

On Writing

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Speaking preceded writing, and some oral languages never added a written form. The first known writing is the cuneiform script the Sumerians used around 4000 BC to record increasingly complex business transactions after mere memory proved inadequate. Written literature followed shortly thereafter, so that by 3000 BC, *The Epic of Gilgamesh* was inscribed on clay tablets and did not have to be handed down orally. Thus, although writing may have been invented primarily as for bookkeeping purposes, it has been used through human history to tell stories.

Not all good writers are accomplished speakers, presumably because speaking requires an ability to perform in public, while writing can be done privately. Nevertheless, the two forms of communication have so much in common that writers generally write as they speak and vice versa. Both speaking and writing are ways to organize your thoughts, and you can learn much about how you and other people think by hearing or reading how you and they communicate. The clarity of the language you use mirrors the clarity of your thoughts.

Above all else, writers must understand their readership to communicate effectively. Such understanding begins with an appreciation of what readers expect to read. Poets take it for granted that their readers expect poetry and don't give them prose. Most of you reading this document are fellows in training, and I assume that you expect to learn something from it about scientific writing, in particular how to prepare original scientific articles. You would be disappointed if I failed to cover that subject, although my other objectives are to discuss writing in general and to convince you that scientific and non-scientific writing are the same.

In addition to understanding what you expect to learn from reading this article, I have to communicate in a language you are familiar with. That means not only that I have to write in English but also that I have to use a comprehensible vocabulary. Some fiction writers may want to send their readers to a dictionary occasionally, but they will lose many readers if every sentence contains a strange word. Similarly, scientific jargon may be appropriate, even

necessary in some circumstances, but it will be meaningless to a general audience and in a research consent form.

Understanding your readers also requires that you provide the structure through which they expect to be informed. Readers like you might tolerate a rambling style in an essay such as this, provided it is short enough and so limited in scope that you don't need to know early in the essay where it is going. But you would consider a scientific article suspect if it deviated from the conventional sequence of title, abstract, introduction, materials and methods, results, discussion, summary, and references, perhaps with tables and figures along the way.

To meet common expectations, the structure into which writing is organized, and every subunit of that structure, should have a beginning, a middle, and an end just as a story does. When you open a book, you probably expect to find chapters that allow you to put the book down momentarily after you finish one or more of them. Within those chapters, you expect to find paragraphs that also let you pause from time to time if you need to. And when you finish the book, you expect that its ending and its beginning will be related through the narrative they encompass. The same is true of a scientific article, wherein the summary is foreshadowed by the introduction and supported by the material in between.

As standard subunits of composition, paragraphs generally should contain one topic apiece. They also should be introduced by a sentence that suggests the topic in the context of the preceding paragraph, and they should end either with a reference to how the paragraph began or with a transition to the paragraph that follows. Short paragraphs, including those used for writing dialogue, stand out because they do not demand sustained attention, but they have a staccato effect that can be irritating. Long paragraphs, on the other hand, look intimidating to readers and usually should be divided into smaller ones.

Paragraphs are more interesting if the sentences within them vary. For example, interspersing short sentences with longer ones pleases the eye because it changes the reading's pace. In contrast, a series of sentences containing clauses of similar length separated by "and," "but," or other conjunctions is monotonous. Better to break up two clauses

with a semicolon occasionally, to throw in dashes or parentheses to set off certain clauses, or to link three clauses together, as I have just done.

However you compose your paragraphs therein, they should be so closely related that readers are compelled to continue reading even though the paragraphs provide a pausing point. I started this document during a ski trip at Snowbird, Utah. During a powder ski lesson there, I was told by my instructor that intermediate skiers complete a turn and then look for a place to stop. Advanced skiers, on the other hand, make one turn after another and try to maintain their motion. I recommend that you think of successful paragraphs as a series of deep powder turns that carry the reader along with you.

Sentences, the subunits of paragraphs, are groups of words that convey a complete thought by means of at least a subject and verb, either or both of which may be understood. Because sentences are read in English from left to right, the subject usually comes before the verb, and confusion may result if the subject and verb—any related words, for that matter—are separated by phrases or clauses. Similarly, “this,” “they,” or “it” are confusing if readers cannot identify what they (the pronouns, not the readers) refer to in a given sentence or in a sentence that precedes it.

