How to peer review

All researchers will encounter peer review in their careers; either as authors when they submit their work to a journal for publication or as a reviewer when they are asked to provide comments on a paper by a journal editor.

Although it is an important aspect of the scientific process, how to peer review is rarely taught in universities and can be a daunting task for those new to it. Compared with conducting research, teaching, and writing your own manuscripts, reviewing someone else’s work may seem relatively easy. In fact, reviewing effectively is a special skill that takes time and effort to develop. This tutorial gives you an introduction to peer review and explains how you should go about reviewing a paper.

By the end of this tutorial you should:

* understand the purpose of peer review and the different types available
* be able to assess whether you would be a suitable reviewer for manuscripts you are invited to review
* know how to evaluate each section of a manuscript
* know what to include in your report.

You will also have the opportunity to test your learning by completing a quiz at the end

# Overview

Pre-publication peer review has been part of science for a long time. Philosophical Transactions, the first peer-reviewed journal, published its first paper in 1665 but peer review may be even older still. There are records of physicians in the Arab world reviewing the effectiveness of each other’s treatments as early as the 9th century.

Peer review is a critical part of the modern scientific process. For science to progress, research methods and findings need to be closely examined and verified, and from them a decision on the best direction for future research is made. After a study has gone through peer review and is accepted for publication, scientists and the public can be confident that the study has met certain standards, and that the results can be trusted.

After an editor receives a manuscript, their first step is to check that the manuscript meets the journal’s rules for content and format. If it does, then the editor moves to the next step, which is peer review. The editor will send the manuscript to two or more experts in the field to get their opinion. The experts – called peer reviewers – will then prepare a report that assesses the manuscript, and return it to the editor. After reading the peer reviewer's report, the editor will decide to do one of three things: reject the manuscript, accept the manuscript, or ask the authors to revise and resubmit the manuscript after responding to the peer reviewers’ feedback. If the authors resubmit the manuscript, editors will sometimes ask the same peer reviewers to look over the manuscript again to see if their concerns have been addressed. This is called re-review.

Some of the problems that peer reviewers may find in a manuscript include errors in the study’s methods or analysis that raise questions about the findings, or sections that need clearer explanations so that the manuscript is easily understood. From a journal editor’s point of view, comments on the importance and novelty of a manuscript, and if it will interest the journal’s audience, are particularly useful in helping them to decide which manuscripts to publish.

### **Different types of peer review**

Although the basis of peer review is the same across all journals, experts providing comments on a manuscript submitted to the journal, there are different types in existence. The most common of these are:

* Closed peer review – where the reviewers are aware of the authors’ identities but the authors’ are never informed of the reviewers’ identities.
* Double-blind peer review – where neither author nor reviewer is aware of each other’s identities.
* Open peer review – where authors and reviewers are aware of each other’s identity. In some journals with open peer review the reviewers’ reports are published alongside the article.

The type of peer review used by a journal should be clearly stated in the invitation to review letter you receive and policy pages on the journal website. If, after checking the journal website, you are unsure of the type of peer review used or would like clarification on the journal’s policy you should contact the journal’s editors

Why serve as a peer reviewer?

Peer review ensures the robustness of the scientific literature and by extension science itself. As such it is an integral part of the scientific processes. As your career advances, you are likely to be asked to serve as a peer reviewer.

As well as supporting the advancement of science, and providing guidance on how the author can improve their paper, there are also some benefits of peer reviewing to you as a researcher:

* You will get to read some of the latest science in your field well before it is in the public domain.
* The critical thinking skills needed during peer review will help you in your own research and writing.
* Serving as a peer reviewer looks good on your CV as it shows that your expertise is recognized by other scientists.

Who is peer review for?

When performed correctly peer review helps improve the clarity, robustness and reproducibility of research.

