Scientific Writing: Structure, Format, Style and Other Attributes of a Research Paper[[1]](#footnote-1)

B. Mohan Kumar

B. Mohan Kumar, School of Ecology and Environment Studies, Nalanda University, Rajgir, Dist: Nalanda, Bihar 803116, India, Email <[bmkumar.kau@gmail.com](mailto:bmkumar.kau@gmail.com)>.

**Introduction**

Communication is central to the development of science. We know about the work of all the great scientists because they published their results. The difficulties caused by not recording knowledge in writing are dramatically illustrated by the famous Inca civilisation (Rosenfeldt, 2000). It is now well known that the Inca Empire flourished in South America from 1200 to the late 1500s when it was destroyed by the Spanish invaders, the *Conquistadors*. The Incas were fabulously rich in gold. They built some of the most amazing stone buildings ever constructed using stone blocks weighing up to 200 tons and fitted together so closely without the use of mortar that, even now, a razor blade cannot be inserted between the blocks. However, our understanding of the methods they used to construct their buildings is fragmentary as is our knowledge of their beliefs and customs. Furthermore, the location of their most famous city, Machu Picchu, remained unknown for 400 years after the death of the last Inca king.

How could this happen considering our detailed knowledge of the much older civilisations of Greece, Rome and Egypt? The reason was that the Incas did not write. The Inca’s lack of a written record was not accidental. The Inca *King Parachuti VII* banned writing because during his reign he concluded that writing spread corruption to his people from surrounding tribes. Accordingly, the use of letters and parchment was banned under pain of death. One Inca leader who dared to develop written characters was burned alive. From then onwards the only form of non-verbal communication allowed was the use of coloured threads with a system of knots. This primitive communication system failed to stand the test of time and consequently much of our knowledge of this great civilisation is still little better than conjecture (*cf* Rosenfeldt, 2000). The Incas did not publish and much of their knowledge perished.

Failure to publish can cause knowledge to be lost today just as in Inca times. Writing or talking about the research helps us to clarify our thoughts and present the research in a wider context (Olshansky, 2003; Nair, 2005). In particular, writing helps us organize our cognitive processes and develop logical arguments. Writing helps clarify dilemmas and sometimes even raise further dilemmas in the hopes that others will be motivated to continue to grapple with the dilemmas and to write in an attempt to clarify. Thus, communication of research results is an integral part of the research process. The most recognized way of doing that is through well presented research publications. The ‘publish or perish’ dictum has been around for a long time. Perhaps the rule is more strictly followed now. Scientists of all categories, particularly those in their early career stages, are under increasing pressure to publish. Thus, publishing research results is important to a scientist for professional recognition and career prospects. It is also important to the community of scientists for advancement of knowledge in the discipline. The publication of scientific results seeks to accomplish both institutional and individual goals. A research paper not only extends understanding of phenomena and theories that the current paradigm deems worthy of study, but also helps support or establish the personal reputation of the writer.

In order to get published, papers should be written well; but many writers, especially early-career professionals, have difficulty with that. As in everything else, getting published is a highly competitive endeavor (Nair, 2005). Most journals receive more papers than they can publish; the more prestigious a journal is, the higher the number of submissions received and rejected by it. Poorly written papers will be the first ones to be rejected. With the explosion of electronic publication and retrieval facilities, readers today are faced with an enormous array of publications. If your article is to be read, it must be presented well. For that reason, editors are forced to accept only well-presented articles. Good writing is also an essence of ‘marketing’ your research. As Nair (2005) points out, in scientific research, our immediate products are often publications. In order to market any product, style is as important as substance. Good packaging cannot make up for poor content; but poor packaging can mask the quality of content.

**Types of research publications**

Various types of publications are available for communicating research results. The most important and highly rated are journal articles that report, for the first time, results of ‘original’ investigations in a scientific journal. Next in order of importance of technical content are book chapters and research reviews that critically examine and synthesize the current state of knowledge on a specific topic and suggest areas for future research. Research Notes or Short Communications represent a category of publications to report ‘work in progress’ that are not yet ready as full-fledged journal articles. Conference presentations are another transient category that may often lead to more permanent forms such as book chapters or journal articles. Theses and dissertations embody results of research on a specific topic undertaken in fulfillment of the requirement of advanced degrees at master and doctoral levels. They too have relatively short lifespan; it is customary that results from theses and dissertations are published as journal articles soon (usually within two years) after the student’s graduation. As a corollary, the academic career of a graduate with an advanced degree depends very much on the publication status of his or her thesis/dissertation research. Other research publications include monographs and research reports that embody results of several years of research, often by a team of scientists, on as specific topic. All these different forms of research publications have some common norms of writing. But journal articles, which represent the most important among all types of scientific publications, will be the focused here.

