

SCIENTIFIC WRITING FOR THE BIOMEDICAL SCIENCES

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A – study design, **B** – data collection, **C** – statistical analysis, **D** – interpretation of data, **E** – manuscript preparation, **F** – literature review, **G** – sourcing of funding

ABSTRACT

Scientific writing is an essential part of a research scientist's career and is usually the end process of many years' hard bench work generating the data for publication. Clear communication of your research findings, the aims and potential importance of your work are the foundation of all good scientific manuscripts. Writing a scientific manuscript in English, especially if English is not your first language, can make an already challenging task even more difficult.

The purpose of this article is to assist authors in the preparation of manuscripts intended for submission to peer-reviewed journals. The article mainly focusses on the biomedical sciences, but researchers of other scientific disciplines can also benefit from the content. We provide useful advice on all the main subsections of a standard research manuscript, from selecting an appropriate title, through to preparing a properly organized discussion. Advice on how each section should be arranged as well as points to be avoided can be found in the guide. As a general guide the most important point of a manuscript is that the research findings contained are presented clearly and accurately without excessive repetition or embellishment. Finally, this article closes with a section which contains language mistakes which are frequently made by authors whose first language is not English.

KEYWORDS: academic writing, biomedical sciences, article sections, tips

INTRODUCTION

Writing a manuscript is an extremely challenging task, particularly if English is not your first language. It can take many weeks and months of drafting and redrafting to get it right. As researchers, we have acquired specific skills related to writing a good scientific manuscript, mainly through our personal experiences as well as those of more experienced co-authors and reviewers. We are also key members of eCORRECTOR, a company providing an expert scientific proofreading service, where we see, on a daily basis, the array of common language mistakes made by scientific authors. This article is designed for authors intending to submit their work for publication in international peer-reviewed journals. The article focuses on biomedical sciences; however, authors from most other scientific fields may also benefit from the advice it contains.

SUBSECTION-SPECIFIC ADVICE FOR A STANDARD MANUSCRIPT

The first part of the paper is, in fact, not the abstract, but the title itself. Although finding a suitable title

should be straightforward, it can often be one of the most difficult parts of a paper to perfect. The title should be concise, yet accurately describe the main findings of the study. In other words, it needs to be short, convey the main result, and be just broad enough, particularly if it will be submitted to higher impact journals. Essentially, a title needs to be a clear statement about your work. Avoid writing general statements (which are, admittedly, considerably easier to write). For example "Drug X increases dopamine release in the rodent prefrontal cortex" is a better title than "The effect of drug X on dopamine release in the rodent prefrontal cortex". This rule also applies to subtitles within the manuscript – if written properly, they will make your manuscript easier to read, and the results will be considerably clearer to the reader.

One of the shortest parts of the paper, namely the abstract, is usually subjected to the largest number of changes. They can be frustratingly minor, yet necessary when you want to include a strong message within the journal's strict word count. The most efficient approach is to write the abstract once you have a good working draft of your paper; during the writing process, the key

points of the paper will have become more distilled in the mind of the author(s).

A good abstract should summarize all the major aspects of your paper in a concise way. Since abstracts are short, stick to your main results rather than trying to cram in as many details as possible. Make sure that the abstract properly reflects your key findings, in addition to the implications of your results. A reader should be able to understand the message of the paper from reading the abstract alone. It is therefore crucially important to get this part of the manuscript right, as it is often the only part a reviewer will have access to before deciding whether to review the whole paper. It is also the first part any reader will look at to obtain information about the quality and content of the paper. Therefore, make absolutely sure that you have drafted and proofread it several times until you are completely satisfied with the text. The closing sentence of a good abstract will identify the implications of your research, for example advances in clinical diagnoses, novel drug effects, or new pathological mechanisms.

Most journals have their own submission guidelines for writing an abstract, and it is crucial to adhere to these guidelines. The following guidelines are taken from the journal "Biological Psychiatry", which, in our opinion, provides a helpful structure to follow [divided into Background, Methods, Results, Conclusions].

An introduction does not need to be long, and it should never become an extended review of the literature. There is no point in trying to impress reviewers with your subject matter knowledge; the key is to be concise and to cover the key points pertinent to the aims of your research. Basically, the introduction should ideally provide a clear and coherent description of the background literature with appropriate referencing of the main claims. It should establish the context of the current work in relation to previous research. The scope and objectives of the study should also be explicitly stated. In addition, details of the methodology and rationale for using it might also be included. It is extremely important to justify the significance of your study and the reasons for carrying out the research. The introduction is where you must make sure the aims and hypothesis are explained clearly. Good examples of grounds for carrying out your work may lie in the extension of previous work, a gap in understanding a particular phenomenon, or resolving a contradiction.

Authors may find following this general structure helpful when preparing their introduction. The first paragraph should be a general presentation of the problem and a discussion of why it is interesting from the academic viewpoint (is it related to energy storage, drinking water, pharmaceuticals, specific diseases, consumer technology, sustainability, food production, etc.?). The following two to three paragraphs should describe in more detail the previous research projects carried out by different scholars with an interest in this problem, as well as related achievements to date of both other teams and your own (try to reference your work in an

appropriately balanced manner). The final paragraph should outline the aims and objectives of the article, along with the overall hypothesis put to the test.

