Writing Tips

Why do you want to publish a paper? Most researchers want people to know about their discovery. Do you? If yes, then you'll need to write such that your readers **understand**, **believe**, *and* **remember** your results. Of the three tasks, the hardest is the understanding.

What writing issues most affect reader understanding? Although grammar, spelling, and word usage are important issues, their misuse rarely prevent a reader from understanding a paper. Instead, a reader's understanding is affected most by larger-scale issues like **organization**, **content**, and **structure**. Of course, smaller details also matter. From my experience, I would list them from most to least importance as follows:

1) Organization and content
2) Paragraph structure
3) Sentence structure
4) Figure and table design
5) Word usage
6) Grammar and punctuation
7) Spelling and other conventions

Unfortunately, the easiest mistakes (or weaknesses) for a reader to detect are those at the bottom. These bottom ones are also easiest to fix, though once fixed, the manuscript may be no clearer or understandable than before. These seven issues also determine how much the readers believe and remember your results. So, you must consider all seven to produce an effective, high-quality article.

Issues 1–5 reflect writing style. Unlike issues 6–7, which follow strict rules, there is no "correct" writing style. However, some styles are better than others for effectively communicating your results. Unfortunately, most journal articles use a style that makes reading unnecessarily difficult. Such poor style inadvertently gets passed to newer generations because most writers learn to write by reading other articles with poor style. So, to improve your style, instead consult a guide for scientific writing (such as this). Moreover, your style affects your readers' impression of you. Of course you want to make a good impression. But a good impression arises from good style, not by writing impressive things. An impressed reader is also more likely to believe and remember your results. And never forget, once your paper gets published, it is there for the whole world to see, essentially *forever*.

Here I give suggestions on all seven issues. In choosing examples, I try to pick common errors made by non-native English speakers. Check back periodically for updates.

- Jon Nelson

1 Organization and Content

A) Make an Outline

To organize your ideas and results (i.e., content), your *most* important task is to make a detailed outline before writing any paragraphs. List your ideas, place them in sections, and label the sections (e.g., "Introduction", "Experimental Setup", "Conclusions"). Look at your list of ideas and edit them to make sure that you

i) Follow a natural order,

ii) Fill any information gap that could lead to reader confusion,

iii) Eliminate ideas that distract from your main point, and

iv) Follow the general section order that the journal requires.

Now I give details on applying i) – iii) to your outline.

i) Follow a natural order

Make reading easier for your readers by ordering in a way they either expect or get useful, easy-to-remember information quickly. Several common ways are

1) **Chronological** Ordering in time, from oldest to newest is common in introductions, in which you describe the relevant history of a topic, and also in experimental procedures. You may also use this to describe how some phenomenon evolves in time and in describing observations. To make things easier for the reader, try to cluster steps or stages into groups of 2–4.
2) **Increasing difficulty** First give the simpler view, without various complications, and then slowly include the complicating details.
3) **Specific to general** Readers have a much easier time understanding a specific case. So start with a specific case and then generalize.
4) **Follow the flow** If you are describing a system or process in which some particle or wave travels in a path through the system (e.g., electric current, a light beam, water), let your description follow the same path.
5) **Breaking into parts** If you are describing a complex, multi-part system (or process or reasoning), break the system into parts, describe each parts separately in order of importance, and then put the parts together. As with 1) above, try to cluster parts into groups of 2–4.
6) **Largest to smallest contribution** If a phenomenon has several sources (e.g., water supply to a lake), give the largest contribution first, the smallest last.

These ordering types can be applied to major sections, minor sub-sections, or just a single paragraph. Readers also expect certain ordering patterns in paragraphs and sentences, as will be discussed in sections 2 and 3.

ii) Fill information gaps

Because you have been thinking about the topic of your paper for years, your mind automatically fills gaps that can totally stop a reader. So, double-check your outline for a) missing steps in your procedure, b) missing parts of a derivation, c) missing bits of supporting information, and d) missing definitions. Also, don't automatically assume that something is obvious and doesn't need to be stated. **Be complete.**

Also, give the information *when the reader needs it*. If you give the information too soon, the reader will forget; if you give it afterwards, the reader will be confused twice: once when he or she needs the information and once when he or she gets it.

iii) Eliminate distracting ideas

Although your research likely resulted in many interesting results, be very careful about mentioning any that do not help support your main point. **Focus on your main point.**