**Journal articles based on location-specific research**

Although most authors would like to see their papers published in international journals, and they are disappointed when their manuscripts are returned for the reason that the study reported is too-location specific to be of relevance to the international audience of the journal (Table 1; Plaisance, 2003). They argue that the nature of research is required to be application-oriented (because of institutional mandate, funding restrictions, etc.) and are therefore location-specific. While regional or local journals, most of which are supported by country specific public institutions and professional societies affiliated to them, may accept more of such location-specific studies, most international journals would prefer to publish research results that have applicability in regions wider than the study location.

*Table 1.* Common Reasons for Rejection of a Manuscript.

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| --- | --- |
| Broad categories | Specific weaknesses |
| The manuscript is not appropriate for the journal | * Outside the scope of the journal * Interpretations/conclusions range beyond what can be reasonably concluded based on the data presented * Repetitive information not sufficiently new and original contribution * Highly location-specific study – does not allow generalization outside the location of the study area. |
| Substantial weakness exists in the article | * Poor presentation and trivial treatment * Language errors: Poor grammar, punctuation, or spelling * Typographical errors * Weak content * Inaccurate information or references * Lack of clarity |
| Problems in the format of the manuscript | * Does not conform to the journal’s format * Poorly chosen title or one that is incongruent with the article * Jargon is used that may be unfamiliar to many readers |
| The article may not conform to editorial priorities | * Contradicts a certain aspect of the stated editorial policy |

**‘What’ vs. ‘why’ and ‘how’ types of research**

Research involves not only investigation and experimentation aimed at the discovery and interpretation of facts but also revision of accepted theories or laws in the light of new facts, or practical application of such new or revised theories or laws. Most (if not all) agricultural science research is application-oriented in nature. But being application-oriented is not the same as being location-specific. What is important is to identify the ‘right’ questions and establish clear objectives before the research is undertaken. In agricultural science research, many field investigations, including surveys that are undertaken as research are limited to finding out ‘what happens when something is done’. The data are then analyzed using statistical packages and papers are written to report that one treatment was better or different from another, prospective users did not like a particular technology, and so on. As Nair (2005) points out, these are examples of ‘what’ type of research. The results might, at best, be applicable to the specific location where the study was conducted, but has uncertain applicability at locations with different biophysical and socioeconomic characteristics. If the research were planned to answer the questions ‘why’ and ‘how’ did things happen the way they did, the results would be more widely applicable. In other words, research should be aimed at establishing cause-effect relations and exploring the principles that form the basis of observed behavior. Often times, the effort needed to do the ‘how’ and ‘why’ type of research is not much more than that for ‘what’ type of research. For example, in a study to compare tropical fruit crops as sources of nutrition, just reporting that one species was better than the other would not be a publishable research paper. On the other hand, supposing the research showed that the fruits of the two species were different in, say, biochemical quality, and therefore they provided nutrients differently, a paper reporting that as the reason for the differential response will have scientific value. Thus, application-oriented research is not just reporting what is observed, but explaining what is observed based on known facts (or new theories). Absence of this sort of analytical insight and reasoning based on theoretical foundations and experimental evidence is a commonly observed technical deficiency in agricultural science manuscripts.

**Sections of a scientific paper**

Most journal articles have traditionally followed, and still follow, the ‘*IMRAD’* format (*Introduction, Materials and Methods, Results, and Discussion*). In addition, we need to pay attention to other parts of the paper such as title, keywords, abstract, tables and figures, and literature citations. Each has specific norms and ‘do’s and ‘don’ts to follow. Different journals and disciplines have different norms and styles, but the bottom line for all is that scientific writing should be clear, concise, and coherent (Nair, 2005). Various style manuals and books are available. Additionally, each journal has its own Instructions to Authors, which should be followed while preparing the manuscript.

*Title*

The title of your paper will be read more than any other part. The general pattern of readers’ approach to reading an article is in the following order: title, abstract, graphical results (tables and figures), materials and methods, discussion (cf. Nair, 2005). Statistics show that for every person who reads the full article, 10 will look at the tables and figures, 100 will read the abstract, and 1000 will read the title. Titles are read by both scientists scanning the contents of a journal and those depending on searches through secondary sources, which always carry the title and author but may or may not carry abstracts. The title may be reprinted in bibliographies and subject indexes, stored in bibliographic databases and cited in other articles. Needless to say, a good title is essential – not only to attract readers who might not otherwise read the paper, but also to help future researchers find important information. A good title should describe the contents of the paper accurately and as specifically as possible within the limits of space; avoid abbreviations, formulas and jargon; avoid verbs; be easy to understand; and report the subject of the research rather than the results.

