How to Write a Review for a Scientific or Mathematical Paper

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Abstract

Reviewing is a difficult and thankless task. The goal of this report is to help us do it a little better.

The task of the referee is to evaluate in a timely manner a paper for publication in a specific journal or conference proceedings. This involves determining if the work presented is correct, if the problem studied and the results obtained are new and significant, if the quality of the presentation is satisfactory or can be made so, and what revisions and changes to the paper are necessary and/or desirable. The evaluation must be with regard to the coverage and degree of selectivity of the specific publication.

Alan Jay Smith [1].

The most important job of a program chair, program committee, and external review committee is to deliver expert, fair, and thoughtful reviews

Kathryn S McKinley [2].

Although a person is not born with the knowledge or ability of how to be a good reviewer, the characteristics (*e.g.,* fairness, thoroughness, integrity) of that person certainly contribute to the activity. Unfortunately, it is rare to find a scientist whose formal training has incorporated instruction in the art of reviewing.

Benos, Kirk and Hall [3].

An article about computational science in a scientific publication is not the scholarship itself, it is merely advertising of the scholarship. The actual scholarship is the complete software development environment and the complete set of instructions which generated the figures.

Buckheit and Donoho [4].

Build a man a fire, and he'll be warm for a day. Set a man on fire, and he'll be warm for the rest of his life.

Terry Pratchett, Jingo, 1997.

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1. Introduction

Writing a review of a paper submitted to a journal or conference is a standard academic task. Likewise reviewing a grant proposal. The task has much in common with reviewing work in other contexts as well.

The results of the review process can have a profound effect on academic's careers. However, I have observed as an author, editor and program committee member and chair that too often the standard of reviews is low. We all have many experiences that bring this home – my most memorable one was being told my grant application was "too poetical." I hadn't even written it in iambic pentameter!

Much of the problem arises from asking over-busy people to do a thankless task again and again. I can't fix that. But one potential problem that can be addressed is the lack of education about what is required [3, 5]. Training in such tasks is usually left to individual graduate project supervisors, and its patchy at best. On the other hand, writing a review can provide insights into your own writing that is invaluable, and so should be done even by junior staff [6].

This document aims to lay out the process of writing a review. There are already several good reports on this topic, but I wanted something that I could adapt and grow with time according to my own understanding of the task, in part to improve my own standard which I do not claim has always been impeccable.

I started this with the ambition of writing a very short (2 pager). Its grown a little out of control. Sorry!

2. General Advice

In general, we should approach writing a review like any other professional task. There is a job to do, and you should approach it like a professional. The key task is to make a clear recommendation, and do it on time, but there is a lot more to cover.

Underlying this are a set of fundamental goals best stated by Allman [7]: clarity and consistency (of decision making), and fairness. However, these are somewhat abstract objectives. What follows is concrete advise on how to achieve these goals in the specific context of a review.

- **Know the guidelines:** [8] Each journal or conference (we will call these generically *venues*) will have specific processes for its reviews. A reviewer should know and follow these. But also, a reviewer should be aware of the guidelines for the authors, particularly the constraints under which they submit their papers, and the advice that the journal gives the authors. There is nothing more frustrating for an author than a reviewer criticising a paper for following the journal's guidelines. Space limits also compromise what an author can include in a paper. Be aware of these.
- **Reviews are confidential:** there is an assumption (either implicit or explicit) that work submitted to a journal or conference will be treated in confidence, *e.g.,* [1, 3, 9]. That is, reviewers must not speak of or write about the ideas. Moreover, you cannot (as a reviewer) use those ideas yourself until the work is actually published[1], and not using ideas you know about can be harder to do than you think. There are exceptions but they should always be discussed with the editor in charge of the paper.
- **Disclose conflicts of interest:** Reviewers should disclose and (usually) avoid conflicts of interest, *e.g.,* [1, 3, 9]. Journals and conferences sometimes have specific guidelines as to how to define a conflict of interest, but it is often obvious. If I have a reason outside of the article's quality to either wish it published, or wish it rejected, then I have a conflict of interest. This can arise because of a personal or business relationship with the author, or because of a personal or business agenda (*e.g.,* the work supports an idea I am otherwise being paid to promote). Conflicts of interest should be disclosed (for instance to the editor of the journal), but do not always rule out writing a review [6]. In some cases the conflict is minor, and in other cases all of the parties experienced enough to write a review would have some conflict. It is a question of managing these conflicts, and that is the job of the editor, not the reviewer.
- **Write a defensible review:** Most reviews are anonymous. This is so that, for instance, junior academics can write what they believe without fear or favour[2] about senior academics who might hold sway over their juniors future

[1] Pre-print archives alleviate this problem a little.