Focusing on your main point, or main message, helps to ensure that the reader understands and remembers your point. It is far better for your readers to understand and remember one point than be confused by several points. By focusing, you also make your manuscript shorter, and thus easier, for the reader. Focus is an application of the KISS principle, a general principle that applies to all levels of a paper:

> **Keep it short and simple (KISS).**

By simple, I mean what Einstein meant when he said "Make things as simple as possible, but no simpler." If you can, make short, simple sections and paragraphs; also, make short, simple sentences, and choose short, simple words. Readers do not like writing that is harder than necessary. They will appreciate your efforts to make things clear and easily understandable. I have *never* heard a reader say "That was too easy to understand."!

Content of the Introduction and Conclusions

All papers have an introduction and nearly all have some sort of conclusions. Here are brief suggestions about the content of these sections.

Introduction Some writers seem to feel they must summarize nearly all the knowledge of their topic in the introduction. The result is an introduction that few readers can ever finish—and if they finish, they're so exhausted that they cannot read the rest of the paper. Introductions should not be exhausting. You only need three or four things:

- **Motivation:** General statement that tells readers why the topic or problem is important.
- **Background:** Give only the bare minimum background needed to understand the problem.
- **Problem:** The problem or question addressed by the study.
- **Result:** Brief statement of the main result, specifically as it answers the question or solves the problem.

Usually, just 2–3 paragraphs are needed. If you need more paragraphs, consider writing a separate Background section. The Introduction should be one of the shortest sections.

Conclusions The conclusions should be the shortest section of the paper. The only requirement is to state the main finding. But you might also

- Briefly mention how the study was done (possibly only a few words).
- Restate the key points (if more than one), linking them together.
- End with a take-home message that naturally terminates the paper.

All of the above can help you make a good, strong outline. Another benefit of a good outline is that it can develop into a list of paragraph points[‡], which can be very useful to a manuscript editor at RPS.

B) Writing paragraphs

When you start to write the paragraphs, don't start with the Introduction; rather, start just *after* the introduction and continue to the conclusions. Then, after writing the conclusions, write the introduction. (Why? Because you must make sure that the introduction really introduces the rest of the paper.) And after writing the introduction, write the abstract.

C) Checking and rewriting

After writing your manuscript, ask one or more people to critically read your manuscript and make suggestions. Specifically ask them to check the content and organization. After outline-making, getting comments is the most useful way to improve your organization and content.

2 Paragraph Structure

Readers expect important information at the beginning and at the end of the paragraph. So put this information in the first and last sentences. Also, try to make these sentences relatively short. And because readers cannot remember many things, don't make the middle section too long.

The most common weaknesses with paragraphs occur when the writer fails to

i) Put the paragraph point or purpose in the first sentence,

ii) Support the point or relate to the purpose in the following sentences,

iii) Cover only one point or purpose, and

iv) Summarize or conclude the discussion in the last sentence.

[‡] http://www.redmondphysicalsciences.com/paragraphpoints.pdf

About i), I often see paragraphs start with statements like "Figure 4 shows the results." Although "the figure shows some results" *could* be a point, readers don't learn anything useful from such a statement. The writer would be far more informative by making a result as the point. Notice how statement b) below is more informative than a).

a) Figure 4 shows the results.
b) The x-ray diffraction spectra indicated a mixture of GaAs and GaN.

In b), the reader gets a useful message in an easy-to-find location: the start of the paragraph. The rest of the paragraph will support this claim by discussing the data in the figure. The data or other supporting information will generally add additional useful information to the point in the first sentence, and thus the final message at the end of the paragraph will differ somewhat from the message at the start. In general, the last sentence emphasizes or reminds readers of the main point of the paragraph.

Of course, not all paragraphs will follow the above four properties. Some paragraphs can introduce the point in the second sentence and some paragraphs have a last sentence that, instead of summarizing, connects to the point or purpose in the next paragraph. But in general, most paragraphs should have the four properties.

Be especially wary of long paragraphs. Long paragraphs, particularly those with 10 or more sentences, often violate iii) above. The solution is to split the paragraph into two paragraphs, each with a distinct, yet closely related, purpose or point.

About paragraph length, if a section has more than one paragraph, try to make the first one short; if the section has more than two, try to make the first and last paragraphs short.