The **materials and methods** section should be relatively straightforward and less time-consuming. Short, sharp sentences are often useful here, as the style of this section tends to be rather dry. The most important aspect is that it contains all the necessary information required for another scientist to replicate your experiments and cross-check your results.

Generally, there are established standard operating procedures that may be revised to reflect the experimental protocol used in the study. It is acceptable to reference previously published methods as long as this is done accurately and the reference contains complete information. If you have a complicated experimental paradigm or numerous experimental groups, it may be wise to describe your methods/structure of experiments graphically, e.g. in the form of a table or a flow chart.

If an ethical statement is required, for example due to the use of laboratory animals or human volunteers, this should be stated clearly. Many journals have their own preferred way to phrase this part, usually mentioned in the guide for authors. It is important to include a separate statistics file describing the statistical analyses used.

The results (and discussion) sections are the heart of any research article. There is often a great deal of flexibility about the arrangement of the results, the order in which they are described, the contents of a figure, and what has to be described within the text of the results. It is down to the author(s) to decide how to structure this particular section to best reflect their goals. The paragraph below mentions some pieces of advice we have found particularly useful when preparing our own papers and editing those of others.

First, it is crucial to make sure the results are organized in a logical order – not necessarily the chronological order in which the study was carried out. It is often helpful to break down your results section into smaller 'bite-size' subsections. This helps to create a rational flow for your results, as they become more in-depth as you progress further. It is widely considered more appropriate for subsections (and titles of figure captions) to be expressed as statements, i.e. "d-tubocurarine induces spike and wave seizures" rather than a vague caption such as "The effect of d-tubocurarine" (see title). When preparing the results section, it is paramount to remember that this section should be written objectively, with all opinions and evaluations left for the discussion. Interpreting your findings should be avoided; however, it is perfectly acceptable to include statements such as "In line with previous findings, we observed..... (citations)."

The results section goes hand-in-hand with the figures used – it is considerably easier to write the results if they are supported by figures. Use this as the foundation for writing your results. It is important to keep this section concise and avoid repetition of what is shown

in the figures and tables. In particular, the numerical values shown in figures/tables should not be repeated in the body of the results section. Beginning the preparation of results by arranging the figures ensures that there is sufficient data to clarify a logical order for the points raised, as well as to warrant publication in the first place. Preparing figures is often the most time-consuming part of the writing process, since it ultimately involves statistical analyses to test research significance. Make sure you use appropriate statistics and tests for normality. Statistical differences are the core of most papers, and reviewers are always asked to comment on whether the correct approach has been used.

When creating figures, it is crucial not to place quantity over quality. There is little benefit for the reader or the author to have a manuscript with 10 single-graph figures when they could be combined into just a few far more comprehensive figures. Ideally, each figure should be a stand-alone result that conveys a particular message. It is important to note that figures, as well as tables, should be self-explanatory, which means that the reader should be able to fully understand the information presented without having to go back to the text. In particular, all abbreviations need to be defined either in the caption or in a footnote. When readers have read through all the figures/tables, they should be able to understand the complete message of your work. Moreover, authors and editors have to ensure that the figures/tables are internally consistent in terms of layout and numbering (i.e., A, B, C – a, b, c – i, ii, iii). It is advisable to check the guidelines of your target journal in this regard.

A useful piece of advice given to one of the authors during their PhD research was that a reader should be able to read your discussion without having read the rest of the paper and be able to understand the main purpose, findings, and importance of your work. Therefore, the first paragraph of the discussion should be a concise summary of key research results – the most important findings, presented in a logical flow. Try to write in a concise manner and do not repeat yourself, unless it is a summary paragraph. Providing the same argument more than once, if not for the purposes of development, is a sign that the discussion has not been constructed properly. The authors should also ensure that the findings are discussed appropriately in terms of other published works. There are several questions that should be answered in this section, e.g., whether the results are consistent with other works or whether they differ, and if so, in what way? It is possible that methodological/analytical differences may account for this. Furthermore, it is customary to end this section with a few closing remarks on the broader significance and future directions of the research presented, preferably regarding the possibility of advancing our existing understanding of a process or new applications.

As you discuss your results, make sure to keep the original purpose of the paper in mind and try to bring the discussion back to this point wherever possible. This

will make the paper seem more focused and reinforce the relevance of the work to the reader. This section is certainly not the place for digressions and introducing new ideas. It is easy to fall into the trap of following a potentially interesting, yet new, idea and then venturing into an area outside the original scope of the study. It may be a wonderfully written paragraph, but in the context of the paper, it might not be as relevant as initially thought. Although it may seem painful, after all that hard work, it is better to remove such unnecessary paragraphs and save them for a different publication, grant application, or review.

