

Careful Scientific Writing: A Guide for the Nitpicker, the Novice, and the Nervous

Elaine R. Firestone and Stanford B. Hooker

Writing scientific documentation has a unique set of caveats, pitfalls, and red flags that other types of writing do not have. The very nature of scientific writing demands the precise use of words and phrases, however, this precise usage is often discounted as being pedantic by many people. The reason for this precision is to communicate sometimes highly technical information to others who may, or may not, be as knowledgeable as the author, and who may, or may not, be a native speaker of the language in which the author is writing. To do this, accurate words and phrases must be used, especially in light of globalization and sciences that involve multiple disciplines.

INTRODUCTION

In this day and age of fast-paced lifestyles, international cooperation among scientists, and the sheer volume of information now needed by scientists, it is more important than ever to have clear and concise writing instead of the verbose and often circuitous writing styles of the past. There is more information and data available now than ever before, because of the explosive growth of scientific knowledge and expanded access to written material through the Web and electronic journals. The very nature of science has become increasingly interdisciplinary with the advent of sciences such as biotechnology (natural biology and laboratory techniques applied to commercial purposes), and Earth system science (a combination of terrestrial, oceanic, and atmospheric sciences).

In scientific writing, words take on more significance than in other types of communication, because the subject matter being discussed is, by definition, precise and exact. The communication of the facts, figures, and methods used in science, as well as the description of the results, also has to be precise and exact. Sloppy writing is often considered synonymous with inexact and, thus, questionable science. For this very reason, reviewers of manuscripts for peer-reviewed journals will often reject a manuscript if there are too many typographical and grammatical errors.

This paper will present the reasons why changes are made, caveats, the most common mistakes, and other concerns germane to scientific writing. Pointers will be given to make documents—both in scientific and other

types of written communication—clearer and more effective.

KNOW THE AUDIENCE

The first question to ask before starting to write anything—scientific or otherwise—is, “Who is the audience?” Is it for first graders? Is it for high school students or graduate students? Perhaps it is for people within the author’s internal working group? There is a large difference in how things are written for children of various ages, versus grad students or accomplished scientists. There is also a large difference in how something is written which is intended for people within an internal working group, as opposed to how it would be written for people outside of such a group. Within a small community, the tendency is to use a lot of jargon, or industry- and company-specific terms no one else will completely understand.

By the same token, the readership of scientific documentation is, in large part, from non-English speaking countries. The writer obviously understands what was written, and the editor might understand what was written, but when a manuscript is edited, the editor has to make sure that others outside of the author’s immediate group will understand it also. If the audience is taken into account as part of the writing stage, the editing and production processes will be much smoother and faster.

STYLE CHANGES ... WHY ARE THEY MADE?

Style manuals, with some exceptions, are supposed to be guides, not rules cast in stone. Similarly, the styles espoused in the guides should not be adhered to blindly without careful thought as to how this will affect the manuscript. It is also important to remember there is a difference between what is a stylistic issue and what is actually incorrect.

Third Person vs. First Person

The accepted style in scientific writing is still “third person.” The reason for this is third person emphasizes the science itself, while first person emphasizes the person or people who did the work. Although first person prose has the effect of personalizing the article, it can also detract from the information being presented.

Some scientific journals accept first-person prose, and indeed, first person is widely accepted. Authors should always inquire before submitting a document, however, as to what the guidelines are for a given journal, especially if the author tends to use first person in their writing style. Journals will return a manuscript for revision if first person is used and the journal requires third person, which necessarily increases the time it takes for an article to be published.

Changing Word Forms

Over time, many words change their form and structure. As an example, in the not-too-distant past, a word like “database” was two words. Even now, there are some people who use this as two separate words because outdated style manuals are still in use. Around 1990, dictionaries started closing up “data base” to make it a compound noun. This, by the way, is a good test to see if a dictionary is current. Other compound words starting with “data,” such as “data set,” however, have not become one word as yet. A good up-to-date dictionary is the best guide in situations like these and for other words that migrate towards being compound words.

