Guidelines for quantitative research practice

Graphic display

When reporting the results of a data analysis, a good place to start is with a graphical display of the data. A well constructed graphical display is often the best way to highlight the essential characteristics of the data distribution, such as shape and spread for numerical data sets or the nature of the relationship between variables in bivariate or multivariate numerical data sets. In graphic display of relationships between variables it is important to report both the data and the model (e.g. trend line).

For effective communication with graphical displays, some things to remember are:
1. Be sure to select a display that is appropriate for the given type of data.
2. Be sure to include scales and labels on the axes of graphical displays.
3. In comparative plots, be sure to include labels or a legend so that it is clear which parts of the display correspond to which samples or groups in the data set.
4. While it is sometimes a good idea to have axes that don't cross at (0, 0) in a scatter plot, the vertical axis in a bar chart or a histogram should always start at zero (see the cautions and limitations later in this section for more about this).
5. Keep your graphs simple. A simple graphical display is much more effective than one that has a lot of extra "junk". Most people will not spend a great deal of time studying a graphical display, so its message should be clear and straightforward.
6. Keep your graphical displays honest. People tend to look quickly at graphical displays and so it is important that a graph's first impression is an accurate and honest portrayal of the data distribution.
In addition to the graphical display itself, data analysis reports usually include a brief discussion of the features of the data distribution based on the graphical display.
7. For categorical data, the discussion might be a few sentences on the relative proportion for each category, possibly pointing out categories that were either very common or very rare when compared to other categories.
8. For numerical data sets, the discussion of the graphical display usually summarizes the information the display provides on three characteristics of the data distribution—center or location, spread, and shape.
9. For bivariate numerical data, the discussion of the scatter plot would typically focus on the nature of the relationship between the two variables used to construct the plot.
10. For data collected over time, any trends or patterns in the time series plot should be described.

Reporting quantitative results

from Anderson (2001, Suggestions for presenting the results of data analyses - pdf available)

The standard deviation (SD) is a descriptive statistic, and the standard error (SE) is an inferential statistic. Accordingly, the SD can be used to portray the variation observed in a sample: mean = 100, SD = 25 suggests a much more variable population than does mean = 100, SD = 5. The expected value (i.e., an average over a large number of replicate samples) of the SD^2 equals var^2 and depends very little on sample size (n). The SE is useful to assess the precision (repeatability) of an estimator. For example, in a comparison of males (m) and females (f), mean = 100, SE = 2 and mean=120, SE = 1.5 would allow an inference that the population mean value is greater among females than among males. Such an inference rests on some assumptions, such as random sam- pling of a defined population. Unlike the SD, the SE decreases with increasing sample size. When presenting results such as a ± b, always indicate if b is a SD or a SE or is t xSE (indicating a confidence limit), where t is from the t distribution (e.g., 1.96 if the degrees of freedom are large). If a confidence interval is to be used, give the lower and upper limits as these are often asymmetric about the estimate. Authors should be clear concerning the distinction between precision (measured by variances, standard errors, coefficients of variation, and confidence intervals) and bias (an average tendency to estimate values either smaller or larger than the parameter).

The Methods section should indicate the (1 -a) % confidence level used (e.g., 90, 95, or 99%). Information in tables should be arranged so that numbers to be compared are close to each other. Excellent advice on the visual display of quantita- tive information is given in Tufte (1983). Provide references for any statistical software and specific options used (e.g., equal or unequal variances in t-tests, procedure TTEST in SAS, or a particular Bayesian procedure in BUGS). The Methods section should always provide sufficient detail so that the reader can understand what was done.

In regression, discriminant function analysis, and similar procedures, one should avoid the term independent variables because the variables are rarely independent among themselves or with the response variable. Better terms include explanatory or predictor variables.

Avoid confounding low frequencies with small sample sizes. If one finds only 4 birds on 230 plots, the proportion of plots with birds can be precisely estimated. Alternatively, if the birds are the object of study, the 230 plots are irrelevant, and the sample size (4) is very small.

It is important to separate analysis of results based on questions and hypotheses formed before examining the data from results found after sequentially examining the results of data analyses. The first approach tends to be more confirmatory, while the second approach tends to be more exploratory. In particular, if the data analysis 'suggests a particular pattern leading to an interesting hypothesis then, at this midway point, few statistical tests or measures of precision remain valid. That is, an inference concerning patterns or hypotheses as being an actual feature of the population or process of interest are not well supported (e.g., likely to be spurious). Conclusions reached after repeated examination of the results of prior analyses, while interesting, cannot be taken with the same degree of confidence as those from the more confirmatory analysis. However, these post hoc results often represent intriguing hypotheses to be readdressed with a new, independent set of data. Thus, as part of the Introduction, authors should note the degree to which the study was exploratory versus confirmatory. Provide information concerning any post hoc analyses in the Discussion section.

Statistical approaches are increasingly important in many areas of applied science. The field of statistics is a science, with new discoveries leading to changing paradigms. New methods some- times require new ways of effectively reporting results. We should be able to evolve as progress is made and changes are necessary. We encourage wildlife researchers and managers to capitalize on modern methods and to suggest how the results from such methods might be best presented. We hope our suggestions will be viewed as constructive.

Checklists for presentation of quantitative research

Checklist for authors

MainDonald 2000

This is primarily directed to the writing of reports and theses. Most of it is also relevant to the writing of scientific papers. Note however that each journal has its own style, which papers published in that journal need to follow.

