Revising Technical Manuscripts to Improve Coherence, Clarity & Conciseness

Celia M. Elliott
University of Illinois
cmelliot@illinois.edu

Three disclaimers:

• I am not a scientist—I’m a science writer and technical editor. The author trumps the editor every time. (But you really should listen to us; we have your best interests at heart. We really do.)

• All of my experience has been in nuclear engineering and physics. I think the ideas I’m going to share with you today are applicable to all science and engineering communications, but your mileage may differ.

• The opinions expressed are solely those of the speaker and are not necessarily shared by the University of Illinois. (But they should be.)

All images in this presentation were purchased from istockphoto.com unless otherwise identified.
Because we think in words, the act of expressing observation in language—of distilling amorphous thoughts into words—is a powerful tool for clarifying your thinking.

Translating your thoughts into words so that you can communicate them to someone else forces you
- to question your assumptions.
- to look for holes.
- to fill in gaps in your thinking.

“The act of composition disciplines the mind; writing is one way to go about thinking, and the practice and habit of writing not only drain the mind, but supply it too.” Strunk and White, The Elements of Style, 3rd ed., p. 70.

“It’s also through writing that we learn to articulate our thoughts clearly; our critical thinking is strengthened and clarified by our expression of it in writing.” J.L. Craig, “Writing strategies for graduate students,” Proc. ASEE Ann. Conf. & Exposition (Nashville, TN, ASEE, 2005).

Antoine Marie Jean-Baptiste Roger, comte de Saint-Exupéry, Mort pour la France, was a French aristocrat, writer, poet, and pioneering aviator. He became a laureate of several of France’s highest literary awards and also won the U.S. National Book Award. He is best remembered for his novella The Little Prince (Le Petit Prince) and for his lyrical aviation writings, including Wind, Sand and Stars and Night Flight.
Will Strunk put it another way:

“Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts.”


In 2011, *Time* magazine listed *The Elements of Style* as “one of the 100 best and most influential books written in English since 1923.”

Every person who calls himself or herself a writer should have a copy of Strunk & White within arms-reach.—*cme*

*No promotional consideration was provided by Allyn & Bacon for this heartfelt endorsement.*
Effective editing incorporates four distinct elements

- Clarifying the selection and presentation of ideas, tailored to the audience
- Organizing the narrative logically
  http://people.physics.illinois.edu/Celia/SciWriter_Advice.pdf
- Using language precisely and concisely
- Correcting “mechanical” errors that detract from a professional presentation

The probability that a first draft will satisfy the highest standards of coherence, clarity, and conciseness asymptotically approaches 0.
Write with the expectation that everything will have to be edited, repeatedly.
Editing should proceed in three separate steps

1. Reading for content (the science)
2. Editing for style (language, tone, emphasis)
3. Proofreading for mechanics (spelling, punctuation, and grammar)

 Allow sufficient time for each step!  
(*editing will always take longer than expected*)

The Elliott editing equations:
\[
\begin{align*}
  t &= 3h + \varepsilon \\
  t &= 3(h + a) + \varepsilon
\end{align*}
\]

Think of the editing process as zooming in on the manuscript to examine it on shorter and shorter length scales, starting at 30 000 feet and finishing with a magnifying glass.

In this talk, I’m going to concentrate on Step 2, because that’s where I think I can help you the most.
1. Look at the science first (macroscopic scale)

Is the information valid, significant, timely, and complete?

Is the context clear? What is new and different? What have you contributed?

Is the information presented at a level appropriate for the audience and the purpose?

Is the narrative arranged in a logical, coherent structure?

Do figures and tables support and clarify the main points of your paper?

The first pass is from the macroscopic (whole manuscript) level—look at the science. Our objective for this part of the editing is coherence.

• Is the information presented valid, significant, timely, and complete? Are the main points clearly identifiable and given appropriate emphasis? Is the context clear?

• Have you supplied sufficient background so that the reader can understand the significance of your work? Have you provided appropriate context through adequate referencing of prior work?

• Is the narrative coherent—is there a clearly defined progression from background to hypothesis to method to results to conclusions?