3 Sentence Structure

Just as with a paragraph, readers expect important information at the beginning and the end of the sentence. The beginning usually has the topic, whereas the end usually has new (or emphasized) information for the reader. Moreover, the topic in the beginning should usually relate to information at the end of a previous sentence. This structure creates strong links between sentences. A very simple example of this structure comes from the old popular song "Dem Bones":

> "The toe bone is connected to the foot bone. The foot bone is connected to the ankle bone. The ankle bone is connected to the leg bone."

In the first sentence, the topic is "the toe bone" and the sentence tells us something about the toe bone; specifically, we find out it's connected to the foot bone. So the new information is the foot bone. Then the second sentence begins with a topic that was mentioned at the end of the previous sentence, thus creating a strong link between the sentences. The pattern continues in the third sentence.

The three most common weaknesses with sentence structure occur when the writer forgets to

i) Put the new or emphasized information at the end,

ii) Focus on a single clear message, and

iii) Put the verb phrase close to the subject it acts on.

The reason for i) is that the reader pauses at the end of the sentence and thus has time to reflect on whatever was just read. For long sentences in which several things need emphasis, the emphasized information should occur right before internal punctuation (e.g., commas, semicolons, or colons) because these places are also followed by a pause. Principle ii) is violated when the sentence contains too much information. In particular, watch out for long sentences. About iii), consider the following example:

> However, the leg positions of walking horses, lions, grizzly bears, zebras, elephants, and all other walking quadrupeds, are often erroneously drawn in art books.

In the above example, 13 words lie in between the topic ("the leg positions") and the verb phrase ("are often erroneously drawn"). These words can make reading difficult because the reader must remember many words before reaching the verb that completes the point ("The leg positions are often erroneously drawn."). Another problem that can occur is that the reader, in seeking the verb that acts on the topic, skims over all 13 intermediate words, thus losing some important information. A better sentence structure is

> However, art books often erroneously show the leg positions of walking horses, lions, grizzly bears, zebras, elephants, and all other walking quadrupeds

In the above version, the verb phrase ("often erroneously show") immediately follows the topic ("art books"). This position is where the reader expects the verb phrase.

Sentence Tense

Use the present tense for well-established results and for referring to objects in the manuscript (e.g., plots, equations), and use the past tense to describe things you did for the present study. The future tense should rarely be used.

Sentence Voice

Use the active voice whenever possible. For example, readers generally prefer to read

> "This paper describes observations of glacial retreat."

over

> "Observations of glacial retreat are described in this paper."

The first sentence above is active because the subject ("this paper") does the action ("describes"). In contrast, the second sentence is passive because the subject does not do the action. (A picky reader might argue that the first sentence should be "In this paper, we describe observations…"; however, the sentence is perfectly clear without the "in" and "we".) The reason readers tend to prefer the active voice is because readers prefer action. Moreover, the active voice often produces more concise (i.e., shorter) sentences.

Most research writers greatly overuse the "is" verb, and the use of this verb form usually produces a passive sentence. The above two sentences show an example: The "is" verb "are described" in the passive sentence became the more active verb "describes" in the active sentence.

But sometimes the passive voice works better. For example, if the use of the active voice would violate one of the previously mentioned aspects of good sentence structure. Moreover, in describing an experimental procedure, the action is generally done by "I" or "we", and the reader may get tired of reading many sentences containing "I" or "we". But please use the personal pronouns occasionally because personal pronouns like "I" and "we" add a personal aspect to the study. Readers are more apt to remember your work if they imagine you in action.

4 Figure and Table Design

Figures and tables add crucial information to the paper and provide support for the authors' claims. Moreover, readers often look at figures and tables before reading much text. But figures and tables (particularly figures) often have weaknesses in their design.

Three principles to make useful figures:

i) The figure supports a central point from the text and its content is consistent with the description in the text.

ii) The figure has just enough markings and data to satisfy i), but no more.

iii) The content of the figure, including its caption, can be understood without reading the text.