Here is the checklist:

1. Did you begin with a brief intelligible summary that gives the main conclusions?
2. Have you given a clear description of the research question?
3. Have you given clear information on the technical background that explains why the project was needed, gives technical information that will help understand your report, and places your report in context?
4. Have you given a clear description of the design of data collection, and of special difficulties that arose in implementing the design?
5. Have you given a brief clear explanation of your methods of analysis?
6. Are your statistical analyses appropriate? Are they correct? Are they reasonably complete?
7. Do you highlight the main points that emerge from your analyses? Do detailed technical information and the details of computer output, where these seem necessary, appear in an appendix?
8. Is your discussion of results clear, critical and incisive? Do you focus on the key issues?
9. Have you used clear and appropriate forms of graphical and tabular presentation? Is all the material that you include pertinent?
10. Have you included references that will assist readers who want more information on technical background and methods of analysis?
11. Have you used a consistent style for all references?
12. Have you addressed potential challenges to the interpretation of results, including challenges that may arise from inadequacies in the design of data collection?
13. Is the layout and general presentation attractive? Consider page margins, headings, line and other spacing, type fonts, graphs, division into sections and paragraphs. Points that will quickly attract the casual reader’s attention appear in italics. In a report for a commercial client, these will often be the main focus of attention. They may become important to a commercial client (and to the report writer) when claims made in the report are challenged, when the report goes to other consultants for review, or when other specialists make use of information in the report.

Checklist for presentation of statistical results

MainDonald 2000

This checklist may be useful both to authors and to referees.

1. Is the objective (purpose) of the study sufficiently described?
2. Is an appropriate study design used, having this objective in view?
3. Is the study design adequately described? If an experiment, is it clear i how the experiment was laid out? ii what were the experimental units, and what measurements were made or samples taken within experimental units? iii how treatments were assigned to experimental units? iv what sources of variability were represented – different error strata etc?
4. Is all information given that is relevant to analysing or assessing results? i Is the standard error of mean or of difference or of other statistics given when appropriate? ii Are standard errors or other measures of variability based on the appropriate source of variation? iii Where standard errors are not available or not appropriate, are there other indications of precision? iv Are results presented to an appropriate numerical accuracy? (Thus means should be given to around 10% of the SEM.)
5. Were there sufficient replicates to give the precision that was desirable?
6. Were trend or response surface methods used when the data required this?
7. Do the statistical analyses connect closely to points that are of scientific interest?
8. Are the statistical methods used appropriate?
9. Are there statements describing or referencing all statistical tests or estimation methods?
10. Does it seem that the validity of the statistical methods – e.g. homogeneity of variance or the form of response curves – has been adequately checked?
11. From your examination of (i) text, (ii) tables and (iii) figures determine i Is there an adequate overview of the data? ii Is the focus on effects that are substantial and of major interest? iii Is the presentation of statistical material clear?
12. Is an appropriate/correct conclusion drawn from the statistical analysis?
13. Are results translated, as far as possible, into subject matter terms?
14. Do graphs convey information tersely and clearly, avoiding irrelevant and/or distracting features? i Are graphs adequately labelled? ii If there are multiple standard error bars, are they all necessary? (But take care that when there clearly are standard errors that are very different, this is reflected by the use of the requisite number of error bars.)
15. Is assistance with the design and/or statistical analysis and/or interpretation acknowledged by i authorship? ii acknowledged help?
16. From the statistical viewpoint is the paper of acceptable standard to be published?
17. Comment on any points not covered by the above questions.

Checklist for use with published papers

MainDonald 2000

Aims and Purpose

1. Do the authors explain their scientific reasons for undertaking the study?
2. Is there a clear statement of what they aimed to achieve?
3. Did the authors review current knowledge, before embarking on their study?

Data Collection

4. How were the data obtained? Some of the possibilities are Sample, Experiment, Informed opinion, Guess.
5. Do the data make sense; are they free of apparent serious anomalies? [Some numbers may be impossible? Or, e.g., a height/weight ratio may be impossible.]
6. Do any of the claims go beyond what the data could support?
7. Do the data answer the research question?
8. Are the measurements/questions clear? Or is there ambiguity? [e.g. using data from a limited local study to support claims that relate to another geographical location.]
9. Are the data valid for the intended use?
10. In a study of human subjects, who had contact with the participants and how?
11. Who/what was studied and what was the selection process?
12. Are the data sampled from the population to which the researchers wish to generalise? [A sample of Sydney-siders is not a good basis for generalising to what Canberra residents think.]
13. Was the study capable of detecting effects of a magnitude that were of interest? [Influences on precision include measurement instruments, experimental or sampling design, and sample size.]
14. What biases may have been present in the data? [Consider, measuring instrument bias, observer bias, selection bias, etc.]
15. Where groups are compared are there extraneous differences? [e.g., in clinical trials, differences that have nothing to do with the treatment.]

Data Analysis

16. Is the arithmetic correct?
17. Does the analysis take account of data structure (fixed effects, random effects, clustering, etc.)
18. Is the description of the method of analysis clear and complete, with a reference given if the methodology is at all non-standard?
19. Has account been taken of clear grouping (e.g. males/females, different species, etc.) in the data? If results were combined across groups, is justification given?
20. Is statistical significance distinguished from practical significance?
21. Do the authors present graphs or tables that allow the reader to assess agreement with the assumed model?

Interpretation and Presentation

22. Do the authors give a clear statement of what they claim to have achieved?
23. Do the data support the claims that are made?
24. Do the authors distinguish substantial effects from effects that, even if perhaps statistically significant, are insubstantial? [Large studies may detect effects that are of little practical consequence.]
25. Do authors seem to rely uncritically on the claims of other authors?
26. Are the interpretations plausible? Do the data support them? Do the data rule out other interpretations?