The following are some of the common ‘do’s and ‘don’t’s for titles (*cf* Nair, 2005):

* The title should contain as few words as possible; the word limit for most journals is 15 or less.
* Low-impact words such as ‘effect of,’ ‘study of,’ and ‘influence of’ should be avoided (realize that every research article represents a study and reports the effect or influence of something).
* The titles should not be too brief or bland; it should be intellectually stimulating.
* Titles should reflect the content accurately and adequately.
* Flashy titles (e.g., ‘Fruits can stop malnutrition’) should be avoided for journal articles.
* If the title suggests an innovative investigation such as ‘Does nearness to markets affect species composition of homegardens: A case study from xx region of xx country’ or ‘Species richness and diversity in homegardens: a boon or bane?’, it has a much better chance to attract the attention of the discerning, busy reader.
* In some journals, the place of study is given on the title; this is particularly useful for agricultural science and natural resource management articles because of the enormous diversity of the practice in different places. Such study locations should not, however, be in excessive detail (xxx watershed of xxx province of xxx region of xxx country). By the same token, the location should be understandable to the readership of the journals (e.g., ‘Western Ghats’ in peninsular India).

*Authors*

The norms in listing authors include the following (*cf* Nair, 2005):

* Only people who have made an important contribution to planning and carrying out the research are listed as authors.
* All listed authors should also have helped in the preparation of the paper.
* Technicians and other helpers are usually mentioned in the acknowledgments.
* Each coauthor should give final approval to the version that is to be published. A related problem is that some of the listed authors, especially those who are well known, may not even have seen the manuscript before it is submitted to a journal. This is objectionable: not only that all authors should contribute substantially to the work reported, but it is unethical to publish something in somebody’s name without that person’s approval.

*Keywords*

These are words by which the paper should be indexed by abstracting services. Many journals do not list keyword anymore; they use words on the title as keywords. When keywords are given, the abstracting services list the article by title and keywords. Therefore, words that appear on the title should not be repeated as keywords. Keywords should be mentioned in the abstract of the paper. The number of keywords is usually limited to five, maybe six. These should be ‘words,’ not phrases or long clusters of words. Moreover, the words should be specific to the article; common words such as plants, soils, models, and people are too general to be of any value as keywords.

*Abstract*

As Nair (2005) points out the abstract should be definitive and not descriptive; it should give facts rather than say the paper is ‘about’ something. It should be meaningful when read in isolation. Since the abstract will be read by about 100 times more people than those who will read the full paper, it should convey the information itself, not just promise it. For example, instead of saying ‘the effects are described,’ mention what the effects are; and, instead of saying ‘the factors will be presented,’ say what the factors are. If the readers are interested in learning how those effects or factors are important, they will read the paper for details. A good abstract is short (150 to 250 words); is written in one paragraph (multiple paragraphs may be allowed for review papers); should stand on its own, i.e., be complete in itself; starts with a statement of rationale and objectives; reports the methods used, the main results including any newly observed facts, and the principal conclusions and their significance; and should contain all the keywords by which the paper should be indexed. The Abstract will be strengthened if quantitative information is included. However, do not include quantitative data and the accompanying statistical values in too much detail. The Abstract should not contain literature citations or references to tables or figures in the paper, abbreviations or acronyms (unless they are standard or explained), or any information or conclusion not in the paper itself. Latin names should be given within parentheses after common names when mentioned for the first time in the Abstract, and again the first time in the text. Make sure that your objectives and conclusions are tied together in the Abstract. According to Day (1998), the Abstract/summary should be an abridged version of the article; it should be written in the past tense and should contain no information or conclusion beyond those found in the article.

*Introduction*

A good Introduction tells why the reader should find the paper of interest, explains why the research was carried out, and gives the reader the background that is needed to understand the paper (Nair, 2005). Specifically, it defines the nature and extent of the problems studied, relates the research to previous work (usually by a brief review of the literature, but only that which is clearly relevant to the problem), explains the objectives of investigation, and defines any specialized terms or abbreviations to be used in what follows. Remember that the Introduction leads logically to and clearly states the hypothesis or principal theme and well defined objectives of the work reported. The Introduction should be relatively brief, not more than 400 words. Avoid repetition: do not repeat the Abstract in the Introduction or the Introduction in the Discussion. Do not go into an extensive literature review. Do not repeat well-known facts nor state the obvious.