The Elements of Style (1) is my favorite primer on word usage and writing style. In it, William Strunk and those who updated his 1918 work emphasize that clarity, boldness, and brevity should be the goals of every sentence. These goals are best achieved by using specific, concrete, and assertive language. According to Strunk et al., good writers and good speakers use the active voice whenever possible; they say “I write” rather than “it is written by me.” They also emphasize the positive and not the negative, preferring “I forget” over “I do not remember.”

Good writers also avoid using “essentially” and other qualifiers (as in “the radiograph was essentially negative”) and use strong verbs rather than weak ones that are defined by adverbs. In this regard, they would rather say “I shout” than “I speak forcefully.” Finally, good

writers and speakers avoid unnecessary words (they state, for example, that “studies suggest,” not “there are studies suggesting”), and they constantly revise their work to keep it lean.

The Elements of Style covers punctuation briefly; a more detailed reference is Lynne Truss’s *Eats, Shoots and Leaves* (2). The title of the latter book underscores how the placement of a comma can change the meaning of a sentence. Thus, a hunter “eats, shoots and leaves” (Strunk and his updaters would put a comma after “shoots,” but Truss prefers otherwise, perhaps because she’s British) in that order. On the other hand, a koala either “eats shoots and leaves” (that is, the koala eats both shoots and leaves) or “eats shoots, and leaves” after finishing its meal.

Punctuation was introduced into written language to signify on paper how people frame and modulate their spoken thoughts. As a result, when you question how to punctuate a sentence, imagine how you might recite it. Commas provide short pauses between words, phrases, and clauses and can be used to set them apart but maintain the flow of a sentence. Semicolons bring the reader almost to a stop and are useful in joining two related clauses that otherwise could exist as separate sentences. Periods are a full stop, indicating that the sentence is complete.

Whatever their style and however they use words, some novelists work from an outline and do not begin a sentence until they have mapped out every plot detail. Others simply set about writing and see where their characters take them. Similarly, some scientific writers complete their abstract before they begin the body of the article, while others start somewhere in the middle and work forward and backward. The first approach risks premature closure; the second promotes false starts. But whichever approach you use, remember that the final article and the abstract should tell the same story.

The reason to bear storytelling in mind is that you are competing with other writers for the attention of potential readers, unless your work is so important that everyone has to read it. Assuming that it is not, you should realize that many people decide whether to read an entire article only if they are intrigued by the title and abstract, so make them as inviting as possible.

The same applies to the introduction, which can put readers off if it is longer than three paragraphs. Use it to explain what problem you are addressing, why the problem is important, what is known and not known about it, and how your study has filled a knowledge gap.

The methods and results sections are the heart of your story. For this reason, because readers will judge the quality of your study on the basis of its experimental design, and because they may want to reproduce the design in their own studies, you should insure that these sections are complete and understandable. Don't spare details in the methods and results sections. Explain your findings in words, reinforcing them with tables and figures that do not duplicate the text.

The discussion section of a scientific article is useful in recapitulating its results, reconciling them with those of other studies, and speculating about their significance. But this section should be brief and should amplify the introduction without repeating it. Brevity is important both because most writing is improved by being spared of superfluities and because most scientific journals have limited space. In fact, many journals either impose word limits or ask peer reviewers to designate what percentage of a submitted article can be cut without spoiling it. In my experience, the discussion section usually is the best place to make cuts.

In summary, structure, clarity, boldness, and brevity are the hallmarks of good writing, be it scientific or nonscientific. Although some writers may forsake these hallmarks in the name of innovation, they will dash most readers' expectations in doing so. If you would be good writers, be good speakers. Read your writing out loud or under your breath, and revise it until you can understand what you have written. Then give it to your colleagues, especially if they are co-authors, to make sure they understand everything you have tried to say.

References

1. Strunk W, White EB, Angell R. The elements of style: 4th ed. Needham Heights, MA: Allyn and Bacon; 2000.

2. Truss L. Eats, shoots and leaves: the zero tolerance approach to punctuation. New York: Gotham Books; 2003.

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