

Lesson:03

The components and stages of writing an article.

Anyone who has gone through the ordeal can confirm this: writing a first scientific article is one of the most difficult and frustrating experiences in a researcher's career. Synthesizing complex research work in a few pages, in a clear and concise manner, may seem at first glance to be an impossible task. Fortunately, by approaching the problem one step at a time and in a structured manner, writing an article becomes much simpler. Additionally, the writing process will, over time, become easier and easier.

A scientific article is generally composed of the following parts:

A title

A list of authors and their affiliations

A list of keywords

An abstract

An introduction

A literature review

A methodology

A presentation of experimental results

A conclusion

A short paragraph of acknowledgments

A list of bibliographic references

A series of appendices

The body of the article is normally made up of parts from the introduction to the conclusion. These parts typically correspond to separate sections presented in this order, each answering a different question:

1. The title

A good title should adequately describe the content of the article, without being too long or too short. The following guidelines can be used when selecting the title:

*Choose a title that will attract the reader's attention and arouse their interest.

*Aim for between 10 and 12 words.

*Use words that highlight the field or application of the research, and its originality.

*Choose words likely to be the keywords of a query in a search engine. For example, the standard keywords of an application or approach.

*Avoid unnecessary words such as “Observations on” or “A study of”.

*Avoid abbreviations and symbols.

*Avoid qualifiers such as “new”, “novel”, “better” or “improved”.

2.2. The list of authors

If the article has several co-authors, it is necessary to determine the order in which their names appear in the article. Seemingly banal, this decision can be a source of conflict because the order of authors is often associated with the importance of their contribution to the work. In particular, greater recognition is traditionally given to the first author on the list, which may advantage that author when applying for scholarships or grants. The rules used to determine the order of authors vary from one research team to another, and this order is normally chosen by the team director.

The rules most often encountered are as follows:

Order of contribution

Authors are listed according to their contribution to the preparation of the article or to the funding of the research, going from the greatest contribution to the least. Some supervisors will intentionally put students on the project as first authors, in order to increase their chances of getting a grant.

Alphabetical order

To avoid conflicts, some people will prefer to put authors in alphabetical order by their last name. This rule is also used for articles with a large number of authors.

Other Considerations

Other rules may also be used to determine the order of authors. For example, in the healthcare field (and, by extension, in biomedical engineering), it is common for the team director to be placed last, which gives them special recognition.

It also happens that authors are sorted according to their affiliation (e.g., university, department, etc.) or their role (e.g., student, supervisor, co-supervisor, etc.).

3. The abstract

The summary plays an essential role in an article. On the one hand, it serves to arouse the reader's interest and quickly remind them of the nature of the work. A good summary will encourage the reader to read the entire article, while a poorly written summary will have the opposite effect. On the other hand, while access to the full article is often limited, the abstract is normally available without restriction. A good summary should be a condensed version of the article, following the same structure as the article and highlighting the main points of each of its sections. Here are some instructions to follow when writing the abstract:

*The abstract must clearly mention the following elements:

*The context and the research problem.

*The objectives and main contributions.

*The main stages of the methodology (e.g., experimental framework, analysis approach, etc.).

*The most important results and conclusions.

*The abstract must clearly highlight the original and innovative aspect of the work.

*The abstract must respect the length constraints imposed by the journal or submission system (typically between 150 and 250 words).

*The abstract must be independent of the article, and should be able to be read without having to consult the latter.

*The summary should not be a second introduction. That is, it must be a complete summary of the article and include the methodology, results and conclusions.

*The abstract should not contain references to the literature, figures or tables in the article.

*The summary should not contain acronyms or abbreviations unless they are known and conventional.

Keywords

Most conferences or journals require authors to provide a list of 3 to 10 keywords that will be used to classify and index the article. Just like the title, the choice of this list is important because it will allow readers to find the article more easily, from a query related to the same theme in a search engine. Follow these instructions for choosing keywords:

*Do not separate compound words forming a single semantic unit. For example, we would put the compound word wireless communications in the list, instead of the words wireless and communications separately.

*Include all important words (single or compound) from the title and abstract. In some cases, it may also be relevant to include important words from the journal or conference title, for example, the compound word environmental science for the International Conference on Energy and Environmental Science.

*Use the plural for keywords designating a quantifiable element. Thus, we will prefer networks to network.