[2] We could argue about the merits of open review, but that's not the current process.

career. However, anonymity is *not* a license to do things that you would not do in public. I always write a review as I would if I knew it could be made public. That does not mean I shy from honest criticism, but it does impose a level of rigour on what I write, and I write comments politely, as I would if the author was in the room with me, and armed with a sub-machine gun.

- **Be constructive:** Criticism should be written in such a way as to help an author write a better paper [1, 10]. Constructive criticism doesn't just list problems, but also tells the author how to change the work to improve it. Definitely avoid things such as sarcastic or abusive comments or anything else unprofessional.
- **Be concrete:** It is not enough just to be positive, you need to be clear and concrete [1, 10]. Vague comments are not helpful. For instance, don't say "there is additional work that should be cited," say specifically what should be cited. I shall more about this in Section 5.
- **Be objective and impartial:** A review process must be fair. To be fair, it should be as objective as possible [1], otherwise it brings into doubt its own validity. Reviewers, for instance, should not seek to manipulate the process to advance their own ideas [3].
- **Approach the review with a positive attitude:** Too often we resent the time involved in reviewing, or otherwise find ourselves with a negative attitude. In reviewing for high-quality venues sometimes people feel they are the "defenders of the faith," and must preserve quality. Of course we do aim to preserve quality but the attitude you should adopt in reviewing is that someone has worked hard on their manuscript, and your job is to help them get their good ideas published. Try to see the big picture, and not get caught in the minutiae of little corrections. No plan survives contact with the enemy, but if you start with this thought in mind, then you look for the good in a paper, which results in a more constructive review, and you may find you enjoy reviewing more as well.

All of this requires work. More work than writing a sloppy and careless review. However, remember that in these days of "publish or perish," an author is engaged in a high-stakes activity in submitting their paper, and if you cannot be bothered being professional about the review, you don't deserve to be playing the same game.

Some commentators on reviewing [5] suggest you do three "readings" of a paper: (i) to get overall impression, (ii) to concentrate on nuts and bolts, *i.e.,* the detailed technical read, and (iii) (after a break from the paper) to look at presentation, but also to check your own view of the paper and revise your review. I agree with this approach, in principle, but you also need to be efficient. Sometimes one read is all it takes to see the critical flaw in a paper.

3. What is a Review?

The answer to "what is a review?" seems obvious, but it is not. Superficially it is a report describing the value (or lack thereof) of a submitted manuscript or project proposal, but we can be more specific about the types of values that are important in an academic or scientific context. Specifically, when we are reviewing we aim to assess several qualities. Each involves subtleties that are sometimes overlooked.

The qualities, roughly in the order of importance I think should apply, are listed below.

1. **Correctness:** [9, 11] There is, of course, a desire that published papers are "correct." A key task of a reviewer is to assess this. However, a reviewer cannot truly assess correctness. They don't (usually) have access to the data or code of the authors, and even if they did they would not usually have time to repeat all results in detail. So correctness is about determining correctness of process. We attack it through questions such as
   - Is the problem being solved clearly stated?
   - Is the stated problem actually solved?
   - Did the authors use the correct tools and techniques?
   - Are they aware of the limitations and assumptions implicit in these tools?
   - Is their sample large enough for the inference they are making?
   - Is their logic sound?
   - Are statements backed up by data or other sources?
   - Does it contradict other established work?[3]

[3] One has to be quite careful about this, because contradictions can be correct, and such works (when correct) are often the most valuable [1].

And there are other examples of such questions in [1, 5, 8, 9].