  **TIP:** Cut and paste the first sentence of each paragraph into a new document. Read it aloud. Does it adequately tell your story? Are there gaps or omissions?

  See http://people.physics.illinois.edu/Celia/Lectures/Paragraphs.pdf for tips on how to build effective paragraphs to incorporate an organic, logical structure in your writing.

• Have you made your case? Have you justified your assumptions, anticipated reader questions and objections, and supported your arguments?

• Is it clear what you have contributed?

• Do figures and tables support and enhance the main points?
Scientists and engineers tend to be highly skeptical about “miracles.”

Arrange your narrative in a logical structure. Make sure there are no gaps in logic or unwritten assumptions. Make the relationships among ideas and data explicit.

Provide transitional statements to tie ideas together.

State assumptions and inferences explicitly and provide supporting detail.

Add authority to your arguments by citing previous work.
Organize the ms. so that the reader can grasp the main points immediately

Provide a descriptive, memorable title
Include an effective abstract (scientific paper) or executive summary (report) and key words
Preview important points in subheadings
Use graphical highlighting (bold, italic, color) to make your main points pop off the page
Use figures to illustrate and emphasize key concepts
Summarize important points at the end of each section

Tip: remember how scientists read papers

For some tips on how to write effective titles, see http://people.physics.illinois.edu/Celia/EffectiveTitles.pdf.

For some tips on how to write effective abstracts, see http://people.physics.illinois.edu/Celia/Abstracts.pdf.
Provide logical transitions

One section ends with:
“... Improved sensitivity is important because amplifiers and signal processors are nonlinear and thus can mix signals that lie outside the desired band; the mixing generates signals with frequencies that appear as in-band noise.”

Begin the next section with:
“To achieve the improved filter performance, high-quality epitaxial films of YBCO have been...”

The logical connection between the two sections is made clear by repeating the idea of improving performance.

If you’ve followed my outlining and paragraph-building advice (http://people.physics.illinois.edu/Celia/SciWriter_Advice.pdf), you’ll already have produced an organically organized, logical narrative line. Reinforce that underlying structure by using transitional statements to tie paragraphs and sections together.
Include **summary statements**

“Testing the physics of nuclear isomers”

**Problem statement (first page):**

“Research in the late 1990s indicated x rays could be used to trigger the release of energy from $^{178}_{\text{Hf}}$ … Some estimates suggested that, with accelerated decay, 1 g of 100-percent isomeric $^{178}_{\text{Hf}}$ could release more energy than the detonation of 200 kg of TNT.”

**Summary statement (last page):**

“These findings can allay DOE’s concern about potential applications of the purported isomer energy source. X-ray induced decay of the Hf isomer does not present a new concern for national security. It also is not a viable alternative as a stand-alone energy source.”

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Provide summary statements at the end of each major section of the paper.

The old speaker’s rule is “Tell them what you’re going to tell them. Then tell them. Then tell them what you told them.” That advice is just as valid for papers and reports as it is for talks.

Take if from a mother—telling somebody something important three times is *not* overkill.

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Next, zoom in to the mesoscopic (section) level—look at the sentences.

In this pass, we’re going to make sure the language we’ve used is precise and unambiguous and that we’ve removed all redundancies and discursive material. Our objectives at this editing stage are **clarity and conciseness**.

### 2. Focus on the “style” (mesoscopic scale)

**Use precise, unambiguous language**

**Avoid gratuitous jargon**

**Use straightforward, declarative sentences and keep them short (<25 words)**

**Use strong, action verbs, not weak verb phrases**

http://people.physics.illinois.edu/Celia/Verbs.pdf

**Eliminate fluffy stuff**

http://people.physics.illinois.edu/Celia/Lectures/Fluff.pdf
Semantics and syntax control clear communication

“Semantics” is the meaning of words; you must have a vocabulary adequate to describe things precisely

The difference between the right word and the almost-right word is the difference between lightning and lightning bug.
—Mark Twain

But don’t rely on jargon!