The abbreviated version of “electronic mail” has been written as “email,” “e-mail,” “Email,” or “E-mail” depending on the style being followed. Currently, there are debates in editorial forums on the Web, and differences in technologically savvy style guides, as to how this abbreviation and others like it, should appear in print. Where dictionaries have not yet taken a position as to how a word should be written, it is important to choose a style and be consistent with its use.

A very important style concern in editing is the spelling of words in British versus American English. Whichever spelling variation is chosen (depending on who is writing the paper, who is the audience, and who is the publisher), always be consistent in the application of the spelling. The one exception to this is spelling proper nouns. Even if American English spelling is used in a document, do not change the spelling of a British proper noun to reflect this. For example, in a paper in American English, do *not* change “Department of Ocean Colour Studies” to “Department of Ocean Color Studies” if the “ou” is used in the original spelling.

This leads to another issue regarding the changing (or simplifying) spellings of many words used in the sciences. Most of the words in question come from Latin or Greek and include the “oe” or “ae” constructs. The trend now is to drop the silent vowel (or vowels) to shorten the word, e.g., “Paediatric” becomes “pediatric.” Many words are being altered in this way and care must be taken when determining what style will be followed.

Readers will not necessarily know to look under a “new” spelling for the same word or root of the word. Conversely, they may not know to look under an “old” spelling if the new version is used.

Date Format

Authors write dates in a variety of ways. Some write “Jan. 2, 1999” (Gregorian calendar), while others write “1/2/99.” This is often changed in scientific journals to “2 January 1999,” specifically because science is often distributed worldwide; the month-date-year format is primarily found in the United States, while the date-month-year format is used in Europe. To avoid any confusion, it is best to spell out all dates using the *name* of the month, rather than the month’s numerical equivalent. This way, although a journal may change the style of how an author writes a date, if the manuscript starts out with the dates clearly written, there can be no misunderstanding of which date is meant.

Other date formats used in scientific writing include the Sequential Day of the Year (SDY) and the Julian Day. The SDY is the day of the year counted from 1 January of every year; in this method, 2 February would be SDY 33. The Julian date, however, is the number of days that has elapsed since 12:00 GMT on 1 January 4713 BCE. Both of these types of dates are used in scientific writing, but they are often confused by authors and editors alike, with the author denoting a date as Julian, when it is clear that the date in question is the SDY.

SI Unit Abbreviations with Values Only

The International System of Units (SI) abbreviations should not be used within text (1).

- Use “200 lines per millimeter” not “200 lines per mm.”
- Use “(in nanometers)” not “(in nm).”

On the other hand, when a unit is used in conjunction with an actual value, always use the abbreviation.

- Use “200 mm” not “200 millimeters.”

CLARITY

Use Simple Words and Phrases

Keep words and sentences as simple as possible. In fact, using longer words and phrases can lead to misunderstanding or confusion. There is a difference, however, in using simpler words and phrasing to mean the *same thing* as longer words and phrasing, and cutting words out of a sentence, which can change its entire meaning or emphasis.

Although now there is more of a push toward shorter and simpler sentences, care must be taken with what is edited out of a sentence. Deleted phrases or simpler words, which might be acceptable for other types of writing, take on new significance in scientific writing. For example, “destabilize” does not mean “not stable,” it means “less stable than before.”

Write What is Correct, Not What “Sounds Right”

Sometimes a sentence is not understood, because the way it was written could make the sentence mean different things. It is better to write in a straightforward manner, rather than to write in fancy prose that can be misunderstood. Remember that *fancy* does not work—and does not belong—in scientific writing, especially when complex scientific ideas are being explained.

Punctuation

If in doubt whether a sentence is punctuated correctly, read it out loud, paying particular attention to where commas are placed. The often-talked about “serial comma” is essential in scientific writing. Consider the following sentences:

- “The authors wish to acknowledge their co-workers, Superman and Batman.”
- “The authors wish to acknowledge their co-workers, Superman, and Batman.”

These two sentences have very different meanings. The first sentence indicates that Superman and Batman *are* the co-workers, whereas the second sentence is clearly a list with three elements: the co-workers, Superman, and Batman.

Hyphenated words are also crucial in scientific writing. The placement of hyphens between two words determines the emphasis on an idea or concept being presented. Consider the following phrases, which could be found in general writing:

- “The child created artwork ...”
- “The child-created artwork ...”