We primarily look for flaws in execution. An incorrect paper (one that doesn't meet these standards) should be rejected, or only accepted with major revisions (that are checked by a subsequent review). However, there are often minor discrepancies that are less serious, and we need to accept that most submissions will not be perfect in every detail we wish, and not reject every paper [1]. Space and time are limited, and no work is ever perfect but a reviewer can help improve the correctness by providing helpful feedback.

2. **Novelty:** Novelty is not originality. A paper should have novel content, but this is sometimes confused with the idea that all papers should be composed of only original ideas. Good science is built incrementally by building on the work of others, and from repetition studies. Synthesis of existing ideas into new tools is also very useful, as is transference of ideas from one field to another. However, authors should be aware of, and describe the context in which their work exists, and how their work relates to this context. And there should be something about the paper that adds to our knowledge, if only by confirming our existing knowledge.
3. **Reproducibility:** Good science is reproducible [8]. A paper should describe its experiments, tools and techniques at a level of detail suitable for a reader to be able to reproduce the results. This is not always possible within the constraints of sometimes short page limits, or the constraints of privacy ethics. However, there are ways to make a paper more reproducible (release of data and computer code are good examples) [4]. Or a longer version may be placed on an archive or other store to provide missing details. All papers should aim for high standards in this regard, and reviews should provide advice about how to improve the reproducibility work described by a manuscript.
4. **Presentation quality:** The quality of presentation of a work affects the ability for readers to understand it and gain knowledge from it. It also affects your ability to review it properly if the paper is too poorly written [1, 11]. This is often treated as a hygiene issue, *i.e.,* the paper is either clean or not. However, I believe that we should be providing more weight to well-written papers, and trying to help authors in all cases to improve the presentation of their work. In this regard concern yourself primarily with the quality of communication, not the adherence to strict (and often outmoded) English rules, though these play a distinct part in good communication.
5. **Importance or interest or significance:** [9, 11]. A final filter for papers is whether the work is interesting. There is an infinite pool of boring papers that satisfy the above criteria. Importance of the work should be considered. But note that "importance" is last in my list, because it is too often today treated by editors and reviewers as the prime criteria. This is foolish. Of course we don't want to publish boring and trite results, but it is intrinsically hard to predict what work will be truly important in the long run[4]. Moreover, this last filter is entirely subjective, and reviews should consist, as far as is possible, of objective and constructive criticism. There is rarely anything constructive in the statement "this work is not interesting." The true test of a paper's significance is how it impacts future research and applications, so let's allow that future to happen.

   A subset of this quality that is more objective is "does the manuscript align with the topics of interest to the journal or conference?" [11]. However, I find this is rarely an issue – authors are reasonably sensible about choosing venues, except in odd cases, which are usually easy to reject on other grounds as well.

   So, in general, I think of this criteria as a hygiene test[5]. Rather than looking for super interesting papers we should test that a paper is not boring.
6. **Ethical concerns:** It is not typical, but in reviewing a paper you may become concerned about some ethical issue. There are three broad classes of potential concern:
   - Scientific misconduct: misconduct formally [12] is considered to be falsification or fabrication of data; and plagiarising results (see below).
   - Authorship ethics (*e.g.,* see [13]): a submitted paper should be the authors' own original work, not previously published and giving appropriate credit to all involved. Double submission is also generally considered a no-no. Conflicts of interest between authors, publishers and commercial interests should also be disclosed.

[4] Some conferences have started to aware "Test of Time" prizes. For instance, they look at papers published a decade ago (in the same conference), and assess their long-term impact. This type of prize has *much* more meaning to me than the standard best paper prize.

[5] A person is either clean or not. Being extra clean is not that useful.

- Scientific ethics: in research where human or animal subjects are used, the research should be considered and approved by an appropriate Institutional Review Board (IRB) and evidence of this should be incorporated into the submission.

A reviewer is not always in the position to assess all of these, and is not expected to be able to do so comprehensively, but should bring any problems to the attention of the editor. Journals and conferences will often have their own specific ethics guidelines, *e.g.,* [13].

Please note that honest errors are not misconduct, and differences of opinion are common. Ethical questions must be handled with care as consequences for bad decisions can be serious (*e.g.,* career ending).