When peer reviewing, it is helpful to think from the point of view of three different groups of people:

1. **Authors.** Try to review the manuscript as you would like others to review your work. When you point out problems in a manuscript, do so in a way that will help the authors to improve the manuscript. Assume that the authors are doing their best to produce an excellent manuscript but need objective outsiders to help identify problems in their methods, analysis, and presentation. Even if you recommend to the editor that the manuscript be rejected, your suggested revisions could help the authors prepare the manuscript for submission to a different journal. Ultimately peer review should be a positive process.
2. **Journal editors.** Comment on the importance and novelty of the study. Editors will use your comments to assess whether the manuscript is of the right level of impact for the journal. In selecting papers for publication, editors need expert help to determine if a manuscript’s research and analysis are sound, and if it makes an important contribution to the field. As such your comments and opinions on the paper are much more important that a simple recommendation; editors need to know **why**you think a paper should be published or rejected as your reasoning will help inform their decision.
3. **Readers.** Identify areas that need clarification to make sure other readers can easily understand the manuscript. As a reviewer, you can also save readers’ time and frustration by helping to keep unimportant or error filled research out of the published literature.

Writing a thorough, thoughtful review usually takes several hours or more. But by taking the time to be a good reviewer, you will be providing a service to the scientific community

Accepting an invitation to review

Editors invite you to review as they believe that you are an expert in a certain area. They would have judged this from your previous publication record or posters and/or sessions you have contributed to at conferences. You may find that the number of invitations to review increases as you progress in your career.

There are several questions to consider before you accept an invitation to review a paper.

1. **Are you qualified?** The editor has asked you to review the manuscript because he or she believes you are familiar with the specific topic or research method used in the paper. It will usually be okay if you can review some, but not all, aspects of a manuscript. Take as an example, if the study focused on a certain physiological process in an animal model you conduct your research on but used a technique that you have never used. In this case, simply review the parts of the manuscript that are in your area of expertise, and tell the editor which parts you cannot review. However, if the manuscript is too far outside your area, you should decline to review it.
2. **Do you have time?** If you know you will not be able to review the manuscript by the deadline, then you should not accept the invitation. Sending in a review long after the deadline will delay the publication process and frustrate the editor and authors. Keep in mind that reviewing manuscripts, like research and teaching, is a valuable contribution to science, and is worth making time for whenever possible.
3. **Are there any potential conflicts of interest?** You should evaluate the manuscript as fairly and objectively as possible. Potential conflicts of interest include:

**a.** The reported results could cause you to make or lose money, e.g., the authors are developing a drug that could compete with a drug you are working on.

**b.** The manuscript concerns a controversial question that you have strong feelings about (either agreeing or disagreeing with the authors).  
**c.** You have strong positive or negative feelings about one of the authors, e.g., a former teacher who you admire greatly.  
**d.** You have published papers or collaborated with one of the co-authors in recent years.

If you are not sure if you have a conflict of interest, discuss your circumstances with the editor.  
Along with avoiding a conflict of interest, there are several other ethical guidelines to keep in mind as you review the manuscript. Manuscripts under review are **highly confidential**, so you should not discuss the manuscript – or even mention its existence – to others. One exception is if you would like to consult with a colleague about your review; in this case, you will need to ask the editor’s permission. It is normally okay to ask one of your students or postdocs to help with the review. However, you should let the editor know that you are being helped, and tell your assistant about the need for confidentiality. In some cases case, when the journal operates an open peer review policy they will allow the student or postdoc to co-sign the report with you should they wish.

It is very unethical to use information in the manuscript to make business decisions, such as buying or selling stock. Also, you should never plagiarize the content or ideas in the manuscript

Evaluating manuscripts

When you first receive the manuscript it is recommended that you read it through once and focus on the wider context of the research.