*Avoid unconventional abbreviations and acronyms. For conventional acronyms, one can also add the spelled form of the acronym as a compound word. For example, we would put the acronym VCSEL and the compound word Vertical Cavity Surface Emission Laser as two separate keywords.

*Do not link, if possible, compound words with a hyphen. For example, put knowledge management instead of knowledge-management.

*Respect the constraints of the conference or journal (e.g., minimum and maximum number of key words, lowercase or uppercase letters, alphabetical order or importance, etc.).

5. The introduction

Being the first section encountered by the reader, the introduction can have a significant impact on their perception of the entire work. A poorly written introduction, or one in which the motivations, objectives or contributions of the research are not clearly described, will leave a bad impression on the reader. It is therefore important to pay particular attention to this section.

A good introduction typically contains the following parts:

Context

The introduction normally begins with a general presentation of the context (e.g., domain, application, process, etc.) in which the research takes place. The role of this part is twofold. First of all, it naturally leads the reader to the specific research problem. Then, it serves to motivate the research by describing the importance of its context.

Problem

Once the general context has been established, it is necessary to identify more precisely the problem or question specific to the research presented in the article. For example, it could be a limitation of existing approaches, a new or different application, an open question, etc. Once again, it is necessary to emphasize the importance of the problem targeted or the question addressed by the research, so that it is not perceived as simplistic or useless.

Contributions

The following part serves to describe the approach proposed to answer the problem or research question. The objective is not to describe this approach in detail (this will be done in the Methodology section) but rather to present its broad outlines, emphasizing its advantages and innovative aspects.

Outline of the article

It is common to end the introduction by presenting the structure of the rest of the article.

6. The literature review

As its name indicates, this section is used to present the main works in the literature on the same subject as the article. The objective is not to provide a complete overview of the work in a field, as done in a Literature Overview type article, but rather to situate the contributions of the article in relation to previous work. This section also demonstrates to the reader their knowledge of the field. Respect the following guidelines when writing the literature review:

*Focus on recent works, if possible considered to be the state of the art for the targeted problem, and on those (perhaps less recent) which contain the ideas closest to those used in the article.

*Limit yourself to quality publications, in reputable journals or conferences. This means that you have to read the referred articles! *Structure the work coherently, for example, according to the approach they propose or their application.

*Identify the respective advantages and limitations of the works cited.

*If the same authors have published several articles on the same subject, cite only the most recent work or that which is most closely related to the article you are writing.

7. Methodology

This section normally constitutes the central core of the article. It is in this that we explain in detail the main elements of his research, the stages of its realization, as well as the experimental approach used to validate his hypotheses.

Structure and titles

Methodology is very often the longest and most complex section of an article. It normally contains several subsections and it is not uncommon to even have sub-subsections. It is therefore important to structure your presentation well, so that the reader can follow and understand each of its parts, without having to go back or read another section.

To make it easier for the reader, it is necessary to choose meaningful titles for the subsections. A good title should give a clear idea of the content of the subsection, using as few words as possible.

Notation

Scientific articles often use mathematical symbols to identify different variables, constants, parameters, etc. of the research method.

The use of such symbols greatly simplifies writing, but can also confuse the reader, particularly if the reader is unfamiliar with the notation used. To make reading as easy as possible, you must make sure to present the notation at the beginning of the methodology. This corresponds to: Specify the general rules of notation. For example, it is common to use a capital letter to designate a matrix, a bold lowercase letter for a vector, and a lowercase letter for a scalar

Define each of the symbols used in the methodology, specifying its type (e.g., number positive integer, $m \times n$ matrix of real numbers, etc.) and its role (e.g., meta-parameter of the model, variable representing a certain element of the model, etc.)

Theoretical framework

Before describing its research method in detail, it can be necessary to present the theoretical framework on which this method is based. The latter is composed of general principles recognized in the field, which are used or adapted in its own method. The objective of the theoretical framework is twofold:

- *Motivate one's own work by linking it to recognized concepts

- *Lighten the presentation of one's method by referring to work using the same concepts

Description of the method Once the notation and the theoretical framework are presented , we can then describe our own research method. Depending on the nature of the research, this description may contain the following elements:

- *The main stages of the methodology (e.g., analysis, design, implementation, etc.).

- *The major components of the system or experimental setup, as well as their role, properties, etc.

- *Calculation processes in the form of equations, circuits or algorithms.

*The theoretical characteristics of the method (e.g., independent variables, dependent variables, treatment of confusing variables, etc. in the case of mathematical modeling, or complexity in terms of calculation time and memory, etc. in the case of an algorithm).