Semantics—the indirect relation between words and meaning; note that words have different connotations in different contexts; e.g. “displacement”

• to a physicist—the effect that the wavelength at which a black body radiates the most energy is inversely proportional to its absolute temperature
• to a mechanical engineer—the volume moved by the stroke of a piston
• to a seismologist—a geological fault
• to a marine engineer—the weight of the water displaced by a vessel floating in it
• to a pharmacist—percolation
• to a botanist—abnormality in the position or form of a leaf or organ
• to a psychologist—a defense mechanism in which an emotion is transferred to another, more acceptable object
“Syntax” is the way words are put together to form sentences

Sloppy syntax can lead to confusion:

“Two months later, in late January of 1957, Bob wrote down the wave function for the superconducting state on a New York subway train.”

The initial focus will be on several superconductors where unconventional behavior has been suggested by other methods, including high-temperature superconductors such as YBa$_2$CuO$_7$.

In English, the way we tell what different parts of a sentence are and how they relate to one another is primarily by the order of the words. If you don’t string them together properly, you can destroy the meaning of the sentence.

A common problem for technical writers is that they try to cram more information into a sentence than the poor thing can possibly handle.
Avoid “abstractitis”

“writing that is so abstruse that even the writer does not know what he or she is trying to say”—Sir Ernest Gowers, GCB

1. **Clarify**—replace jargon with accessible terminology; use simple subjects and direct action verbs; de-convolute syntax

2. **Quantify**—replace wimpy, qualitative adjectives with quantitative descriptors

3. **Objectify**—give concrete examples; use analogies

As defined by Ernest Gowers and quoted by Bryan Garner in *Garner’s Modern American Usage*, *abstractitis* is writing that is so abstruse that even the writer does not know what he or she is trying to say. Here’s a description of the phenomenon:

“The words …danced before my eyes in a meaningless procession: cross-reference to cross-reference, exception upon exception—couched in abstract terms that offer no handle to seize hold of—leave in my mind only a confused sense of some vitally important, but successfully concealed, purport, which it is my duty to extract, but which is within my power, if at all, only after the most inordinate expenditure of time.” (*Yale L.J.* 167, 169 [1947]).

While Gowers in this case was talking about the Internal Revenue Code, he could easily have been describing many physics papers.

Gowers’ use of a 68-word sentence is a rant for another day.
Use these techniques to revise for clarity and conciseness

We’ll look at how to apply each of these editing techniques next.

Write shorter sentences
Limit the number of modifying clauses & prepositional phrases
Keep verbs close to nouns
Express ideas in positives, not negatives
Avoid indirect constructions; put the subject first
Eliminate unnecessary words
De-nounify verbs
Write shorter sentences (<25 words)

The following sentence (63 words), while grammatically correct, is impossible to understand on the first reading:

“A program of chemical analysis and receptor modeling is proposed in which samples obtained at the EB ENTEK sites will be used to estimate the sources and/or source regions of trace elemental deposition into the area and the effects of specific urban areas on the airborne particulate matter compositions and thus, their potential contribution to the contamination of the area’s water supplies.”

Avoid long strings of nouns used as adjectives, too mean field anisotropic superconducting reverse bias toroid magnet <sigh>

Write short sentences—less than 25 words.

Avoid long strings of nouns used as adjectives—“mean field anisotropic superconducting reverse bias toroid magnet” (or MASRBTM, to its fans)

Follow the “three preposition” rule.* If you have a sentence that contains more than three prepositions, rewrite it before it wanders off to die.

Writing shorter paragraphs will also help your reader follow the logic of your narrative. For more information on how to write strong paragraphs, see http://people.physics.illinois.edu/Celia/Lectures/Paragraphs.pdf.

*With thanks to Stephanie Teich-McGoldrick, who first introduced me to the three-preposition rule.
What’s wrong with this sentence?

“The development of the theory of convection began some 85 years ago with Lord Rayleigh’s analysis of instability in fluids heated from below, but it was not easy for geoscientists to accept that a mechanism applicable to a fluid like water could also be relevant to understanding the behavior of the solid mantle composed of silicates.”