Ask questions such as:

* What research question(s) do the authors address? Do they make a good argument for why a question is important?
* What methods do the authors use to answer the question? Are the methods the most current available or is there a newer more powerful method available? Does their overall strategy seem like a good one, or are there major problems with their methods? Are there other experiments that would greatly improve the quality of the manuscript? If so, are they necessary to make the work publishable? Would any different data help confirm the presented results and strengthen the paper?
* Were the results analyzed and interpreted correctly? Does the evidence support the authors’ conclusions?
* Will the results advance your field in some way? If so, how much? Does the importance of the advance match the standards of the journal?
* Will other researchers be interested in reading the study? If so, what types of researchers? Do they match the journal’s audience? Is there an alternative readership that the paper would be more suitable for? For example, a study about renal disease in children might be suitable for either a pediatrics-centric journal or one that is targeted at nephrologists.
* Does the manuscript fit together well? Does it clearly describe what was done, why it was done, and what the results mean?
* Is the manuscript written well and easy to read? If the manuscript has many mistakes, you can suggest that the authors have it checked by a native English speaker. If the language quality is so poor that it is difficult to understand, you can ask that the manuscript be corrected before you review it.

After your first reading, write one or two paragraphs summarizing what the manuscript is about and how it adds to current knowledge in your field. Mention the strengths of the manuscript, but also any problems that make you believe it should not be published, or that would need to be corrected to make it publishable. These summary paragraphs are the start of your review, and they will demonstrate to the editor and authors that you have read the manuscript carefully. They will also help the editor, who may not be a specialist in this particular field, understand the wider context of the research. Finally, these paragraphs will highlight the manuscript’s main messages that will be taken away by readers.

You can then proceed in evaluating the individual sections of the paper

Title, abstract and key words

The title, abstract and key words are items that will help other researchers to find the published paper and decide if they will read further. Abstracts must be a clear, short summary of the full manuscript. Researchers want their work to be read, so it is important that their abstract be interesting and hold the reader’s attention. More people will read the abstract than will read the full paper, so it should be easy to understand by readers without a specialized background.

Some questions to ask yourself about the title, abstract and key words are:

* Does the title accurately say what the study was about? If not, can you suggest a different title?
* Does the abstract effectively summarize the manuscript?
* Could the abstract be understood by a researcher outside your specialty?
* Does it include enough information to stand alone? Does the abstract contain information that is unnecessary?
* Is there any information in the abstract that is not in the main text of the manuscript?
* If present, will the key words help readers to find the article? Are they specific, and do they represent the manuscript content?

Introduction

Like the title and abstract, the Introduction tells the reader what the manuscript will be about. However, unlike the abstract, the Introduction gives the background for the research question.

While reviewing the Introduction, ask the following questions:

* Does it explain the background well enough that researchers outside your specialty can understand it?
* Does it accurately describe current knowledge related to the research question?
* Does the Introduction contain unnecessary information? Can it be made more concise?
* Are the reasons for performing the study clear?
* Are the aims of the study clearly defined and consistent with the rest of the manuscript?
* Have the authors missed any key references that would be important for a reader to access? Make suggestions for additional, relevant references if necessary.

Materials and methods

The study’s methods are one of the most important parts used to judge the overall quality of the paper. In addition the Methods section should give readers enough information so that they can repeat the experiments. Reviewers should look for potential sources of bias in the way the study was designed and carried out, and for places where more explanation is needed.

The specific types of information in a Methods section will vary from field to field and from study to study. However, some general rules for Methods sections are:

* It should be clear from the Methods section how all of the data in the Results section were obtained.
* The study system should be clearly described. In medicine, for example, researchers need to specify the number of study subjects; how, when, and where the subjects were recruited, and that the study obtained appropriate ‘informed consent’ documents; and what criteria subjects had to meet to be included in the study.
* In most cases, the experiments should include appropriate controls or comparators. The conditions of the controls should be specified.
* The outcomes of the study should be defined, and the outcome measures should be objectively validated.
* The methods used to analyze the data must be statistically sound.
* For qualitative studies, an established qualitative research method (e.g. grounded theory is often used in sociology) must be used as appropriate for the study question.
* If the authors used a technique from a published study, they should include a citation and a summary of the procedure in the text. The method also needs to be appropriate to the present experiment.
* All materials and instruments should be identified, including the supplier’s name and location. For example, “Tests were conducted with a Vulcanizer 2.0 (XYZ Instruments, Mumbai, India).”
* The Methods section should not have information that belongs in another section (such as the Introduction or Results).

