

Proposal for a tutorial on Using Bayes to Interpret Non-significant Results

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Keywords: Bayesian inference; Bayes Factors; confidence intervals; likelihood intervals; non-significant results; evidence.

1. Outline the objectives and scope of the tutorial.

The purpose of the tutorial is to present simple tools for dealing with non-significant results, an area which cognitive scientists have consistently found problematic. In particular, people will be taught how to apply Bayes Factors and likelihood intervals to draw meaningful inferences from non-significant data, using free easy-to-use on-line software: Software which allows one to determine whether there is strong evidence for the null and against one's theory, or if the data are just insensitive, a distinction p -values cannot make. These tools have greater flexibility than power calculations and allow null results to be interpreted over a wider range of situations. Such tools should allow the publication of null results to become easier.

The online software for Bayes Factors (with instructions) is here:

http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm

And the online software for likelihood intervals here:

http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Likelihood.htm

2. Explain how the tutorial will be delivered giving a detailed description of the material that will be covered.

The tutorial will consist of lectures by me; after the second hour people will be able to use their internetted laptops to work through examples on the software, and thereby interactively follow the points I make, and also explore the tools for themselves.

Schedule:

9:30 – 10:30 Basics: The different aims of significance testing and Bayesian inference (including the three moral and inferential paradoxes of significance testing and their solution)

10:45 – 11:45 Bayes Factors

12- 1 Examples with Bayes Factors, to illustrate appropriate and inappropriate use, and robustness checks (Bayesian analysis can of course be misused in ways we will clarify)

2-3 Confidence intervals, likelihood intervals, credibility intervals with examples, including the (little discussed) four principles for using intervals inferentially in theory testing

3:30 – 4:30 Examples showing the complementary strengths and weaknesses of Bayes factors and interval methods for interpreting null results

4:45 – 5:30 Discussion of e.g. any particular data people wish to bring, and free questions

The tutorial will emphasize how statistics, both Bayes factors and interval estimates, can be brought into more intimate contact with theory than has typically been the case, and appropriate ways of doing this. (Interpreting null results requires making contact with theory.)

My emphasis will be practical rather than ideological, though conceptual arguments will be important.

3. Justify why it is important to have a tutorial in the proposed area at the conference.

Users of statistics have been criticised for decades for their interpretation of non-significant results. Users have either used null results to count against a theory that predicted a difference (without establishing that the results actually counted against the theory) or ignored the results as uninformative (without establishing that they were). One only need pick up any recent issue of almost any journal to see this. (I don't exclude many of my own papers from this criticism!) In that sense the topic has been important to clarify for a long time. Recently, however there was been a resurgence of interest in Bayesian and likelihood methods, and the recent developments are particularly useful for users of statistics. Little can be more important than that we as a community draw appropriate inferences from data, and get the most from our data. The issues are applicable to the whole community of cognitive scientists, and hence appropriate for a meeting of the Cognitive Science Society. Several strategies for dealing with null results will be taught, as well as reasons why the most common strategies, orthodox as well as Bayesian, can be problematic.

4. Specify how relevant the topic is for the conference (i.e., does it focus on an emerging or cross-disciplinary research topic?)

Bayes has been making a resurgence for getting on 10 years now in cognitive science. Part of the interest has been in Bayes as a model for how the mind works. While the workshop has nothing to say on what the best theory of the mind is, theories of how we should analyse data are clearly relevant to theories of how the mind works. More importantly, part of the recent interest in Bayes is precisely on the topic of the workshop – principles and methods for drawing statistical inferences. Indeed, at the meeting of the Society last year Kruschke held a very successful workshop on Bayesian inference based on his book. I will be teaching a slightly different philosophy and different methods (but which complement Kruschke's approach). Kruschke

covered Markov Chain Monte Carlo methods and hierarchical modelling; the workshop will not cover these topics. This workshop offers different tools to the researcher, simple tools for dealing with a t-test (i.e. 1-df contrasts – which is all we are normally really interested in), tools which a researcher could directly use straight after walking out of the workshop (without learning R, BUGS, or anything else). I will make most use of the notion of strength of evidence rather than posterior probabilities. In terms of data, the Bayesian analyses taught just require the sort of summary statistics SPSS or other packages produce. I believe that a majority of people will leave transformed in how they conceive of non-significant results, however they then choose to deal with them.

5. State why you are well suited to organize a workshop in the proposed area.

Dienes (2008) is an introduction to orthodox, Bayesian and likelihood inference which has an associated website with free online software. Dienes (2011) discusses the arguments for Bayes, and also provides practical advice for using Bayes. I have been teaching students to use Bayes at the University of Sussex since 2005 on the undergraduate course Philosophy of Psychology, and the masters course Philosophy of Science, thereby coaching hundreds of students on applying Bayes to over a hundred different papers of their choice. This experience has helped me both pedagogically and in seeing how to apply Bayes in a practical way. I have now submitted (and had reviewed) more than half a dozen standard research papers with Bayesian analyses in them (using the same software that I will be teaching). The Bayesian analyses have not been queried, so my arguments for their use and interpretation seem unproblematic to the community so far! Four of the papers are now published (see

http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/Bayes.htm

and scroll to bottom for examples of published papers using Bayes as a tool). I have also lectured on using Bayes in China, Norway, Greece and around the UK.

In January I ran the proposed workshop as a one-day national workshop for the Economic and Social Research Council (ESRC) National Centre for Research Methods. Some feedback:

“Thank you again for an extremely informative day that was very well delivered. Sussex students must be very pleased about having such a clear and articulate statistics tutor,” from a UK Professor of Psychology and Research Director of Department. “I’d like to thank you for a very enjoyable and stimulating workshop last Tuesday. Your web page is also extremely helpful,” from a lecturer in Genetics. “I came to the workshop not sure about how useful it would be or how easy to understand – Zoltan made it really interesting and clear with examples. I will definitely use this in my research,” from a psychology postgraduate.

6. Identify the likely audience for the tutorial.

Specifically, state whether the tutorial will introduce participants to an area, or whether it will cover an advanced topic for participants who already have knowledge in a particular area.

The audience is anyone who uses statistical inference – i.e. just about everybody attending the Meeting could be interested. I will assume the audience is familiar with a t-test; I will not assume more detailed knowledge. But those with more extensive knowledge will also appreciate the material (I have lectured on the material to undergraduates as well as to statisticians; it has been well received in all contexts).

8. Specify any special requirements for the tutorial - particularly, any specialist equipment or software required by participants..

A laptop per participant, or one laptop between two. Ideally the laptops should be connected to the net.

9. Provide full contact details: name of contact person, affiliation, address (including post code/zip and country), telephone, fax, e-mail, names and affiliation of additional author(s).

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References

- Dienes, Z. (2008). *Understanding Psychology as a Science: An Introduction to Scientific and Statistical Inference*. Palgrave Macmillan
 Website: http://www.lifesci.sussex.ac.uk/home/Zoltan_Dienes/inference/index.htm
 Dienes, Z. (2011). Bayesian versus Orthodox statistics: Which side are you on? *Perspectives on Psychological Sciences*, 6(3), 274-290.