It is crucial to realize that a research paper – despite the significant effort put into preparing it – might not be perfect. Whilst you do not want to draw attention (either your own or that of the reviewers) to the shortcomings of your own study, it is important to be slightly self-critical. After perfecting the content of the publication, authors must reassess it from the viewpoint of possible limitations and areas that might be interpreted more cautiously. The last stage of writing a paper is re-checking it structure-wise, e.g., checking whether paragraphs and subsections are constructed properly. Long paragraphs (20 lines or more) or many short paragraphs (five lines or fewer) make reading difficult. This is also the last opportunity to arrange the text in a logical manner so that it essentially tells a story consisting of the main points of your work.

A good research paper is concise, straightforward, and avoids the use of any unnecessary “filler words”. Or, in the words of Antoine de Saint-Exupéry: “Perfection is achieved not when there is nothing more to add, but when there is nothing left to take away”.

COMMON LANGUAGE MISTAKES IN SCIENTIFIC WRITING

It is beyond the scope of this paper to provide a comprehensive list of language-related mistakes in scientific writing. Our experience at eCORRECTOR demonstrates that even native English speakers frequently introduce errors into their papers if their language skills have not been consolidated along the way. Using a specialist proofreading service is the most efficient way of making sure that the publication is ready for print. It is advisable to let someone else read the paper: our minds tend to overlook the logic-related gaps in structures we have created ourselves. Despite our shortcomings, each author can perfect his or her work language-wise by following a few simple steps.

1. Keep your writing simple and straightforward. Long sentences with several subordinate clauses often lead to confusion. They may be perfectly clear in your native language, but ambiguous when put into English. It is best to split up such sentences into two or three shorter ones, making sure that the meaning of words such as ‘substance’ or ‘process’ is obvious. If there is more

than one complex, it is possible to refer to these as ‘complex 1’, ‘complex 2’, etc. On the other hand, using only short, single-phrase sentences may seem somewhat immature. This aspect of the text must be balanced – conjunctions are indispensable when it comes to structuring the flow of thoughts within your publication.

2. The bulk of a paper, including the experimental methods and results, is generally written in the past tense. Shifting between past and present tenses in the middle of a description should be avoided.
3. Misplaced apostrophes, such as in ‘Alzheimers’ disease’ (should be ‘Alzheimer’s disease’) or ‘Both precipitate’s were...’ (should be ‘Both precipitates were...’), are a common source of misunderstandings. Similarly, in statistics, it should be a ‘Student’s t-test’ with a capital letter and an apostrophe, since ‘Student’ was a pseudonym used in research.
4. When denoting decimals, for Polish readers, a comma (,) is used rather than a decimal point (.). This mistake can be dangerous if the target reader assumes the English manner of writing numbers. Stating ‘Carefully add 1,250 g of the unstable catalyst’ when this should be 1.250 g, might lead to one thousand two hundred and fifty grams being added, when it should be just one and a quarter. All English-speaking countries use full stops (periods) to separate decimals.
5. Another frequent problem is the misuse of ‘made’ where ‘carried out’ or ‘run’ is needed. For example, ‘The experiment was made under both acidic and basic conditions’ should in fact be ‘The experiment was run (performed) under both acidic and basic conditions.’ In English, we *make* a cake or *make* a noise, but *carry out* or *run* experiments. Many researchers, including senior investigators, also make this mistake when talking about their PhD and say ‘when I made my PhD research’, whereas it should be ‘when I carried out my PhD research’.
6. Linking devices must be checked for their function, as it is easy to misguide the reader by using “furthermore” or “consequently” in the wrong context.
7. Mixing UK and US English spelling is probably the most common inconsistency in academic papers. This can be improved easily by running

a spellcheck in a text editor. This may also identify many other typos or errors in the text. It is also important to keep in mind that in American English, a comma is placed before “and/or” in lists, the so-called “serial comma”, which is omitted in British English.

8. Although it is acceptable in most forms of writing, contractions such as “we’re” or “it’s” should be eliminated from academic publications. It is tempting to use them and shorten the word count but definitely should be avoided.
9. Each language has its own sentence structure. Some are appositional, meaning that the word order is less fixed and the meaning may be decoded largely based on inflectional endings, while others – including English – require a specific way of forming sentences. It is crucial to check whether each sentence has a clear subject, verb, and object in the correct order.
10. The so-called false friends, or *faux amis*, are a constant source of trouble when searching for the correct equivalent in a foreign language. For instance, the word “eventually” causes many misunderstandings among Polish scholars, due to the association with the word “ewentualnie” [alternatively]. The correct meaning of this English word relates to the outcome, not to the alternative.
11. Authors (both native English speakers and scientists from non-English speaking countries) are frequently confused about when to write out numerals. As a general rule, numbers up to nine are spelled out, while numerals are used from 10 onwards, unless associated with a unit of measurement/time, in which case numerals are used (except at the start of a sentence). Numerals are also acceptable in a list, especially a list with numbers both lower and higher than 10.

As mentioned before, this list could be expanded to include a wider array of aspects to consider while revising a publication. Since English is considered to be the *lingua franca* of the scientific community worldwide, most papers are prepared in this language. Reviewers are trained professionals with a mission to fish out articles with the greatest scientific potential. Going through the points mentioned above increases the probability of receiving positive review results, since the findings will be presented in a confident and considered manner.

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