You may suggest if additional experiments would greatly improve the quality of the manuscript. Your suggestions should be in line with the study’s aims. Remember that almost any study could be strengthened by further experiments, so only suggest further work if you believe that the manuscript is not publishable without it

Results and figure

Readers will usually first look at a manuscript’s title, abstract and results. Therefore the results section including any figures and tables are some of the most important parts of the manuscript. You should carefully examine the figures and tables to check they accurately describe the results. If you think it necessary, you can suggest any changes that would make the results easier to understand.

* For figures, check that the plotted parameters are clearly defined. Figures and tables should include measures of uncertainty, such as standard error or confidence intervals, as well as the sample size.
* Table headings and figure legends should be detailed enough that readers can understand the data without reading the main text.
* Look for places where data are unnecessarily repeated in figures, tables or main text. The text should point out key findings or trends, not repeat data presented elsewhere. Similarly figures that present a very small amount of data can often be combined with another or deleted and replaced with an explanation in the manuscript text.
* If a result is not central to the study’s aims, it is often acceptable to summarize it but not present the data. However, failing to show important data, or too many instances of “data not shown,” are unacceptable and you can recommend that it be added into the main manuscript.
* Interesting data that are not needed to support the study’s major conclusions might be better presented as supplementary material rather than the main text of the paper; feel free to point out such data in your comments.
* Feedback on whether the data are presented in the most appropriate manner; for example, is a table being used where a graph would give increased clarity? Do the figures appear to be genuine, i.e. without evidence of manipulation, and of a high enough quality to be published in their present form?

TIP: *If you suspect image manipulation or believe it would be beneficial to see the uncropped and unedited versions of the images inform the editor in the ‘confidential comments’ to the editors section. They can then request the original figure files from the authors.*

* Watch for places where the authors have included interpretations in the Results section. This section should simply state what the results were, not what they might mean. Interpretations and inferences belong in the Discussion section. (However, for journals that combine the Results and Discussion sections, results and interpretations do not need to be separated.)

Statistics

Most scientific manuscripts include statistical analysis, and a study’s conclusions depend on the results of these analyses. If the data are analyzed or reported incorrectly, the manuscript will mislead readers. Therefore, as a scientist, and as a peer reviewer, it is important to have a solid understanding of statistics, and to carefully examine the statistical methods and reporting in manuscripts you review. If you do not feel qualified to fully evaluate the statistics, tell the editor this in your comments so that they know to ask someone else to review them.

Some questions to ask as you review statistical analyses and results are:

* Was the sample size appropriate and/or justified? Did the authors perform a power analysis as part of their study design?
* Did the data meet the assumptions of the tests used? (e.g., many statistical tests can only be used for data with a normal distribution. Data such as proportions or counts of the number of events are generally not normally distributed and have to be either transformed or, preferably, analyzed with statistical models suitable for these data types). Were the tests used appropriate?
* Are the individual data points statistically independent? If there were repeated measurements (for instance, multiple measurements on the same patient), have appropriate statistical models been used?
* Have potential sources of bias (e.g. confounding variables) been considered and accounted for in the analysis?
* When percentages are presented, are the numerator and denominator clear? E.g., “Of the 500 bee colonies, 200 (40%) were affected by the virus,” or, “Forty percent (200/500) of the bee colonies were affected by the virus.”
* Are p-values reported where appropriate? Generally, a p-value should accompany all statistical comparisons mentioned in the text, figures and tables. The actual p-value should be stated (e.g. p = 0.049 and p = 0.0021 rather than p ‹ 0.05 or p ‹ 0.01). However, it is acceptable to state p ‹ 0.0001 if the value is below this threshold. The Statistical Analysis section should also state the threshold for accepting significance, such as "Values of P ‹ 0.05 were considered statistically significant"