The purpose of i) is to ensure that your figure is useful yet does not introduce confusion. The purpose of ii) is to prevent distraction from other things. Moreover the content should not be too crowded, as may happen when the author aims to support too many points. Probably the most common problem I see with figures is violation of principle iii): the figure caption does not explain the markings in the figure. (This principle also applies to table captions.) Readers are attracted to the figures (and tables) and can learn a lot about the study by looking at them. But if the reader must look in the text to understand the figure, the reader may quit reading the paper. In such a case, you have lost your reader because you were too hasty with your figures. Make a complete figure caption.

Three more figure principles to consider:

a) In a plot, choose your scale to maximize your plot area.

b) Do not rely on color to distinguish data.

c) Put any scale factors together with the units in parenthesis next to the axes labels.

The reason for a) is to maximize the resolution in the data. The main reason for b) is that many printers (and most copiers) produce only black and white pages. If you had used color to distinguish two curves, then the curves may be indistinguishable in the black and white copy. Principle c) also applies to tables, except for tables, the scaled units (e.g., "(10^3 kg)") should appear in the column heading.

5 Word Usage

A single mistake in word usage can completely change a sentence's meaning. So be very careful when choosing words! However, in many cases, the writer can choose amongst many words and still have roughly the same meaning. So, which words are best? For all types of writing, the words should be chosen to make the sentences clear, concise, and consistent.

Clear

Being clear involves several considerations: one should use words that can be interpreted in only one way, and one should use the simplest terms that all readers can understand (if not, the word should be explained). There are many ways to be unclear, but the way that I saw most often in my classes involved the overuse of "it".

Don't use "it" unless it can be interpreted to represent only one object.

The same applies to other pronouns, such as "they", "this", "that", "these", and "those". But, except for "they", these pronouns can be used effectively if they are used as adjectives: "these principles", "this valve". Use of "it" is vague. All vague words should be avoided. For example,

Don't use "etc.", "and so on", and similar terms.

Other aspects to being clear is to use specific examples whenever possible, to use simpler and more familiar words, to define any terms that may be unfamiliar to some readers, to put words that modify another word close to the modified word, and to use strong nouns and verbs. In short, being clear means the words are both easy to understand and very hard to misunderstand.

Concise

Being concise means to use the least amount of space to express your intended meaning. Often, parts of sentences, even whole sentences, can be removed without altering your point. Sometimes, you can combine sentences that share the same topic. More often

though, you can substitute shorter words for longer words and remove words. For example, use just "to" instead of "in order to". See many more examples at http://www.redmondphysicalsciences.com/concise.pdf . By being clear and concise, a writer can reduce the space used for writing by 50% or more, depending on how non-concise the original passage was. Such a reduction will please the reader and improve the effectiveness of the writing. It can also save you much money on page charges.

Consistent

Being consistent involves using the same units, terms, and conventions throughout the text, figures, and tables.

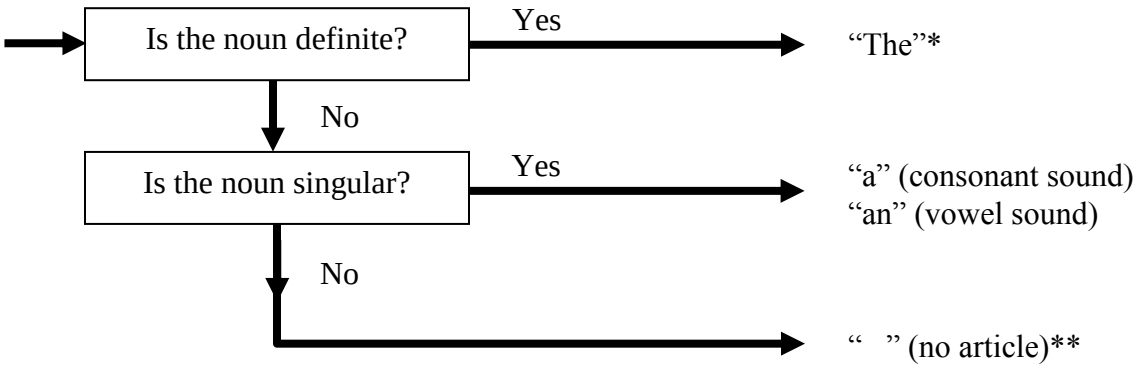
Effectively communicated scientific and engineering writing must also be cautious. In general, the writer must make more than just word choices to be cautious; being cautious arises from choosing the right content; however, the writer should also remember to avoid overstatements and exaggerations.