*Materials and methods*

This section has a critical importance because the cornerstone of the scientific method requires that the results be reproducible (Day, 1998). A good referee should pay special attention to this section of the text; in case of doubt regarding the possibility of reproducing the experiments, he/she should reject the paper, even if the results and conclusions are outstanding. The purpose of this section is to present in as simple and direct manner as possible what has been done, when, and how, and how the data have been analyzed and presented. You must provide all the information needed to allow another researcher to judge your study or actually repeat your experiment. The section should include (*cf* Nair, 2005):

* The description of the study location to the extent such information is relevant to the study.
* The design of the experiment or survey or other modes of investigation.
* Any plants or animals involved, with exact descriptions (genus, species, strain, cultivar, line, etc.).
* The materials used with exact technical specifications and quantities and their source or method of preparation (generic or chemical names are better than trade names, which may not be universally recognized).
* The assumptions made and the methods followed, usually in chronological order, described with as much precision and detail as necessary. Standard methods need only be mentioned, or may be described by reference to the literature as long as it is readily available. For example, if the data are analyzed by SAS just say so; it is no longer necessary to give even a literature citation to SAS (but this depends on the journal). Similarly, standard and specific soil test methods or plant measurements need not be described or even referenced to some obscure or antiquated citation. Remember, however, that sometimes different methods are available for estimating (obviously different forms) of a nutrient or parameter; in such cases, the specific method must be given; e.g., it is just not sufficient to say that ‘available phosphorus was determined’; specify by what method: Bray I or Mehlich I or whatever. If the method is new it should be described in detail. Furthermore, methods of interpreting data should be described.
* Do not go overboard with excessive description of common procedures. Keep in mind and respect the general level of the readers’ understanding and familiarity with your procedures. Remember, however, that the journal’s editors may ask for additional details of any item, and in such circumstances the authors should oblige.
* Make sure that there are no ambiguities in abbreviations or names, all quantities are in standard units, all chemicals are specifically identified, experimental designs and details are stated, nothing is included that does not relate to the results that follow, and that there are no unnecessary details that may confuse the reader.
* It is customary to write Materials and Methods in past tense. There is no standard ‘rule’ on the use of active or passive forms (‘I/we took ten samples’ versus ‘Ten samples were taken’); follow the journal’s norms, and if the journal is not strict about it, use your personal preference.

*Results*

This is the core section of the paper, presenting the data that you have found. It is usually easiest to follow the results if you present them in the same order as you gave the objectives in the Introduction. As Day (1998) and Nair (2005) point out, present your results simply and clearly, report only representative data rather than endlessly repetitive data, do not report large masses of data; reduce them to statistically analyzed summary forms and present in tables or figures along with essential statistical information to understand and compare them (least significant differences and multiple range test in tables and standard error bars in figures), repeat in the text only the most important findings shown in tables and graphs, include negative data – what was not found if (but only if) they affect the interpretation of results, in the text, refer to every table and figure by number, include only tables, figures and graphs that are necessary, clear and worth reproducing, in the text, write single-digit numbers in words unless followed by a unit. But do not start a sentence with a numeral even if followed by a unit (e.g., Twenty hectares – not 20 ha – of field was selected for the study.), while presenting an approximate value, use a definite number not a range (e.g., approximately or about 200 plants, *not* approximately 80 to 200 plants) and in text, use ‘to’ instead of a dash to express a range (e.g., 2 to 4 plants, not 2–4 plants). The text be short and objective without verbosity. The data need to be presented simply and clearly, since they represent new knowledge emerging in the world. The tendency to repeat in words results already exposed in figures and/or in tables, a recurrent error, mainly in young researchers, should be avoided.

Tables and figures are an integral part of a well written scientific paper. Quite often, tables and figures appear in the Results section; but there are exceptions. While tables present accurate numbers, figures show trends and features. Do not present the same data in tables and graphs. If the information can be presented in a sentence or two in the text, do not present them as tables or figures. Do not assume that a table or figure is always better (Day, 2998; Nair, 2005). Journals do not allow too many tables and figures; the usual range is three to four of each. Therefore, be judicious in the selection of materials to be presented as tables or figures. Analysis of variance tables are not usually allowed as tables.

Each table and figure should stand on its own; i.e., the reader should be able to understand it fully without having to read the text. If the reader is asked to ‘see text for details,’ the chances are that the reader will rather leave this paper and go to another one than spend time on your paper (Nair, 2005).

Figures should be clear and legible; presenting a cluster of graphs each with its own standard error values makes the figure really clumsy. A common problem is that with easy availability of color printers and software programs, the authors use color graphs. But, journals print usually in black and white (color printing is at authors’ cost, which is prohibitively expensive), and when the color graphs are printed in black and white, they may end up as a fussy mass of indistinguishable lines! Use extreme care in preparing your graphs and figures. Graphs should maintain an overall balance; a histogram with too broad bands, and/or highly uneven heights are awkward. Select the appropriate graphical mode to present your data: e.g., use histograms instead of a continuous graph (by joining data points) to present discontinuous data (e.g., yield of a crop in four different locations). Photographs are allowed in journal articles when the information cannot be presented quantitatively in graphs or other forms of visual presentations and these are also numbered as figures (unlike in some old publications that used to label them as ‘Plates’).