Common problems with methods and statistics

There are a number of common problems you might consider when reviewing the methods and statistical analysis of a study. These include:

* **Replication that is absent or inadequate.** Replication is essential in order to minimize sampling error. If a study does not have the right number of replicates, general inferences cannot be made from it and the power of statistical analyses done on the data would be too low. The result of low statistical power is that real differences or treatment effect cannot be detected.
* **Confounding.** The problem of confounding means that differences due to experimental treatments cannot be separated from other factors that might be causing the observed difference. Confounding can be avoided by careful experimental design, such as proper replication, controls and randomization.
* **Poor sampling methods.** In observational studies, random sampling is needed to make sure that the experimental sample is representative of the whole population. If random sampling has not been used, check that the authors justify their sampling methods.
* **Lack of randomization.** In experimental studies, “treatments” must be randomly allocated to experimental units (or vice versa), to make sure that the groups being compared are similar and factors that could confound interpretation of treatment effects are minimized.
* **Pseudoreplication.** The sample size should reflect the number of different times that the effect of interest was independently tested. For instance, if there are repeated measurements on the same set of subjects, as might occur when measuring individuals repeatedly over a period of time, individual data points are not independent. In these cases, averages per individual, or appropriate statistical models that account for repeated measures (e.g. mixed effects models), should be used to analyze the data. If the statistics are not explained, pseudoreplication can often be spotted by looking at the degrees of freedom (essentially, the number of independent pieces of information) of the statistical tests

Discussion and conclusion

In the Discussion and Conclusion sections, authors should interpret the results, place them in context of previous findings, and explain what they mean for future research, as well as for possible real-life applications. If the author has not made these points as clear as they should be, note this in your review.

Other questions to ask include:

* Does the Discussion fit with the aims of the study stated in the Introduction?
* Are there any alternative interpretations of the data that the authors should have considered in their Discussion?
* Is there any general background that belongs in the Introduction section rather than the Discussion?
* Have the authors adequately compared their findings with the findings of other studies?
* Do the authors present data in the Discussion? All relevant data should be presented in the Results section, although important or interesting results can be summarized as part of the Discussion. For example, a sentence such as “Group B’s one-year survival rate was significantly higher than Group A’s,” is acceptable in the Discussion. But a sentence such as, “Group B’s one-year survival rate (1200 / 2000, 60%) was higher than Group A’s (800 / 2000, 40%) (P ‹ 0.05),” belongs in the Results section.
* Do the authors mention how the study’s results might influence future research?
* Are the limitations of the study noted? If not, what limitations have you found?
* Are the authors’ conclusions supported by their data? Have the authors overstated the importance of their findings?

References

Pay attention to how the authors use references as you review the rest of the manuscript.

Some issues to watch for include:

* Are there places where the authors need to cite a reference, but haven’t? (In general, citations are needed for all facts except those that are well-established, common knowledge; that come from the current study; or that are clearly phrased as the authors’ own hypothesis.)
* Do the authors cite all the most relevant previous studies and explain how they relate to the current results? If not, note which references are missing.
* Are the cited studies recent enough to represent current knowledge on the topic?
* Do the authors cite the work of a variety of research groups? This is preferable to mainly citing papers from one or two research groups, especially if one of the most cited groups is one the authors belong to (although it is not always possible in very small fields of study).
* Do the authors cite many review articles? It is better to cite the original studies.
* Are all of the citations helpful to the reader? Note any places where the authors seem to be reviewing literature simply to show the depth of their knowledge, or to increase citations of their own previous work.
* Do the authors cite findings that contradict their own (where they exist), as well as those that support their claims? It is important that the authors provide a well balanced view of previously published work

# Reviewing review articles

A review article is written to summarize the current state of understanding on a topic, and peer reviewing these types of articles requires a slightly different set of criteria compared with empirical articles. Unless it is a systematic review/meta-analysis methods are not important or reported. The quality of a review article can be judged on aspects such as timeliness, the breadth and accuracy of the discussion, and if it indicates the best avenues for future research. The review article should present an unbiased summary of the current understanding of the topic, and therefore the peer reviewer must assess the selection of studies that are cited by the paper. As review article contains a large amount of detailed information, its structure and flow are also important.