6 Grammar and Punctuation

Grammar and punctuation here refers to the accepted rules for word usage and punctuation marks (e.g., commas, semicolons, and colons.) I describe here only some of the more common mistakes made by non-native speakers of English.

Articles

A common error I see is the wrong use of articles for noun or noun phrases. But choosing the correct article is easy if the writer follows the procedure in the figure below.



*Also can be "this", "that", "these", "those".
** Also can be "some", "all".

First, ask yourself if the noun or noun phrase is definite. If "yes", then use "the" before the noun. But if the answer is "no", you must ask if the noun is singular. If "yes", then use an "a" if the start of the noun has a consonant sound and "an" otherwise. If the answer is "no" to both questions, then use no article. That's all.

But it is not always easy to determine if the noun is definite, or, in some cases, if it should be definite (because sometimes you have a choice). To be definite means that the writer and reader should know the specific object, place, or thing. Here are six ways for the noun to be definite:

1) Noun was already mentioned.

To remove ice, we used a hammer. The hammer was made of stainless steel.

2) Noun is a unique thing.

The moon revolves around the Earth.

3) Noun has a superlative adjective. (e.g., biggest, lowest, first, third, last)

The *largest* crystal had grown the slowest.

4) Noun is followed by words that uniquely identify it.

This sliding is due to the melting *that comes from sliding and high pressure*.

5) Noun refers to a unique group or an obvious group that includes the object.

The snow crystal brings delight to many people.

In the last example, you could chose instead to write

Snow crystals bring delight to many people.

And finally, sometimes the noun simply is known:

6) From the previous discussion, the reader is expected to know the specific object being mentioned.

Subject-verb agreement

A singular or uncountable subject must have a singular verb form, whereas a plural subject must have a plural verb form.

Only about *1% of the particles* become cloud droplets.

The subject above is plural, so one must use the plural verb "become" (not "becomes").

> The *seeding of the droplets* ***and*** *measurement of the droplet concentration* are difficult.

The verb is plural ("are") because the subject includes two things, the seeding and the measurement. But if these two things become one, for example, by adding "simultaneous", the subject becomes singular:

> The ***simultaneous*** *seeding of the droplets and measurement of the droplet concentration* is difficult.

If the subject is uncountable, it is treated as singular.

> *The water* was converted into droplets.
> *Some of the water* was converted into droplets.

In the second case, the subject is "some", but it is modified by "of the water", and thus gains the uncountable nature of the latter. In contrast, "some" will be plural if modified by a countable noun:

> *Some of the reports* were good.

The same holds for fractions:

> *One-third of the water* evaporates.
> *One-half of the crystals* melt.

When the subject includes "or" or "nor", the subject has the characteristic of the last item:

> Either deposition or *riming* occurs during growth.
> Neither the crystals nor *the droplets* fall to the ground.
> Neither the crystals nor *the balloon* falls to the ground.

In the above "deposition" and "riming" are uncountable and thus treated as singular. In general, processes (such as these) are uncountable. In the third case, the first noun is plural, but the second and last noun, which is closest to the verb, is singular; thus the verb is singular.

Commas, Semicolons, and Colons

Commas

A comma indicates a pause within a sentence. As such, it separates items, provides a brief rest for the reader, and allows the writer to create emphasis. So, to help your readers, use a comma whenever you can. Some specific uses are

i) With coordinating conjunctions (i.e., for, and, nor, but, or, yet, so = "FANBOYS") to join independent clauses:

The net flux decreased, but the partial flux increased.

ii) In a list of three or more items:

We used a hammer, some nails, and epoxy glue to fix the bench.

iii) After introductory words:

Therefore, the surface value exceeds the bulk value.
Whenever the temperature went below 10 ˚C, we increased the voltage.

iv) For adding additional, non-essential information:

The rate of glacier flow increased, which agreed with theory.
The Coriolis force, not gravity, causes the apparent deflection.

In the second example, the non-essential information "not gravity" lies in the middle of the sentence, and thus one needs a comma at each end. These are called 'balancing commas'.

v) Separating adjectives that independently modify a noun:

A quick, light tap with the hammer corrected the problem.

A common error with commas occurs with the word "because": In general, you should not put a comma before because unless you want a pause before making your argument. For example, write

We used the 0.1 M sample because the others contained excessive impurity.