*The following advice should be considered when describing the method:

*To facilitate the reader's understanding, present the general principles of the method before its details. For example, we can illustrate the method using a conceptual diagram and describe the different components of this diagram.

*Ensure the reader has all the details necessary to reproduce the work described in the article.

*Justify your choices of analysis, design, etc. using theoretical arguments (e.g., mathematical proof), recognized principles or empirical data (in this case, these must be abundant). Cite works from the literature if necessary.

*Center the content of this part around the research objectives and contributions presented in the introduction. The main contribution should thus occupy a larger part than the minor contributions.

Experimental protocol

*As the number of research works continually increases, the experimental validation of this work becomes more and more important. Consequently, even if an article offers original contributions and good results, it can still be rejected if its experimental protocol is incomplete or inadequate.

A good experimental protocol should therefore have the following two properties:

Sensitivity and Specificity

The experiments must make it possible to validate or invalidate an initial hypothesis. The experimental conditions must therefore ideally have been controlled to properly measure the desired effects (sensitivity) and only measure these effects (specificity).

Reproducibility

As with the method description, it is essential to provide all the necessary details to repeat the experiments described in the article and obtain the same results or conclusions. This may include: The data used in the experiments, the nature of

this data and its sources. If this data comes from simulations, describe the process and parameters used to generate it. The environment in which the experiments were carried out. For example, if the tests were carried out by computer means, specify their hardware and software characteristics (e.g., number of processors and their speed, quantity of RAM, programming language, etc.). If the tests use measuring instruments, all their relevant characteristics will be specified (e.g. brand, precision, method used, etc.).

*The different approaches tested, as well as the parameter values used during the tests.

*Metrics used to assess the validity of the approaches tested.

Relevance

*An equally important property of the experimental protocol is its relevance. Characteristics common to relevant protocols are as follows:

*The data corresponds well (e.g., size, complexity, etc.) to that which may be encountered in the research application.

*The approaches used as comparison standards are considered state-of-the-art.

*The procedure for determining the parameters of the tested methods is non-biased, so as not to favor certain methods to the detriment of others.

*Evaluation metrics are those commonly used for the problem in question.

8. Results

The role of this section is to present its main results and analyze them according to the questions and hypotheses of its research. The results are normally presented in the form of tables and figures, the sequence of which respects a logical order. For example, this sequence could correspond to different experiments, each aimed at a certain research question or used to study a certain property of the proposed approach. The text in this section should follow this same sequence and, by referring to the tables and figures, highlight the results necessary to answer the research questions and hypotheses.

Tables and Figures

After reading the title and abstract of an article, many readers will directly consult its tables and figures to decide whether it is worth reading or not. These tables and figures must therefore be visually interesting and easy to understand

without having to refer to the text. Here are other instructions to follow when developing tables and figures:

*Limit yourself to tables and figures directly related to the research objectives, questions and hypotheses.

*Do not use tables or figures if their content can be easily presented in the text.

*Create a legend for each table or figure which, without being too long, allows its content to be understood without having to refer to the text.

*Put the legend above the tables and below the figures (or, where appropriate, follow the instructions provided in the conference or journal template). *Ensure that all tables and figures are cited in the text, and that they are numbered according to their order of citation.

*When referring to a specific table or figure in the text, capitalize the first letter. For example: “As shown in Figure 1...” or “See Table 1 for...”.

*Avoid tables and figures that exceed the permitted width or height. *If the content of a table or figure comes from another article, cite that article in the caption. If a figure is reproduced in its entirety, ensure that you have permission from the copyright holder of that figure.

*Use a figure as often as possible to illustrate complex diagrams, instead of explaining these diagrams in words (i.e., a picture is worth a thousand words).

*Choose a table instead of a figure if the exact value of a result is more important than its trend or the relationships it expresses.

*Order, if possible, the columns and rows of a table in a logical sequence.

*Choose titles for table columns and/or rows that highlight their role.

*Avoid horizontal or vertical lines within a table as much as possible.

*Produce graphics and illustrations on the computer, never by hand.

*Put any detailed explanation of a figure in its legend and not directly in the figure.

*Avoid colors to distinguish the elements of a figure (e.g., the curves of a graph) because the article could be printed in black and white (unless it is, for example, an article on generation or perception of colors). Instead, distinguish these elements using different styles (e.g., dotted lines, different fonts, etc.).