*Common mistakes in reporting results*: Once you have presented converted data, do not present the same data in a different way. For example, if the data are plotted, then don't include a table of data as well. The caption with any figure or table should include all pertinent information. One should not have to go into the body of the paper to find out the results of statistical tests on the data, or the rationale behind a curve fit.

Raw data are not usually included in your results. Raw data include lists of observations, measurements taken in order to obtain a final result (e.g., absorbance, relative mobility, etc.).

Use an appropriate number of decimal places (if you need decimal places at all) to report means and other measured or calculated values. The number of decimal places and/or significant figures must reflect the degree of precision of the original measurement. See our analytical resources for information on uncertain quantities and significant figures. Since the number of significant figures used reflects the level of precision of the measurement or calculation, there is never any need to qualify a measurement or calculation as ‘about’ or ‘approximate.’

Graphs and other pictures that represent data are called figures, and are numbered consecutively. Tables are distinguished from figures, and are numbered consecutively as well. For example, a paper with two graphs, a reproduction of a segment of chart record and two tables will have figures 1, 2, and 3, and tables 1 and 2.

Do not draw conclusions in the results section. Reserve data interpretation for the discussion.

In fact, most well-designed experiments result in support for the null hypothesis. Be prepared to interpret whatever you find, regardless of what you think you should find. The purpose of experimental science is to discover the truth - not to make the data conform to one’s expectations.

*Discussion*

This is the section where you explain what the results mean and what their implications are. Nair (2005) suggests that here, you pull everything together and show the importance of your work through analytical interpretation of your results. The reader should not end up saying, ‘So what?’. Undoubtedly, this is the most difficult part of the paper.

A good discussion should (*cf* Nair, 2005):

* Not repeat what has already been said in the review of literature.
* Relate the results to the questions that were set out in the introduction.
* Show how the results and interpretations agree, or do not agree, with previously published work.
* Present the theoretical implications of the work.
* Indicate the significance of the results.
* Suggest future research that is planned or is needed to follow up.
* Deal with only the results reported in the study, staying away from generalizations and conjectures that are not substantiated by the results presented.
* State conclusions, with evidence for each. A major problem in many manuscripts is that instead of ‘discussing’ the results, the authors simply state – often repeat – the results. Drawing reference to previously published work is important. But, sometimes discussion degenerates to superficial statements such as ‘this work agrees with the work of author X (some unknown author’s work, published several years earlier)’ as though the objective of research was to see if the results agreed with some other author’s (obscure) work published 20 or more years earlier! Analytical insight is what we should strive for in the Discussion section.

Another common problem in Discussion sections is the tendency to move away from the stated objectives and try to ‘solve all problems.’ Admittedly, agricultural science researchers are often under pressure from funding agencies and administrators to produce fast and easy results and technologies for immediate dissemination. Authors therefore tend to ‘please’ the authorities by indulging in pedantic discussion and conclusions that do not emanate logically nor are substantiated by the results presented (Nair, 2005). Some amount of speculative discussion is, however, in order to elicit excitement and motivate future research. The classical joke of ‘‘Sherlock Holmes and the mystery of stars’’ is reproduced here: ‘‘Mr. Sherlock Holmes and his sidekick Dr. John Watson went on a camping trip. They pitched their tent under the stars and went to sleep. During the night, Holmes awoke and nudged his friend ‘Watson, look up at the stars, and tell me what you deduce.’ Watson replied, ‘I see millions and millions of stars. Astronomically, it tells me that there are millions of galaxies and potentially billions of planets. Astrologically, I observe that Saturn is in Leo. Theologically, I can see that God is all powerful and that we are small and insignificant. Meteorologically, I suspect that we will have a beautiful day tomorrow. What does it tell you?’ Holmes went silent for a moment, then said: ‘Watson, you idiot, somebody has stolen our tent’. The point is: do not take your interpretations too far! The line between ‘optimum’ and ‘excess’ is often faint; the scientist has to do some balancing act to separate rote from reasoning.

Some journals, but not all, allow a Conclusion/ Summary section. If a separate section is not allowed, the last paragraph or a few sentences of the Discussion can be used to state the conclusions. Conclusion should, rather than just repeating results, state well-articulated outcome of the study and briefly suggest future line of research in the area based on findings reported in the paper. It is not uncommon to find ‘conclusions’ such as ‘more research is needed before conclusions can be drawn.’ Well, then, why do you want to publish this now?