It’s impossible to understand the meaning of this long, convoluted sentence on the first reading. Even if you’re a native English speaker.

Even if you’re a geophysicist.
One of the easiest ways to improve your writing is to write short (<25 words) declarative sentences using active verbs. If you routinely write sentences containing more than 25 words, you likely have long strings of prepositional phrases, weak verbs, misplaced modifiers, and indefinite pronoun references—all leading to difficulty in interpreting your meaning.

Refer to Ms. P on “like,” which is used incorrectly in the example, but that’s a rant for another day. (q.v. http://people.physics.illinois.edu/Celia/MsP/Like.pdf)
Here’s how to fix it:

“Convection theory began some 85 years ago, with Lord Rayleigh’s analysis of instabilities in fluids heated from below. While convection clearly explained the behavior of fluids, geoscientists were reluctant to apply the theory to movement in the Earth’s solid silicate mantle.”

Two sentences of ≈20 words each
Subjects come first
Verbs are verbs
Concise and direct
Keep verbs close to their nouns

Several schemes ranging from minimal computational cost and poor accuracy to high computational cost and high accuracy can be employed.

Several schemes can be employed, ranging from minimal computational cost and poor accuracy to high computational cost and great accuracy.

A program to be used in conjunction with a PC data acquisition card was written.

A program was written for use with a PC data acquisition card.
Recast negative expressions—
a positive is easier to understand
and is usually more concise

*Although some data supported the hypothesis, it could
not be concluded that output scaled linearly with
current.* (17 words, hard to parse)

Data to demonstrate linear scaling of output with
current were inconclusive. (11 words)

*Arcing under high-current operation could not be
avoided without the use of the insulated feedthrough.*
(16 words, hard to parse)

The insulated feedthrough prevented arcing,
even during high-current operation. (10 words)
Avoid beginning sentences with “There are...”—put the subject first and plunge right in

There are several methods to produce thin metal substrates—hot stamping, cold rolling, and cleaving.”

Thin metal substrates may be produced by several methods—hot stamping, cold rolling, and cleaving.

This rewrite has the added advantage of putting the important part of the sentence (“thin metal substrates”) first and the examples directly after “methods,” where they belong.

Train yourself to spot “There is...” and “There are...” sentences and rewrite them in the passive voice, which puts the important point first in the sentence (“front loads”).
Make sure *indefinite pronouns* refer to the correct antecedent

Non-commutative geometry is obtained when the latter equation fails and is replaced by another equation, as in the case of the quantum Hall system. The interpretation of this effect in superstrings is startling, however, because *it* is a fundamental theory of spacetime, and *it* means that we cannot think of spacetime in terms of ordinary smooth geometry, as in general relativity.

**or any antecedent...**
Avoid the big A’s—amphibologies and anthropomorphism

Beware of words with multiple meanings
A sintered mixture for the experimental heating rod was prepared from martensitic steel and 5% nickel. *This element* proved to be unsatisfactory.

A subtle but important *point* about the series of *points* generated is that they are not statistically independent.

Don’t give human traits to inanimate objects
The substrate *tells* the YBCO how to align during growth.

The dial *needs* to be set at …
Be sure to use the right word
Alternate or alternative?
Ability, capacity, capability?
Affect or effect?
Principle or principal?
Optimal or optimum?
Biannual or biennial?
Compliment or complement?

Bryan A. Garner, *Garner’s Modern American Usage*
(New York, Oxford University Press, 2003)

Theodore Bernstein, *The Careful Writer*
(New York, Atheneum, 1965)

Ms. Particular’s Micro-Lectures on Style and Usage
(http://people.physics.illinois.edu/Celia/MsP/MsParticular.htm)

Be on the lookout for homophones (words that sound identical when spoken but have different meanings and often different spellings), too.

One of my favorites: “While rigorous proof of the result (1) is not simple, it can be readily understood on a hand-waiving level.”
Other misused and abused four-letter words in technical writing: need, ones, data, very, less (for “fewer”), lead (which is not the past participle of to lead), like, over, fact, hope (and its evil stepchild, hopefully), and worst of all, due2.
No more naked “this”es—just don’t

In some pellet designs, the average ionic charge, Z, and the laser intensity, I, are large enough that the distribution function is predicted to be non-Maxwellian (flat-topped). This has important consequences: reduction of the absorption rate, electron flux, and modification of the continuum x-ray emission rates.

