

## Revising Technical Manuscripts to Improve Coherence, Clarity & Conciseness



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### 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.)

**The goal of the scientific writer:**  
*coherence, clarity, conciseness*

*“Perfection is achieved, not when there is nothing left to add, but when there is nothing left to take away.”*



*—Antoine-Marie-Roger de Saint-Exupery*

**Distill, distill, distill...**

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.

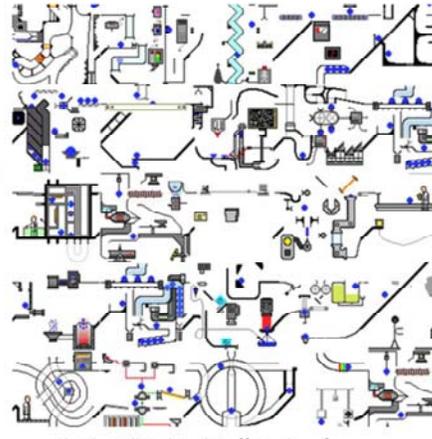
“The act of composition disciplines the mind; writing is one way to go about thinking, and the practice and habit of writing not only drain the mind, but supply it too.” Strunk and White, *The Elements of Style*, 3rd ed., p. 70.

“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.”**



The Blue Ball Machine, <http://ytmnd.com/>

Quotation from W. Strunk Jr. and E.B. White, *Elements of Style*, 3<sup>rd</sup> ed. (Needham Heights, MA, Allyn & Bacon, 1979), p. 23.

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](http://people.physics.illinois.edu/Celia/SciWriter_Advice.pdf)
- **Using language precisely and concisely**
- **Correcting “mechanical” errors that detract from a professional presentation**

## 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!**  
*(it will always take longer than expected)*

**The Elliott editing equations:**

$$t = 4h + \epsilon \quad [1]$$

$$t = 5(h + a) + \epsilon \quad [2]$$

Think of the process as zooming in on the manuscript.

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** (section) level—look at the **science**.

- Are the main points clearly identifiable and given appropriate emphasis?
- Do figures and tables support and enhance the main points?
- 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 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?
- 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?

## Narrative must be clear and logical

"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."

Used with permission

- Reveal the underlying relationships of ideas and data**
- State assumptions and inferences explicitly and provide supporting evidence**
- Avoid gaps in logic or unwritten assumptions**

Scientists and engineers tend to be highly skeptical about “miracles.”

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.

Arrange your narrative in a logical structure.

**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>.

## **Use descriptive headings to guide the reader through the text**

### **“New Mechanisms for Regulating Bone Formation”<sup>1</sup>**

#### **Section headings:**

**Mutations Help Pinpoint Function  
Narrowing Down the Possibilities  
Building Better Bones**

**Running head: *Regulating Bone Growth***

**Key words: evolutionarily conserved region (ECR), gene regulation, genome, knockout mice, microscale computed tomography, osteoblast, osteoclast, osteocyte, osteoporosis, sclerosteosis, sclerostin (Sost), Van Buchem’s disease, Wnt signaling**

<sup>1</sup>R. Hanson, *Science & Technology Review*, UCRL-TR-52000-13-3 (March 2013), pp. 18–20.

If the journal allows it, replace the generic “Introduction,” “Methods,” “Results,” “Discussion,” “Conclusions” section headings with content-rich, meaningful, memorable phrases that will capture the reader’s attention and provide sign posts to guide him or her through the manuscript.

## 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 following my outlining and paragraph-building advice ([http://people.physics.illinois.edu/Celia/SciWriter\\_Advice.pdf](http://people.physics.illinois.edu/Celia/SciWriter_Advice.pdf)), you'll already have 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”<sup>2</sup>

### **Problem statement (first page):**

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

<sup>2</sup>Maurina Sherman, <http://www.eurekaalert.org/features/doe/2005-08/drnl-ttp082205.php>

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. Tell them. Tell them what you told them.” That advice is just as valid for paper and reports. Take it from a mother—telling somebody something important three times is *not* overkill.

## **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>

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

- Are the main points clearly identifiable and given appropriate emphasis?
- Do figures and tables support and enhance the main points?
- Is the narrative coherent—is there a clearly defined progression from background to hypothesis to method to results to conclusions?
- 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?
- 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?