In the first phrase without the hyphen, the emphasis is on the fact that the child was the one who created the artwork. In the second phrase, the emphasis is on the artwork, which the child created. When writing about scientific methods, results, etc., this type of switch in emphasis can be crucial to the correct and complete understanding of the paper.

Using the hyphen (-), en-dash (–), and em-dash (—), correctly is an important part of writing and editing. The hyphen, or dash, is used to link words of unequal weight or importance, e.g., the example given above with the “child-created artwork,” as well as to provide breaks in words at the end of a line of text. The en-dash is used to link words of equal weight, e.g., Earth–sun distance; to indicate a range of numbers, e.g., 1–5; and to connect words in a phrase that already includes a hyphen, e.g., the Raleigh-Durham–Winston region. An em-dash, however, is used to set off parenthetical text that is explanatory in nature, such as in the first sentence under the heading “Know The Audience” on the first page of this paper, and to indicate the source of a quotation (1). A more in-depth discussion of the uses of these three punctuation marks can be found in most reference books on the English language.

Consistency

Another issue to keep in mind is to keep the terms consistent. If there is a part called a “widget,” call it a widget all the time. Do not use other words for it when the same part is being used.

Most people are taught to keep verb tenses consistent when writing, that is, if present tense is being used, then keep present tense throughout the paper. Scientific writing often has to violate this teaching. Authors of scientific experiments, for example, will write about a problem that existed in the past, then write the results of that experiment in the present, and then write what is predicted to happen in the future. This is not wrong. It is merely a facet of this type of writing which editors must be aware of and not change.

Judgement Words are Subjective

Subjective words, which the author uses to make a judgement call on the text being presented, are usually in the beginning of the sentence, but sometimes they appear in other places. These are words such as “obviously” or “clearly.” The sentence will read something like “Obviously,” or “Clearly,” or “It is obvious that....” In most cases, it is only obvious to the author or the author’s immediate group. Because these types of words can confuse or insult the reader, they should be edited out of the manuscript, or better yet, not used at all.

SCIENTIFIC WRITING CAVEATS

Acronyms

In many types of government, corporate, and scientific writing, acronyms are very prevalent. In scientific writing, there are many long phrases which can tempt an author to create an acronym. Care should be taken when

choosing what should, and should not, be made into an acronym. If a phrase only appears once or twice after the initial mention, it is not good practice to make an acronym from it. It only makes reading the paper more difficult. The exception to this is when the acronym itself is more well known than the definition, e.g., NASA, FBI, or IRS.

In addition to whether it is necessary to create an acronym, these constructs can have another problem. The author or editor submits an acronym, with the proper capitalization, however, what is submitted may not be what is actually published. The journal may typeset it in

- Initial caps and then small caps for the rest of it,
- Small caps altogether, or
- Initial caps and lowercase for the remainder of it—no matter what the author actually submitted.

Electronic Publishing Concerns

Science is now advancing so quickly that many researchers are publishing their findings on the Web, rather than in peer-reviewed journals. This method of publishing results in a double-edged sword. On the one hand, this makes the information more-readily available to the scientific community and greatly decreases publishing time and costs. On the other hand, Web sites are not permanent—what is on a Web site today, may be gone tomorrow. This is a caveat for authors who reference Web-based papers. A Web address given in a reference may not exist by the time the paper is published. This is a major concern in scientific writing where scientists are constantly referencing other scientific papers, especially in the instance of a paper documenting seminal findings. Avoid using Web addresses in manuscripts unless the information being referenced cannot be found anywhere else.

Papers published on the Web also do not have the professional status in the scientific community as those published in a peer-reviewed journal. Anyone can post papers on a Web site and make it look professional and official. It is unlikely these papers—unless they are simultaneously published in a conventional print medium—ever undergo professional editing or the peer-review process and hence, the scientific validity of the information presented could be called into question. Anything that degrades the quality of the scientific results jeopardizes the future capabilities of the author, including research funding, the reputation of the author, future career moves, etc.

In this age of submitting camera-ready copy to journals to decrease typesetting costs, the manuscripts being submitted are not edited by the journal. Camera-ready copy is, literally, camera ready, which the journal's

printers will electronically scan to make a digital image. Whatever mistakes, whether grammatical, typographical, or scientific, will be printed as is. This fact makes it more important than ever to write carefully and have the paper edited prior to final submission.

Additional Caveats

In scientific writing, the solidus, or slash (/), should only be used in equations, not in text as a way of connecting words. The most prevalent instance of this is “and/or.” This construct is an example of sloppy writing and should be revised accordingly (1).

Another caveat for the scientific writer or editor, is the use of clichés, both as old sayings and as phrases the author has made into a cliché through overuse. “Rome was not built in a day,” is an example of an old saying meaning things take time to do ... they do not happen overnight. An example of a phrase the author has made into a cliché is when an author has trouble starting sentences and constantly uses a lead-in phrase such as, “In addition to ...”, throughout the manuscript.

CONFUSED WORDS AND PHRASES

There are a number of commonly used words and phrases that are used interchangeably in everyday discourse and written prose, which actually have very definite and unique meanings and should not be used interchangeably in scientific writing.

“From ... to ...” vs. “Between ... and ...”. The construct of, for example, “from 1 to 5” indicates a range of some type and includes both end points, whereas the construct of “between 1 and 5” excludes the end points and only 2, 3, and 4 are included in the range (1). Be very careful when writing or editing a paper that uses the “between ... and ...” construct. More than likely, the author means to include both end points, in which case, the “from ... to ...” construct should be used. When editing a manuscript that uses “between ... and ...” always query the author to find out what was really meant.

“Due to”. “Due to” means “caused by,” not “because of” (1). Do not write things like “due to the weather conditions, the center was closed,” because what is really being stated is “because of the weather ...” If, however, the phrase “the radiometric uncertainty was due to ...”, is written, this is correct because it is used to mean “caused by.”

“Since” vs. “Because”. In various types of communication, the word “since” is used as a synonym for “because.” Although this is acceptable in informal use, do not use it in scientific writing. The primary connotation of “since” is temporal (or time). Consider

the meaning of the sentence “Since the launch of RocketBoy, something happened.” Does this mean from the *time* RocketBoy was launched something happened, or does it mean *because* RocketBoy was launched something happened? Time is often a critical part of science experiments or methods, and as such, confusion between these two words is not acceptable.

“Comprise” vs. “Compose”. With these two related, but often-confused words, the thing to remember is that “the whole comprises its parts,” as in, “The 48 contiguous states comprise the mainland of the United States.” “Compose,” however, means “to form by putting together,” as in “The mainland of the United States is composed of 48 contiguous states.” Do not use “comprised of” ... this is incorrect.

“Impact” vs. “Effect”. As has been said before, many words are used interchangeably in informal writing. These two words are no exception. “Impact” is a very trendy word used these days to mean “effect” when in fact, impact means to hit or strike. Unless an author is discussing something being hit or struck, do not use “impact” instead of “effect” in scientific writing.

“Was” and “Were” vs. “Has been” and “Have been”. There is a subtle difference here between these two sets of words. “Was” and “were” are used when some event occurred in the past, such as, “RocketBoy was launched in 1997.” It was an event in the past. “Has been” and “have been,” however, are used in writing for things that happened in the past, but could be happening now as well, e.g., “Scientists have been skeptical about the claims that ginkgo extract improves your memory.” This means that they were skeptical in the past, as well as being skeptical now (2).

“Input,” “Output,” and “Throughput” When Used as Nouns. These words are already plural in nature, but they usually take a singular verb, e.g., “the output was considerable.” They are called *collective nouns* and do not require an “s” at the end, contrary to common usage (2).

Affected Words and Phrases

Affected words and phrases are things that people use to make themselves sound better, but a) people do *not* sound any better using them, and b) most of the time, the words and phrases take up more room on the printed page, thereby increasing production and printing costs.

Commonly used words and phrases that fit this category are given below.

Utilize, utilizing, utilization. Change these words to “use, using, or usage” whenever possible in text. If one of these words is used, however, in a proper noun, such as “Department of Utilization Studies,” do not change it.

... in order to... Reword this phrase as “to” when it falls in the middle of a sentence. For example, the phrase “This was done in order to ...” should be modified to read “This was done to ...”

Upon. Change this word to “on” when that is what is really meant. “He put the sensor upon the table.” This sentence really means “He put the sensor on the table.” Sentences, however, that start out “Upon entering the room ...” are correct as written and should not be changed.

Methodologies. This word can almost always be changed to “methods.” Phrases abound such as “utilizing the methodologies...” instead of “using the methods...” There is no real reason for using these types of constructs beyond trying to make the writing sound more important than it is, trying to take up more white space, or trying to hide what is really being said. Some disciplines, agencies, and corporations use this type of language all of the time. Scientific writers, however, should avoid using it and scientific editors should remove it from a document whenever possible.

REFERENCE BOOKS

As was stated previously, style manuals, with some exceptions, are supposed to be guides, not the rules cast in stone. Here are a couple of recommended manuals for the science writer or editor:

- Council of Biology Editors, *Scientific Style and Format*, 6th Ed., Cambridge University Press, Cambridge, UK, 825 pp., 1994.
- Dodd, J.S., (Ed.), *The ACS Style Guide, A Manual for Authors and Editors*, American Chemical Society, Washington, DC, 460 pp., 1997.

These, of course, are in addition to a good dictionary and thesaurus, and some basic style guides, such as, Strunk and White’s classic “Elements of Style.” Depending on the type of scientific writing or editing, specialized references, such as Dorland’s or Stedman’s medical dictionaries (3 and 4) may be needed.

Other good sources of scientific information in a given discipline are college textbooks. When editing, the author or other subject matter expert is not always available to answer questions. In those instances, it is vital that scientific editors have other resources at their disposal to answer questions that may arise. In addition to textbooks, various libraries, other scientific colleagues, and the Web are often good sources of information.

DISCUSSION

There are three steps to any scientific pursuit:

- a) Pose a hypothesis;
- b) Collect the data to confirm or refute the hypothesis; and
- c) Defend the results publicly, i.e., before peers at conferences and in the scientific literature.

The last step is the most important, because if it is not successfully executed, no one will know the work was done; therefore, the entire scientific process—which is based on building the next generation of understanding on the previous one—is subverted. To successfully defend the results, the ideas must be clearly presented in a forum recognized by the scientific community.

Authors do not always have the advantage of having a professional editor review their papers. For these authors, it is very important to get someone who is learned—not necessarily in science—but one who is knowledgeable in grammar, spelling, and syntax to read the paper before it is submitted. A fresh set of eyes can be indispensable to an author.

Clearly written papers are more easily translated into other languages. This, in turn, increases the accuracy of the translations—which enables the scientific ideas to be communicated better—and decreases the cost of the translation process.

SUMMARY

In this age of international and interdisciplinary communication, scientific documentation must be clear and concise. Bridging the gap between the different scientific disciplines and the different sectors of society is more important than ever. Journals, white papers, gray literature, and all other types of scientific writing are now often available electronically (as an e-mail attachment or on different computer media), or via the Web, in addition to actual printed documents. It is vital to have this information, both electronic and printed, in language that can be easily read and understood. Excellent written communication in the sciences is more vital now than ever before in history.

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Elaine R. Firestone, ELS

Senior Technical Editor
NASA Goddard Space Flight Center/SAIC GSC
Code 970.2
Greenbelt, Maryland 20771
(301) 286-4553
elaine.firestone@gsfc.nasa.gov

Elaine Firestone works for SAIC General Sciences Corporation at NASA’s Goddard Space Flight Center. At Goddard, she is the co-editor of the *SeaWiFS Postlaunch Technical Report Series* for which she is responsible for the editing, typesetting, and production. Elaine is a board certified Editor in the Life Sciences (ELS) and has been an STC member since 1997.

Stanford B. Hooker, Ph.D.

Deputy Project Scientist
NASA Goddard Space Flight Center
Code 970.2
Greenbelt, Maryland 20771
(301) 286-9503
stan@ardebeg.gsfc.nasa.gov

Stanford Hooker is in charge of the field program for the SeaWiFS Project at the NASA Goddard Space Flight Center where he is involved in remote sensing research and applications, in addition to being the co-editor of the *SeaWiFS Postlaunch Technical Report Series*.