4. What Goes in a Review?

Many journals and conferences have their own form for a review, and this must be followed. However, I find it useful to keep in mind the key components of a review when composing it. These are:

- **Metadata:** I always start a review by reiterating the author, title and any reference number, just so that the review can't be misplaced.
- **A clear recommendation:** [1] the recommendation is the critical component of a review. *Make a decision*. Sometimes reviewers forget it, but more commonly, they are vague. Please make this precise, and map it to the categories for the specific journal or conference. Commonly it will be a points based rating (*e.g.,* 1-5, but make sure you calibrate your scores to the correct scale) or provide a recommendation of the form:
  - accept;
  - accept with minor changes;
  - major changes (implicitly requiring another round of reviews); and
  - reject.

  Some journals will have sub-categories, or just different categories. Adapt!

  Note that being too permissive or too accepting are both bad. Likewise rating all papers 3 out of 5 (or otherwise on the fence) is not useful. You are there to help create a dividing line [1]. *Make a decision.*

  Some academics believe the recommendation should be only reported to the editor, not the authors *e.g.,* [3]. I disagree! It is easier (for the reviewers and editor) to hold a secret court, but I believe that transparency of decision making is a key aspect of fairness. Nevertheless, you must follow the policy of the particular venue in question.
- **A short summary of the paper:** [1, 10] A short summary (1-5 sentences) to show what you believe the paper to be about is often helpful for an editor. It's like an extra version of an abstract, as seen from another perspective, and helps put context around the following comments.
- **A short list of the paper's key strengths (if any):** It's worth putting a short bullet list of 2 or 3 key strengths of a paper. It helps you approach the review with a positive attitude when you have to do this. It also makes sure that the author get's some positive feedback in what is likely to be a sea of negativity (from other reviewers).
- **A short list of the paper's key weaknesses (if any):** One difficulty for an editor or author when they receive a long list of criticisms is to determine which are most important, and which are least. Providing a short list of the main weaknesses (again a bulleted list of 2 or 3 is enough) aids greatly.
- **A critique:** [1] The main body of the review is usually a list of detailed criticisms of the manuscript. This is discussed in detail in Section 5.

The length of the critique depends on the quality of the paper. I find that it is longest for borderline papers. Really good papers often need little feedback, and poor papers often have a few important issues to deal with before they reach the detailed critique stage. So borderline papers that could be accepted, but need lots of work have the longest critiques.

It's hard to say much more because the details of this section depend so much on the particular journal, conference, topic, style and particular manuscript. However there are two useful points I think that can help:

1. Divide your critique in some way so as to give advice about which points are most important, and which are less. *e.g.,* major flaws vs minor flaws vs typos [5, 7, 10].
2. Make clear which are necessary changes, and which are stylistic suggestions [1].

Without these guides, authors and editors cannot easily disentangle the important pieces of a potentially long list of comments, or resolve contradictory comments from multiple reviewers (which happen more often than you might hope).

Finally, please ensure that your recommendation and your critique are well aligned [1, 10]. It is difficult for an editor to use a review where either

- there is a recommendation to reject, but blandly positive or non-committal criticisms; or
- a recommendation to accept, but strong negative feedback.

Avoiding these cases seems obvious, and yet not all reviewers do.

5. Concrete comments

The critique of a paper should be (as noted above) concrete and constructive where-ever possible [10]. For instance:

- don't say "it's wrong" – explain why;
- don't say "this work has been done before" without a citation;
- don't say "some claims are questionable." Any claim can be questioned, even if the answer is always "It's correct!" [14].

Also be specific: say exactly where and what should be improved (page, column and line number if possible).

Many other examples could be added, and indeed you could write an entire report just on this topic. However, I would rather introduce a thought process that would be helpful in general. I aim to think "what will or should the authors do with this comment?" The answer is that authors will "triage" the comments in some variant of the following manner:

- the comment is easy to fix, so just do it;
- the comment is hard to fix, but the reviewer raises an important point, and so this also should be assiduously addressed;
- the comment is confusing and hard to understand, so do something and pretend you have fixed the possible problem;
- the point raised is essentially unbounded (*e.g.,* discuss the paper in the context of Western philosophy in general and particular), or at the very least is about a different paper than the one we wrote, so we will argue for why the paper should not be changed in that way; or
- the comment is incorrect, but we have to find a polite way to say that without starting an argument with the reviewer.

Note that in each case something is done to "fix" the paper, but it might not be what you as a reviewer wanted done. *Clear, constructive comments result in the right behaviour from the authors.* Muddy, abstract comments result in confusion, and poor responses.

You may hope that a paper you don't like is going to be rejected, and hence it doesn't matter what the author does, but you need to provide helpful criticism because other reviewers (and the editor) may decide otherwise, but more generally many papers (even ones I don't like) get accepted somewhere.

The last bullet above is interesting. A good author will not respond to an incorrect criticism with a knee jerk complaint about the reviewer, but will think deeper about why the misunderstanding occurred, and attempt to edit their text to improve the clarity. This is still a good outcome. As a reviewer, you don't have to be 100% correct, as long as you listen to reasonable return arguments, and your editor interprets the ensemble of reviews appropriately. However, this is not an excuse to be careless!

6. What Not to Do and Be

The author's reputations, and your feelings about the authors, whether they be positive or negative are not relevant to the review of a manuscript submitted for publication[6] [1, 2, 15–17]. I have heard it said by senior editors that they look more favourably on a paper by X (where X was a very famous statistician). But this type of prejudice and discrimination – *that's what it is!* – leads to negative outcomes like disadvantaging early-career researchers and countries without large funding for research. Many conferences now have a strict "double-blind" or masked review policy where-by the authors are anonymised in submissions to avoid overt as well as unconscious bias[7]. They recognise that even the appearance of bias can have negative effects [15]! On the other side, the only good reason to preserve anonymity of *reviewers* is to preserve their ability to write a frank review with fear of reprisal.

Reiterating this important point, the authors of the paper should not matter. Likewise the institution and research group to which the authors belong. If it is not entirely obvious issues such as race, gender and religion of authors are completely out of bounds. The content is the thing being assessed. Bad content by famous people should be rejected. Good content by unknowns should be accepted. Thus reducing bias increases quality [2], however, blinding is primarily a means of enforcing a higher degree of *fairness* on a system that is implemented by (mostly) well-meaning but flawed humans. The reality and appearance of fairness is a crucial issue for the reputation of science as a whole.

A reviewer is not a copy editor [5]. Your job is not to correct typographical, grammatical and spelling mistakes. Inevitably we end up doing this to some extent, but I think of it as a favour to the author, not my job as a reviewer. And if a manuscript is replete with errors, then I will not review it, and send it back with only the comment that it is not in a suitable state for review.

A reviewer is not *the* guardian of ethics, though I do not mean a reviewer should ignore this issue (see above). It is perfectly reasonable and desirable to criticise ethical problems in a work. However, it is not the job of the reviewer to instigate proceedings against authors. It is the job of the editor and journal management to decide how ethical criticism should be handled. Moreover, accusations of unethical behaviour are usually treated *extremely* seriously, and so extra care should be taken when making such. A careless or ill-thought statement can have impacts on people's lives and careers.

Also Hanlon's razor – "Never attribute to malice that which is adequately explained by stupidity" – is useful. More often than not, a problem is the result of an oversight rather than a deliberate effort to defraud.

A reviewer does not have to review every component of a paper [6]. Sometimes a review's expertise is needed for a particular component of the paper. At an editor's discretion, a reviewer may work on just this component, otherwise it is exceedingly hard to obtain reviews for multidisciplinary papers. Reviewers should be clear about their areas of competence, however.

A reviewer does not have to be a senior academic. It is beneficial from all points of view to have junior staff [2, 6], and even students [18], participate in the review process. Junior staff often bring a fresh perspective and energy to the process [19]. They also avoid some of the problems with old fogeys like me having inflexible, fixed points of view. Junior staff can also gain valuable education in what it takes to publish papers by participating from the other side [2]. However, it can be helpful for junior staff to seek advice from mentors when they are learning, and this is one situation where I believe confidentiality may be bent, with the consent of the editor [3].