## 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!

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**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.*”**



*s*-wave



*d*-wave



*p*-wave



## **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**

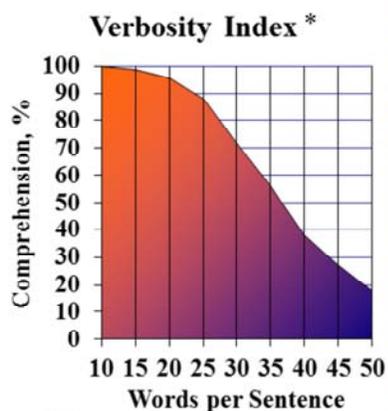
As defined by Ernest Gowers and quoted by Bryan Garner in *Garner’s Modern American Usage*, *abstractitis* is writing that is so abstruse that even the writer does not know what he or she is trying to say. Here’s a description of the phenomenon:

“The words ...dance 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



\*Illustration only, does not represent actual data.  
(But it could.)

Use *short* sentences,  $\leq 25$  words

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

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

## Write shorter sentences...



### ...and control your modifiers

**Avoid long strings of nouns used as adjectives**  
**mean field anisotropic superconducting reverse**  
**bias toroid magnet**

### Get your modifiers in the right place

**The initial focus will be on several super-**  
**conductors where unconventional behavior has**  
**been suggested by other methods, *including***  
***high-temperature superconductors such as***  
***YBa<sub>2</sub>CuO<sub>7</sub>.***

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.

## 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 too long—56 words!**

**It uses noun-ified verbs (*development of*)**

**It uses “to be” verbs and indirect construction**

**It uses infinitives and gerunds instead of active verbs**

**It violates the three-preposition rule\* (10 preps)**

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>)

\*More on the three-preposition rule (3PR) next semester—stay tuned!

## **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.*

**Data to demonstrate linear scaling of output with current were inconclusive.**

*Arcing under high-current operation could not be avoided without the use of the insulated feedthrough.*

**The insulated feedthrough prevented arcing, even during high-current operation.**

## **Avoid beginning sentences with “There are...”—use the passive voice 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 ...

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 displaced 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 arrangement of words in a sentence.

## **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>)**

## Eliminate commonly abused *FLWs*\*

### “only”

*The linear relationship in the plots at  $T \geq 1340$  K **only** agreed with experimental data when  $t \leq 10$  ns.*

### “with”

*We show that solitons undergo a strong blueshift in fibers **with** a dispersion landscape that varies along the direction of propagation.*

### “etc.”

~~*It is well known that*~~ *localized magnetic moments and the couplings between them are two indispensable factors to induce long-range spin ordering in solids, exhibiting ferromagnetism (FM), antiferromagnetism (AFM), ferrimagnetism, etc.*

\*<http://people.physics.illinois.edu/Celia/MsP/FLWs.pdf>

## 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***

**Eliminate fluff**

**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*, 3<sup>rd</sup> 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*  
 $\Lambda = \lambda/2\theta$ , *and vice versa*  
given *the fact that*  $\tau_\alpha = \sigma q_\alpha \int n(s) ds$   
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*

## Replace *wordy expressions*

*due to the fact that*

*on the order of*

*in the near future*

*a very limited number of cases*

*it appears to be indicated that*

*in spite of the fact that*

*subsequent to*

*at the present time*

*in consequence of this fact*

*as compared with*

*in combination with*

**because**

**about**

**soon**

**few**

**apparently**

**although, despite**

**after**

**now**

**thus**

**versus**

**with**

## 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 Gibbs free energy.* (16 words, more direct)

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### **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

**Proofreading examines the manuscript one word at a time**

**Acronyms, mathematical symbols, and special characters are defined at first usage**

**Format and typography are consistent and conform to manuscript preparation rules**

**Technical writing conventions are observed**

**Grammar and usage are flawless**

**Punctuation and spelling are *perfect***

**TIP: Start at the bottom right-hand corner and read backwards and up**

## **Maintain witless consistency throughout the text**

**Terminology—always call the same things by  
the same names**

**Typography—use of italics and boldface**

**Expression of numbers**

**Definitions of symbols or special characters**

**Legends in figures**

**Style of subheadings, captions, table titles**

**Use of color**

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.

## **Present a professional-looking document**

**Select an appropriate font and size**

**Use no more than two font styles**

**Automatically hyphenate the document to avoid annoying white spaces in justified lines**

**Position graphics strategically**

**Select an attractive page layout**

**Adequate white space**

**Clean, uncluttered appearance**

## To recap:

*Distill, distill, distill...*

**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**

**Make your own editing checklist and use it**

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***<http://physics.illinois.edu/People/Celia>***