*Use informative titles to identify the axes of a graph. Specify the axis units next to these titles.

Statistical analyzes

Results must always be interpreted objectively, without extrapolating or seeking conclusions not supported by them. Thus, a reader should normally be able to arrive at these conclusions on their own, if presented with these results objectively. A conclusion that seems a priori supported by the results may, however, prove to be erroneous if it does not have the required statistical significance. This error is often encountered in comparing different approaches, where an approach is declared the best if its average performance over a number of tests is greater than that of other approaches. However, if the number of tests is very small or the standard deviation of the results is very large, these results may be largely due to chance.

To avoid these kinds of errors, it is recommended to use statistical hypothesis testing. To carry out such a test, you must first formulate a hypothesis (called the null hypothesis) related to the question you are trying to answer.

Interpretation of the results

It is generally not enough to analyze the results using statistical tests; they still need to be interpreted. For example, a statistical test could indicate that on average, calculation method A gives results closer to reality than calculation method B, with a confidence level of 95%. However, the test does not give any interpretation of the result, that is to say no information on why method A is better than method B. It is therefore wise to put forward plausible explanations (based on on the methodological details of approaches A and B, and on the characteristics of the data they process) for the results obtained.

9. The conclusion

The conclusion serves to summarize the objectives, contributions and main results of the research. This section typically has the following three parts.

Reminder of the objectives and contributions

The conclusion often begins with a brief reminder of the objectives and contributions of the research. Even if these elements have already been stated in the introduction, they may have been forgotten while reading the article.

Additionally, having now read the article, the reader is now able to better understand and appreciate these goals and contributions.

Summary of key results and main conclusions

The following part helps answer the research questions or evaluate the achievement of the objectives, by highlighting the key results of the article and its main conclusions. This part should address the following questions:

*Do the results help answer the research questions or confirm the hypotheses?

*How do the results compare with those in the literature?

*If certain results go against the initial research hypotheses, how can we explain these results?

*In light of the results, what are the strengths, weaknesses and limitations of the research or the proposed method?

*What are the main implications of the results?

Future work

It is customary to end the conclusion by suggesting future work to answer new or additional questions raised by the research. If the work described in the article is part of a multi-stage research project, we can also mention what the next stage will be.

10. Acknowledgments

Between the conclusion and the references, you can insert a short paragraph to thank the people (other than the authors) and organizations who helped carry out the work.

Contributions that may be recognized are: Advice or assistance that has had a significant impact on the advancement or scientific value of the work. In the case of a journal article, this may include suggestions offered by referees.

*Funding from a public or private organization.

*Data used in the experiments, which were provided by other researchers, an organization, or a company (in some cases, this type of contribution will guarantee a full place in the list of authors rather than 'a simple thank you).

*The implementation of a method developed by other researchers, in the form of a program or source code, as well as any help to understand this method

11. The bibliography

The bibliography of an article contains the list of articles, technical reports, theses and other publications cited in this article. The following instructions should be considered when developing this part:

*An article must contain a bibliography and refer to works other than those of the authors. Even a short conference paper should normally include at least 5 references.

*Limit to references having a direct link to the work described in the article. Except for Literature Overview articles, an article should not have much more than 40 references.

*Ensure that each reference included in the bibliography is cited in the text of the article. *Respect the style imposed by the conference or journal (e.g., ACM, APA, IEEE, etc.).

A style specifies, among other things:

*The order of references (e.g., alphabetical, citation, etc.) in the bibliography.

*The format of the in-text citation. For example, (Aras et al. 2006).

*The format for the name of the authors (e.g., S. Aras or Aras, S.), etc.

*Avoid, if possible, citing unpublished work. Identify articles accepted but not published with the mention “in press” or “forthcoming”.

*Do not cite personal communications unless they contain essential information not available elsewhere. Ask the author’s permission before including these types of references.

12. Appendices

An article can sometimes have one or more appendices, located at the very end, which present certain important elements (e.g., results in the form of tables or figures, diagrams, mathematical proofs, etc.), but not essential to understanding of the article. This type of appendix is most often found in journal articles, where length constraints are less restrictive.

Here are some guidelines to follow for appendices:

Append only those tables or figures that support the conclusions of the article but are not essential to its understanding. You should not have to consult an appendix while reading the article.

To avoid breaking up the layout, consider appending large tables or figures.

Be sure to refer to the appendices in this body of the article and, if possible, provide a short description of these appendices in the text.