*Non Sequitur* (“It does not follow”): This is the simple fallacy of stating, as a conclusion, something that does not strictly follow from the premises. Mismatch between stated objectives and discussion/conclusion is another very common problem in manuscripts. Indeed, all sections of the paper should be tightly and coherently tied together. For example, if the title suggests that the study is on insect population in a mixed-plant system, the paper should focus on that, *not* on, say, reporting and discussing yield of crops and elucidating how adopting such as practice can reduce deforestation!

*Superficiality*: The purpose of a discussion is to interpret the results, not to simply state them in a different way. In most cases a superficial discussion ignores mechanisms or fails to explain them completely. It should be clear to the reader why a specific result came to pass (Turabian, 2007). The statement, “The result agreed with the known theoretical value,” tells us nothing about the mechanism(s) behind the result. What is the basis for expecting a particular result? Explanations may not be easy and your explanation may not be correct, but you will get most or all of the available credit for posing a reasonable explanation, even if it is not quite right. Superficial statements, on the other hand, will cost you.

*References*

The reference list must include all, but only, works cited in the text. Unfortunately, there is no standard norm or regulation regarding literature-citation style or listing journal abbreviations; each journal/publisher follows its own style. However, irrespective of the style, all journals ask for names of authors, journals (or other publications such as books), and relevant volume and page numbers of the article. Most journals list the title of the article, but some do not. Journals may list the last names and initials, or first and last names, of all authors. Most journals list literature in name – year system, but some follow the numbering style. Better to follow the journals’ Instructions to Authors and look up the recent issues of the journal. References cited should be the most appropriate ones for the context.

Quote only citations that are most relevant and recent. If books are listed, cite the latest edition. Cite only publications that are easily accessible by international abstracting services. Limited-circulation publications and work in progress (working paper, discussion paper, abstract of paper presented at a conference, extension pamphlets, and such other so-called ‘gray literature’) should not be listed. Manuscripts ‘in preparation’ or ‘submitted’ or ‘in review’ should not be listed; but those in ‘press’ can be. The ‘in press’ category includes manuscripts about which the authors have received written notification from the journal that they have been accepted for publication following the journal’s pre-publication procedures such as peer review. While citing ‘in press’ articles, remember to update the publication status before, your paper is finally printed. To ensure that, you should notify the editor of the change in status as soon as an ‘in press’ article is published, and then, at the proof stage, update the listing of the article. Any information that is pertinent to the paper but is not available in literature that can be accessed by libraries may be cited as ‘personal communication’ when the information is from someone other than the authors, or ‘unpublished data’ when the information is from one or more authors of the current paper. These should be listed in text (not under References), and should include the source as well as year and if possible month. Electronic sources may be listed under References or as personal communications depending on their nature. For example, email messages or information posted on an individual home page come under personal communications, whereas institutional Web-pages can be cited under the References section. Each listed reference should have a specific purpose and be the best for the situation. Journals usually allow only about 25 references for a research article and publications that are ‘old’ (published more than 15 years age) are discouraged (unless they are seminal works). Repeated references to the same author’s various publications on the same topic, no matter how outstanding that author is, may also be avoided (Nair, 2005).

*Chicago-Style Citation*

*The Chicago Manual of Style* presents two basic documentation systems, the humanities style (notes and bibliography), and the author-date system. Choosing between the two often depends on subject matter and nature of sources cited, as each system is favored by different groups of scholars. The humanities style is preferred by many in literature, history, and the arts. This style presents bibliographic information in notes and, often, a bibliography. It accommodates a variety of sources, including esoteric ones less appropriate to the author-date system.

The more concise author-date system has long been used by those in the physical, natural, and social sciences. In this system, sources are briefly cited in the text, usually in parentheses, by author’s last name and date of publication. The short citations are amplified in a list of references, where full bibliographic information is provided. For numerous specific examples, see chapters 16 and 17 of *The Chicago Manual of Style*. Online sources that are analogous to print sources (such as articles published in online journals, magazines, or newspapers) should be cited similarly to their print counterparts but with the addition of a URL. Some publishers or disciplines may also require an access date. For online or other electronic sources that do not have a direct print counterpart (such as an institutional Web site or a Weblog), give as much information as you can in addition to the URL.

*Units*

SI system (*Syste`me International d’ Unite´ s*) is used for reporting measurements in all research publications. SI units are indicated by the respective symbols in singular and usually without periods (full stops); thus g, kg, cm, m, h, and so on, for both singular and plural usages; leave a space between the numeral value and the unit (6 m, 25 kg). A commonly used and widely understood unit of mass is ton (t), which is 1000 kg or 1 Mg. When reporting yields, the term Mg ha–1 is preferred; do not write ‘metric ton’. The base unit of time second (s), use hour (h), day (d), week (w) or year (yr) as appropriate. In biological papers, use of months (mo) may be avoided, especially for periods less than 6 mo; even for more than 6 mo, use a qualifier such as about or approximate (e.g., about 9 mo). The US National Institute of Standards and Technology maintains online resources for SI (http://physics.nist.gov/cuu/); most other countries will have comparable offices/institutions with similar responsibilities. Consult a good style manual (see the list of Recommended Readings at the end of this article) for guidance.

*Language*

English is the current *lingua franca* of science. The English used in science is, however, slightly different from the English used in other forms of communications such as news media and literature. Furthermore, each discipline has its own special usages and terms. Science is international, and the chances are that English will not be the first language for many who read your paper. It is therefore essential that your writing is clear, consistent, logical, and coherent. Indeed, accuracy, brevity, and clarity constitute the *ABC* of science writing. English, though spoken in various ways throughout the world, is written principally in two styles: the US and UK versions. Basically, these two forms are similar; but there are some differences in spelling of some words and a few expressions. There is nothing right or wrong between these two forms; either can be used. What is important is to be consistent throughout your paper.

*Verb tense*: Turabian (2007) considers use of the wrong verb tense, at best, is irritating to read and reflects poorly on writing skills. At worst, the reader can be confused as to what facts are already known and what was newly discovered in the actual study that is the subject of the paper. As a rule, use past tense to describe events that have happened. Such events include procedures that you have conducted and results that you observed. Use present tense to describe generally accepted facts. Reference to results of a specific study should also be in past tense. Mixing tenses is even worse.

*Subjectivity and use of superlatives:* Technical writing differs from the writing of fiction, opinion pieces, scholarly English papers, etc. in many ways (Turabian 2007). One way is in the use of superlatives and subjective statements in order to emphasize a point. We simply do not use such writing styles in science. Objectivity is absolutely essential.

Superlatives include adjectives such as ‘huge,’ ‘incredible,’ ‘wonderful,’ ‘exciting,’ etc. Your definition of incredible might be different from that of someone else - perhaps a fivefold increase is incredible to you, but not for the next person. It is much better to use an objective expression, such as “Oxygen consumption was five-fold greater in the presence of uncoupler, which is a greater change than we saw with the addition of any other reagent.”

Similarly, we don't write that we believe something. We present the evidence, and perhaps suggest strong support for a position, but beliefs don't come into play. In particular, we do not “expect” a particular set of results, or “wire” a hypothesis so that it appears that we correctly predicted the results. That sort of practice is another example of lack of objectivity (Turabian, 2007).

*Grammar and spelling*: Avoid obvious grammatical errors. Clear written communication requires proper sentence structure and use of words. Make sure that your sentences are complete, that they make sense when you proofread, and that you have verb/subject agreement. Spelling errors in a paper make you look amateurish (Turabian, 2007). One letter changes the chemical compound you describe; cycloheximide vs. cyclohexamide.

*Inaccurate word or phrase*: Changing temperature had the following affect on the subject. ‘Affect’ is a verb. ‘Effect’ is a noun. The data lead to the assumption that *x* has no relationship to *y*. If you base a conclusion on data, then your conclusion is a *deduction*, *not an assumption*. In fact, in experimental science assumptions are usually avoided. A purpose of *controls* is to eliminate the need to assume anything. The word 'data' is plural. Another example is: ‘principle’ vs. ‘principal’.

*Anthropomorphism*: Sometimes you cannot easily find the right wording in order to explain a cause and effect relationship, or you may not understand the concept well enough in order to write an explanation. Anthropomorphism is a type of oversimplification that helps the writer avoid a real explanation of a mechanism (Turabian, 2007).

*Hedging* is an expression of tentativeness and possibility and it is central to academic writing where the need to present unproven propositions with caution and precision is essential. It allows writers to anticipate possible opposition to claims by expressing statements with precision, caution, and diplomatic deference to the views of colleagues (Hyland, 1996). Myers (1989) who argues that “hedges are part of a wider system of politeness designed to redress the threat research claims contain to the ‘face’ of other scientists”. While writers seek to gain recognition in their field by making the strongest claims they can, such claims are likely to challenge existing assumptions of the discipline and undermine colleagues’ research agendas. In science, hedges play a critical role in gaining ratification for claims from a powerful peer group by allowing writers to present statements with appropriate accuracy, caution, and humility. Hedges help negotiate the perspective from which conclusions can be accepted.

