interests include the science of moral judgment and Bayesian data analysis. He received the Troland Research Award from the National Academy of Sciences, and the Remak Distinguished Scholar Award from Indiana University. He has been on the editorial boards of several scientific journals, including Journal of Mathematical Psychology, Psychological Review, and Journal of Experimental Psychology: General, among others.

Recommended textbook: Doing Bayesian Data Analysis: A Tutorial with R and BUGS. The book is a genuinely accessible, tutorial introduction to doing Bayesian data analysis. The software used in the course accompanies the book, and many topics in the course are based on the book. For reviews of the book at Amazon.com, click here. Further information about the book can be found here.

Bayesian data analysis is not Bayesian modeling of cognition. Data analysis involves "generic" descriptive models (such as linear regression) without any necessary interpretation as cognitive computation. The rational way to estimate parameters in descriptive models is Bayesian, regardless of whether or not Bayesian models of mind are viable. The concepts and methods of Bayesian data analysis transfer to other Bayesian models, including Bayesian models of cognition. Read more at this blog entry.

This page URL: http://www.indiana.edu/~jkkteach/WorkshopICPSR2014.html