Writing a reviewer report

Whether you recommend accepting or rejecting the manuscript, keep in mind that one of your goals is to help the authors improve this and future manuscripts—not to make them give up in despair. Avoid overly negative wording or personal comments, point out the main strengths of the manuscript as well as its weaknesses, and suggest specific ways to fix the problems you identify. Also, avoid making overly brief and direct comments, as these can give your report an unfriendly tone. Reviewers for most journals are anonymous, so if anonymity is important to you, avoid comments that could make your identity obvious to the authors.

If the editor sent specific instructions for the reviewer report, or a form to fill out as part of the review, you should write your report in the requested format. If you received no specific instructions, the reviewer report should be divided into two parts:

1. comments to be read only by the editor, and
2. comments to be read by both the editor and the authors.

Comments for only the editor:

In this section, give the editor your recommendation for the manuscript and, more importantly, your reasons behind it. These usually have to do with the manuscript’s scientific soundness, novelty, quality, importance, and suitability for the journal. Editors take many factors into consideration when deciding whether a paper is right for their journal so providing evidence or reasoning for your recommendation is extremely helpful.

TIP: *Recommendations are usually one of the following: accept manuscript in its current form, publish with minor changes, publish only if major improvements are made, or to reject the paper.*

Comments for both the editor and authors:

In this section, write a detailed report reviewing the different parts of the manuscript. Start with the short summary of the manuscript you wrote after your first reading. Then, in a numbered list, explain each of the issues you found that need to be addressed. Divide the list into two sections: major issues and minor issues. First, write about the major issues, including problems with the study’s method or analysis. Next, write about the minor issues, which might include tables or figures that are difficult to read, parts that need more explanation, and suggestions to delete unnecessary text. If you think the English language of the manuscript is not suitable for publication, try to give specific examples so that the authors know what and how to address the problems.  
Be as specific as you can about the manuscript’s weaknesses and how to address them. If the manuscript has line numbers, include the page and line number(s) specific to the part of the study you are discussing. This will help both the authors and the editor, who may later need to judge if the authors have fixed the problems in their revised manuscript. For example, instead of, “*The explanation of the proposed mechanism is not clear.*” You might write, *“The explanation of the proposed mechanism should be more detailed. Consider referring to the work of Li and Smith, et al. (2008) and Stein and Burdak, et al. (2010).*”

Keep in mind that the authors – and even the editor – may not be native English speakers. Read over your comments after you finish writing them to check that you’ve used clear, simple wording, and that the reasons for your proposed changes are clear.

# After the review

After you submit a review you should receive a notification that the review was successfully received. Some journals will inform reviewers if the manuscript was accepted or rejected, while others do not. Some journals send reviewers the comments of other reviewers on the same manuscript along with the decision letter; reading these comments can help you improve your future reviews.

If the authors revise and resubmit the manuscript after review, the editor will often review the changes to decide if the reviewer comments have been fully addressed. Sometimes, however, the editor will send the manuscript back to the original reviewers to get their feedback about the acceptability of the revised manuscript. If this happens, focus on if the authors have resolved the problems you pointed out in your first review. Try to avoid raising new problems unless they have to do with the author’s revisions. For example, if you asked the authors to explain their methods more clearly, and can now see problems with the experimental design that were not apparent before, it is still appropriate to mention them.

If the authors decided not to follow one or more of your suggestions, and explained why in their response letter, evaluate their reasons fairly and decide if you agree with their decision. If your suggestion arose from a misunderstanding of the manuscript, check to see if the authors have revised the relevant section to make it clearer or if they have explained a particular problem as a limitation of the study. Be fair. If you still feel strongly that the manuscript should not be published because of a problem that has not been addressed, you should indicate this to the editor and explain why a particular change or addition is necessary.