According to Hyland (1996), a writer wants a message to be understood (an *illocutionary* effect) and to be accepted (a hoped for *perlocutionary* effect such as persuading, convincing, scaring, enlightening, inspiring, or otherwise getting someone to do or realize something). But no matter how clearly, convincingly, and appropriately reader-centred material may be expressed, the writer's ability to influence the reader's response is severely restricted. The scientific writer can only guide the reader to a particular interpretation through the use of formal meanings but external factors, particularly the reader's prior knowledge, affect interpretation (Bazerman, 1985). Readers can always refute a claim. All statements require ratification and because readers are guarantors of the negativity of claims this gives them an active and constitutive role in how writers construct them. This is why mitigation is central to academic writing, as hedging signals the writer’s anticipation of the opposition to a proposition.

By foregrounding ‘these data’, the writer presents a view where data, vested with authenticity, are attributed with primary responsibility for an interpretation; they become the source of the claim. Judgemental epistemic verbs, particularly speculative (e.g. *assume, predict, propose)* and evidential verbs (e.g. *appear, seem),* in impersonal phrasings are a principal means of withholding personal commitment (Hyland, 1996). The tentativeness relates mainly to the commitment the author wishes to bestow on the statement rather than a strict concern with the truth of its propositional relationships. Another strategy to achieve distance from a claim is to attribute its source, or underpinnings, elsewhere. Thus, writers may refer to wider bodies of knowledge when moving away from what can be confidently implied by their results or methods. Reference to methods, the models employed, or the conditions under which the results were obtained are an important means of hedging personal commitment.

*Quotes*: When you write a paper related to literature, history, current events, and many other fields, direct quotes may be essential to a full discussion of the subject. In science, there is very rarely any call for a direct quote (Hyland, 1996).

*Proofreading*

Incomplete sentences, redundant phrases, obvious misspellings, and other symptoms of a hurriedly-written paper can cost you. Check spelling of scientific names, names of people, names of compounds, etc. Spelling and grammatical errors can be embarrassing. Since many very different terms have similar names, a spelling error can result in a completely incorrect statement. When you print off your paper, please make sure that tables are not split over more than one page, that headings are not “orphaned,” pages submitted out of sequence, etc. Remember, someone has to read this thing! If the reader is an editor or reviewer, you might get a rejection notice because you were too sloppy.

**Other general guidelines**

Presentation style involves a whole host of issues. Several style manuals, other books, and electronic manuals are available to help us write better. At the very minimum, we should strive to present our ideas clearly and concisely. Choose your words accurately and carefully so that they mean exactly what you want to say, and the words are familiar and easy to understand. Minimize (if not avoid) use of relative and qualitative terms that could be understood differently in different situations (e.g., adjectives such as good, bad, low, so on); if they have to be used, explain them at first mention. Use the minimum number of words to express your ideas. Most journals insist on maximum of 6000 words for a full-fledged journal article. If you are presenting an idea or term that the readers may not be familiar with, explain that; do not leave it to the reader to guess. Avoid long-winding sentences and jargons. This does not mean that all sentences should be brief, or subject-specific-technical terms should be avoided. Avoid short paragraphs (of less than three sentences) except in some special circumstances. Scientific-writing style involves more than proficiency in English language. Even so, nonnative English users could sometimes be at a disadvantage. The only way to overcome this problem is to practice and try more and more (Nair, 2005). Do not hesitate to share your drafts with your colleagues and do not hesitate to revise, revise, and revise again!

Other presentation-style and English-related issues include: active and passive voice, double negatives, parallel construction, positioning subject and verb, pronouns, punctuation, sentence construction, tense, transition (between paragraphs as well as sentences), and proper use of words that are similar but have different meanings (e.g., affect vs. effect; principle vs. principal). The *ampersand* (&) signs is usually avoided in scientific writings. *EN dashes* (–) and not hyphens (-) represent a range of values.

Issues of ethics and the rights of the author to ensure the originality of the paper, in order to avoid accusations of plagiarism or of any violation of intellectual property are also important.

On a final note, publishing good-quality papers early in your career is certainly the best thing you can do for advancing your career. But working under the pressures of ‘publish or perish’ culture, many fall into the trap of ‘number craze’ and sacrifice quality for numbers by breaking up data and even unethically reporting the same (or almost the same) data in different manuscripts in different journals (Nair, 2005)! While numbers are important, too many skimpy papers even in good journals will do more harm than good in the long run. Equally damaging would be the other extreme of waiting for the most perfect paper only to end up with no or very few publications in your career. It is important to strike a balance between quality and quantity. Papers should be written only when you have something new to report, and we should strive to make every paper an improvement over the earlier one.

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1. *Workshop on Scientific Writing. Jenderal Soedirman University, Purwokerto June 2017* [↑](#footnote-ref-1)