A certain amount of energy is required to cause an electron to spin flip when it is beside another electron. Thus, the energy required is double this and is provided by the incident photons.

“This means that…” i.e., or thus

NOTES:
Eliminate fluffy stuff

Redundancies and wordy expressions
Pointless modifiers
Tautologies
Generalities that sound important but contain zero meaningful content

http://people.physics.illinois.edu/Celia/Lectures/Fluff.pdf

“Vigorous writing is concise. A sentence should contain no unnecessary words, a paragraph no unnecessary sentences, for the same reason that a drawing should have no unnecessary lines and a machine no unnecessary parts.” W. Strunk Jr. and E.B. White, *Elements of Style*, 3rd ed. (Needham Heights, MA, Allyn & Bacon, 1979), p. 23.
Eliminate *unnecessary words*

the results *tend to suggest*
they are *both identical*
*estimated to be* about 0.75 mg
such as copper, iron, and *etc.*
*divided into two equal halves*
*bright yellow in color and elliptical in shape*
\[ \Lambda = \lambda / 2\theta, \text{ and vice versa} \]
given *the fact that* \( \tau_a = \sigma q_a \int n(s) ds \)
*were reexamined in order to confirm the presence*
*It is known that* nanocrystallites can form shear bands

“A phrase such as *‘it is interesting to note that’* adds no information and only delays getting to the point of the sentence.” *Scientific Style and Format*
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<th>few</th>
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I always use wimpy verbs and complicated syntax; sounds more “scientific.”
Change nouns ending in -tion, -ment, and -ance back into verbs

The most common use for Raman spectroscopy is for the observation of phonons. (13 words)

Raman spectroscopy is most commonly used to observe phonons. (9 words)

A numerical approach was devised that enables the fast and efficient determination of the ternary diagrams associated with our Gibbs free energy. (22 words)

A new numerical approach quickly and efficiently determines the ternary diagrams associated with the Gibbs free energy. (17 words, more direct)

In English, we change verbs into nouns by adding a suffix to the verb, usually resulting in a wordy, clumsy sentence. Streamline your writing by converting these ersatz nouns back into the verbs they came from.
3. Now for proofreading (microscopic scale)

*Editing concentrates on ideas and expression*

*Proofing concentrates on mechanics—*
  - Spelling
  - Grammar
  - Punctuation
  - U.S. English usage
  - Scientific writing conventions

At this level of editing, we go through the manuscript with a magnifying glass, looking at every letter and every character, on all parts of the page, one by one.
Humans are evolutionarily wired to be alert to change in their environments (the ones that weren’t tended to get eaten and thus be removed from the gene pool) and to expect change to mean something.

If you talk for four pages about a “solar collector” and suddenly introduce a “solar absorber” on Page 5, a careful reader will wonder if something qualitatively different is being described.
It took reading everything backwards to discover that an author had “Supermasssive black holes” in his title, abstract, and header of every page of his 38-page manuscript. Both the author and I had proofread the manuscript at least three times before I discovered the mistake.

**Profread—proofred—proofread!**

Be aware of the special pitfalls for technical proofreaders

$\propto$ or $\alpha$

$x$ or $\times$ or $\chi$

**Tips for proofreading technical material**

- Proofread from a hard copy—*always*
- Proofread right to left, bottom to top
- Proofread *everything*
- Use a spellchecker, and check *every* highlighted word
- Use ALL CAPS sparingly

*Allow enough time!* (Refer to the Elliott equations)
To recap:

*Distill, distill, distill...*  
“no unnecessary lines and no unnecessary parts”

Focus on important ideas, logical structure, precise language, “mechanical errors”

Editing should proceed in three steps: content, style, proofreading

Pay attention to transitions and reader cues

Clarify, quantify, objectify

NOTES: