

Editorial

Tools for Writers

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1. Introduction

Communication of research results is an essential part of science, and publication is an essential part of communication. For readers, students, and historians of science, the sequence of ideas from one paper to the next traces the evolution of scientific thought. Writing helps sharpen one's scientific reasoning. For all these reasons, writing is an essential skill for a scientist.

It is commonly said that the introduction is the hardest part of a paper to write. For example, the website Grammarly has extensive discussion on this topic.¹ Although its advice is aimed at academic theses, which tend to be more expansive than journal articles, the main ideas are also applicable here.

The introduction to a paper is typically the first section, and it often consists of more than one paragraph. It typically has three parts.

1. Importance of the problem; why the reader and astronomers in general should care.
2. Survey of relevant previous work, with citations to specific papers. This part is essential to place your work in context.
3. The aim/thesis/main point of the paper in one or a few sentences.

If the paper is long and complicated or if its organization is unconventional, it is customary for the last paragraph of the introduction to provide a brief outline of what material appears in each section.

A good introduction doesn't always conform strictly to this model. For example, Maravelias and Kraus (2022) did a great job of stating the importance of their problem and providing a literature review along the way.

In this essay, the next section discusses part 2 above, and the third section part 1.

2. Writing the brief literature summary

If your expertise is still in development, you can also draw inspiration from (not copy!) text written by other astronomers

on the topic. Be sure to use your own words. It is sometimes possible to express other authors' ideas better than they did.

There is no need to go back to the dawn of the subject area. A good background source may be one that is a few years old and cited by several papers related to yours. In the review, include work you used to guide your research, but also provide context with parallel, independent results by others. You should not give a false impression of being the only game in town (Hughes, Benz, and Prato 2023). Deciding what to include takes judgment, and experience helps. As with other writing, it's better to include too much material than too little, because it's easier to remove material from a manuscript than to add. Once your submitted article reaches the peer review stage, an expert referee can help.

Don't just list references. Limit yourself to the most important ones, and briefly summarize each one's contribution to the field. Cadmus (2015) provides a nice literature summary in the section named "Background."

A helpful tool for searching the literature is the NASA Astrophysics Data System (ADS).² For any given paper, it links to both the papers cited by that paper and also those that cite the paper. Perhaps you have a reference paper for background, but it's a few years old. To find more recent work, use the "Paper Form" option in ADS to bring up the reference paper and click "citations" to find papers that cited the reference paper. If you want to look for review articles, you can search for the journal *Annual Reviews of Astronomy and Astrophysics* (bibliographic code ARA&A).

For more general searches, use the "Modern Form" option. You can search for papers by a given author, about a given star, or about a given topic/keyword in either the abstract or the full text. By changing my search options, I have at times found completely new information. I think of it as trying to see through a dense forest. Changing your line of sight will give you new views through the trees.

You shouldn't cite papers that you haven't at least skimmed. Therefore, following this advice involves reading a lot of papers. By so doing, you will acquire the familiarity with the topic that will give your introduction an expert feel. Don't worry if you don't understand every technical detail in every paper. With time, you'll acquire the skill of gleaning the information that you need and can understand, while leaving the more difficult

¹ <https://www.grammarly.com/blog/how-to-write-an-introduction/>

² <https://ui.adsabs.harvard.edu>

information for later. Not least, one of the best ways to learn to write is to read many papers.

3. Writing the first paragraph

Some writers have difficulty producing the first paragraph of an article. A useful starting point for such people—as for those whose native language is not English—may be a large language model such as ChatGPT.³ Much is being written, in many contexts, about large language models. Recently, American Astronomical Society Editor-in-Chief Ethan Vishniac (2023) has written a thoughtful, skeptical editorial about the applicability of ChatGPT to writing scientific papers.

I have only limited experience with ChatGPT. From a variety of reading, I understand that it is not trustworthy regarding factual material, because it is designed for mimicking patterns in existing texts, which may not be accurate. It is known to output false information, or to “hallucinate.” Another recurring theme is that it cannot be trusted to do literature searches.

It may be useful for producing “boilerplate” prose for an introductory paragraph. I tried it out with the question, “Why are RR Lyrae stars important in astronomy?” and received a chatty but nicely written, fairly sensible paragraph about period-luminosity relations, metallicity dependences, the cosmic distance scale, and so forth. I did not check whether this output was a verbatim copy of something on the Internet, nor did I try the prompt a second time to see how the output changed—tests that might have been instructive.

To my follow-up question about who has done research on RR Lyrae stars in the past ten years, it returned mostly nonsense. I have difficulty envisioning how this software could be helpful in writing a methods/observations section, an analysis section, a discussion section, or a conclusions section.

I also tried to use it to improve a paragraph written by a former student, with mixed results. The grammar and

phrasing were improved, but the logically poor sentence order was unchanged.

If you want to try using ChatGPT, or another large language model, you should do the following:

- Rigorously fact check the output.
- Restyle the output so that it harmonizes with your own writing style. Remember, I suggested using ChatGPT as a starting point. If your own grammar needs improvement, you might consider using the grammar checker on Grammarly, the website referred to above.
- In the acknowledgements section of the paper, describe how you used the large language model, as you would any other advanced software, and how you adapted the output.

Adventurous folks may want to try an open-source application such as LLaMA, which is advertised as a ChatGPT equivalent that can run on a high-end laptop.⁴ The fact that it is open source means that a specialist can decipher how the algorithm was trained and get insight into its workings.

Readers are encouraged to email me their thoughts about use of large language models. Best wishes for your writing!

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³ <https://openai.com>

⁴ <https://arstechnica.com/information-technology/2023/03/you-can-now-run-a-gpt-3-level-ai-model-onyour-laptop-phone-and-raspberry-pi/>

⁵ <https://aas.org/posts/news/2023/06/citation-ethics-publishing>