Or write

Hence, because the other samples contained excessive impurity, we used the 0.1 M sample.

Semicolons

Use a semicolon to i) separate independent clauses without using a conjunction

The net flux decreased; however, the partial flux increased.

and ii) to separate items in a series when one or more items have commas.

> The results showed that aged samples had low O_2 levels; the new samples from sites A, B, and C had high CO_2; the samples from site D had typical gas levels, and samples from sites E–G had high N_2 levels.

Colons

Use a colon to introduce a word or words:

> We thus had to accept the unfortunate result: all samples were contaminated.
> Only one material was suitable: high-purity copper.

To introduce a list:

> Our supplies consisted of the following: food, clothing, and a radio.

(The same statement can be written more concisely as "Our supplies consisted of food, clothing, and a radio." But this way does not emphasize the three items as strongly.) And finally, colons are used to show that two statements are closely related:

> Jones and Fujita were correct: the sample had two crystalline phases.

7 Spelling and Other Conventions

Any word can be misspelled, and often this happens due to mistyping. Spell-checking programs catch most such errors, but some escape. The types that usually escape are similar-sounding words such as using the verb "affect" instead of the noun "effect" or using "then" instead of "than". Although spelling errors rarely make a paper hard to understand, they are distracting and reflect poorly on the writer. When a writer makes a spelling error, the reader may suspect even larger errors lurk in the manuscript.

Two common word-related errors made by non-native English speakers are hyphen (and dash) use and over-capitalization.

Hyphen (-), En dash (–), and Em dash (—) use

Use a hyphen for compound words like

> half-life and
> freeze-dry,

for two or more words that act together to modify another like

> 2-mm-long crystal,
> first-order phase transition, and
> well-known theory,

and also for cases that end in certain words:

10-fold,
country-wide, and
water-like.

However, use an en dash as a substitute for "and", such as

ethanol–methanol mixture,

for "to", such as

carbon–oxygen bond,

and for "versus", such as

temperature–time plot.

Also use an en dash to link names of two persons:

Fermi–Dirac statistics and
Young–Laplace equation.

But use an em dash to add information that may be skipped:

All variables—humidity, temperature, and droplet concentration—showed a sudden change upon entering the cloud.

Capitalization

The most common capitalization mistake I see from non-native English speakers is overcapitalization, particularly of the words in acronyms. Remember this: when you make the acronym, you use capitals, but the original words do not have capitals unless they are proper nouns. For example,

We used a scanning electron microscope (SEM).

Notice that "scanning", "electron", and "microscope" are not capitalized. Also, as part of the general principle "**be complete"**, remember to define acronyms in the abstract and main body separately. The same holds for unfamiliar terms.

Equations

Equations should always be punctuated as if they were words. In particular, follow them with a comma if you must continue the sentence with a clause (e.g., giving a condition starting with "where" or "in which"), or a period if they are the end of a sentence. Some examples:

To find x, we use

$$y = a\,x, \quad (3)$$

where a = 2.5.

or

To find x, we assume a = 2.5 and use

$$y = a\,x. \quad (3)$$

But sometimes one does not have a pause after the equation and thus requires no punctuation:

Johnson and Elliot (1999) used

$$y = a\,x \quad (3)$$

to find the value of x. In their case, they assumed a = 2.2.

Do not introduce an equation with colons (:) *unless* you have already described the equation in words:

Johnson and Elliot's (1999) equation tells us that y is proportional to x:

$$y = a\,x. \quad (3)$$

Spaces

Two places I often see incorrectly spaced are 1) between numerical values (numerals) and units, and 2) next to parenthesis.

1) Units

With the exception of angular units (e.g., degrees °, arcminutes ′, and arcseconds ″) and percentages (%, ‰), all units must be preceded by a space. This includes temperature degrees:

11.3 μm s^{-1} -or- 11.3 μm·s^{-1} -or- 11.3 μm/s
-80 °C

But for angular units and percentages, use no space:

359°
99.5%
112‰

2) Parenthesis

Always put a space on the outside of parenthesis and put no space on the inside:

All 30 samples (excluding the first two) showed abnormal levels.

==========

Update information:

06-27: I added an example to section 2: Paragraph structure, and added the section on commas, semicolons, and colons. Some minor changes were added elsewhere.
07-01: Added subsection on spaces.