Your review should typically be anonymous, so do not do anything to reveal your name.

Your review should not be self-promoting. Think very carefully about suggesting to an author that they should cite one or more of your own papers (think about how it would look if the review were made public).

And a reviewer is not there to prove themselves. You don't have to "seem smart" or make comments to prove you did something. Just do a good review.

There are more bad behaviours reviewers can indulge in. Some are covered here, but a good summary of many of the others is given in [14].

[6] The authors may matter in some other contexts. For instance some grant applications specifically list the reputation of the authors as a criteria.

[7] There are objections to double-blind reviewing, for instance, as detailed in [2, 15], so it is not yet used everywhere, but its use appears to be increasing.

7. Other Issues

You may end up writing very many reviews. I have written hundreds (literally). This cannot take over your life, and so you must become efficient at it. Like any other task you become faster with practice, but also think about processes that help you. And while due care is needed, I do not try to craft the sentences of a review with the care I might in my own manuscripts.

A critical issue for an editor attempting to resolve contradictory comments (this happens more than you would think) is to have information about the level of confidence you have in your review. It seems desirably that all reviews are conducted by true experts in the particulars of a manuscript. However this is often impractical. Often in a niche, or in a rapidly evolving area, there are few such. And often they are busy with many other reviews, of have serious conflicts of interest with the current authors. Less expert (but hopefully still knowledgeable) people are sometimes tapped. The key issue is for the editor to understand the limits of your expertise, particularly with reference to sections of a work that are out of your field.

Sometimes a review form includes a section called "comments to the editor," or something similar. This is a section that can be used to write confidential comments that go to the editor, but not the author. This section should *not* be used, except for comments such as your confidence in your review, or to document potential conflicts of interest. An author has the right to understand as much as possible what information has been used to form a decision about their paper. They have a right to transparency. They probably have the right (in some jurisdictions) under freedom of information laws to obtain such comments. Don't use this to hide information from authors. It's sneaky, underhand and not the intention of this part of a form.

A paper should be assessed on its merits. This seems obvious, but often reviewers seem to review some other paper that they wanted to read, and complain that the current paper is not that. Cormode calls this "moving the goal posts" [14], but its worse than this – you are essentially saying that they are playing the wrong game altogether. The paper should say what it is about, and be assessed on that basis, not what you as the reviewer would like it to be.

A serious impediment to the rapid advancement of science is simply how long it takes to get work published [20]. Excessive delays can also damage peoples' careers [1]. A review should be timely [1, 3, 20]. Different venues have different expectations, but should should aim to adhere to the expected timeline, and agree only to reviews such that you believe this is possible [9]. But don't be lazy. The system only works when enough people participate.

Finally, but not unimportantly let us reiterate the goal of objectivity. A review should be objective as much as possible. A reviewer must be careful how much of their own "knowledge" (or really their own opinion) they bring to the review. You must bring something, or you are not an expert, but do not allow your beliefs and expectations to overrule the findings of the paper. Don't make a decision about the paper, and then justify it. Build the decision from the paper.

8. Conclusion

Many people contributed to my understanding of the review process over the years, but this report contains the resulting opinions of only one academic. It was written at least in part to help me firm up my own ideas about writing reviews, and thus improve my own standard of conduct.

It is backed up in places [1, 3, 7, 14, 21, 22], and it is interesting how much commonality there is in recommendations from different fields of research.

However, some of my opinions are clearly not shared by all academics (I have seen much evidence of that fact). However, should you disagree, all I ask is that you have a good reason. A reason you can articulate, and are willing to state in public.

There are some differences in reviewing a journal paper vs a conference vs a survey vs a tutorial vs a proposal [1], and we have not considered these in detail here. But if you try to understand the motivations for ideas discussed here, the differences should often be obvious.

It is easy to fail in performing your review well, and this is rarely treated with the seriousness it deserves. However, an author puts their life and soul into their work. To treat it carelessly is an abuse of power, and should be considered almost criminal. Above all, please follow the "golden rule" of peer reviewing, McPeek *et al.* [20] "review for others as you would have others review for you."

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