

# Style in Scientific Writing

by Steve Aaronson

This space is usually devoted to a macroscopic view of scientific information: the characteristics of individual papers, of journals, of aggregates of journals, and even of whole countries or scientific disciplines. This wide-angle view is useful and necessary, but it also makes it easy to lose one's sense of perspective. It is worth remembering that communication of scientific results is accomplished mainly by the written word.

Language is the starting and ending point for science. In 1789, Antoine Laurent Lavoisier wrote that, "It is impossible to dissociate language from science or science from language, because every natural science always involves three things: the sequence of phenomena on which the science is based; the abstract concepts which call these phenomena to mind; and the words in which the concepts are expressed. To call forth a concept a word is needed; to portray a phenomenon, a concept is needed. All three mirror one and the same reality."<sup>1</sup>

The principle by which phenomena and concepts are reduced to language is style. It is no less important in scientific writing than in poetry.

Although a sense of style is indispensable for any writer, defining exactly what is meant by the word *style* is difficult. Jonathan Swift's definition is succinct: "Proper words in proper places, make the true definition of a style."<sup>2</sup> But style is more than proper words in proper places. In literature, the writer may deliberately and self-consciously use style to help convey meaning. For instance, narrating an outrageously comic scene in an understated style may reinforce the satirical effect. But in science writing the best style is transparent; the reader sees through the words to the underlying phenomena and concepts. The best scientific writing is characterized by brevity, clarity, and precision.

In 1888 Ludwig Boltzmann compared scientific style to musical style. "Just as a musician recognizes Mozart, Beethoven or Schubert from the first few bars, so does a mathematician recognize his Cauchy, Gauss, Jacobi or Helmholtz from the first few pages."<sup>3</sup> Charles Darwin is reported to have said, "I think too much pains cannot be taken in making the style transparently clear and throwing eloquence to the dogs."<sup>4</sup> Even as early as 1667, Thomas Sprat implored the members of the newly formed Royal Society of London for Improving Natural Knowledge to "reject all the amplifications, digressions, and swellings of style; to return back to the primitive purity, and shortness, when men delivered so many *things*, almost in an equal number of *words*."<sup>5</sup>

More recently, style has been defined statistically. Martin Robbins, a teacher of science writing at the Massachusetts Institute of Technology, has his students compute percentages of word usage in selected examples of scientific writing in order to analyze

and understand the writer's style.<sup>6</sup> He explains that this type of style analysis is similar to first-year work in a traditional art school, where students use the work of the masters for models. In this case, the "masters" include Einstein, Oppenheimer, Gardner, Hoyle, Bronowski, Asimov, Russell, Whitehead, Carson, and Krutch. The students take samples of the writing of each, and then compute the types of sentence structure and word usage. For instance, one student found that a 426-word sample from Jacob Bronowski's *The Identity of Man* had 3 paragraphs, 21 sentences averaging 20.3 words per sentence, an average of 1.8 syllables per word, an average of 2.65 prepositional phrases per sentence, and an average of 0.6 adjectives per sentence. The sentence structure was 24% simple, 48% complex, 14% compound, and 14% compound-complex.<sup>7</sup>

This type of statistical analysis can be extended to include paragraph strategies, transitions, vocabulary, rhetorical devices, and figures of speech. Its primary value is that it allows students to examine style without being distracted by content. Robbins feels that as a result of the assignment, the students "become aware of how much a writer's style is part of what he says."

It is an obvious but often forgotten fact that recognition—of both a discovery and its discoverer—depends on the use of language. Scientific findings must be translated into comprehensible language—which then will be published. The physicist John Rader Platt wrote,

The failure to recognize a brilliant man is only partly due to the stupidity or stubbornness of the scientific community; it is also partly his own fault.

For brilliance has an obligation not only to create but also to communicate. A scientist cannot really go 'voyaging through strange seas of thought alone.' The more penetrating eye will see him to be surrounded by a cloud of witnesses. He takes from others; he gives to others. He must address the problems of his time. He must translate his thoughts into the language of his contemporaries. He must scatter them abroad for interaction. A thought which has not penetrated to other minds will die unfruitful.

As a result, the scientist can hardly be recognized posthumously, like the artist or poet. He is much less independent, much more bound to the current needs and purposes of the scientific community. His achievement of thought needs to be at the same time an achievement of communication and leadership which must be acknowledged by the group—by at least one editor! —before its intellectual viability fades away.<sup>8</sup>

It is unfortunate that so many of us devote so little attention to our choice of words. Although we don't like to admit it, many scientists believe that scientists had better *sound* scientific—the more scientific the better. This often means using scientific jargon instead of plain language. The defenders of scientific jargon claim that it allows greater brevity and exactitude than ordinary language. It is true that most of those familiar with

jargon find it agreeable. The cognoscenti are pleased by what they perceive as jargon's precision and aura of scientific objectivity. They are also delighted by the fact that their jargon renders their field incomprehensible to outsiders, enabling them to cultivate the impression that only they—the experts—can understand the deep mysteries involved.

Jargon can be a useful form of shorthand, especially in cases where the discovery of a new substance or property demands that new terms be coined. But even in such cases, the discoverer is often unaware of the implications of the names he chooses. For example, Platt points out,

Without Newton himself, we might never have had 'force' or 'mass' in the equations of motion; or they might have had very different definitions and emphases. Philosophers have pulled and hauled at them for centuries; the difficulties were ineradicable, because these symbols were written from the beginning in the Newtonian equations that worked. The Father of Physics has imprinted 'force' and 'mass,' like intellectual genes, into every cell of the physical sciences today.

Kepler, on the other hand, seems to have eschewed, largely on aesthetic grounds, the anthropomorphic concept of 'force' between heavenly bodies. In this question of taste, he anticipates Einstein. If history had put the Kepler mind in the Newton body, it might have delayed the discovery of universal gravitation, which would have been difficult for Kepler—but it might have accelerated the discovery of general relativity.

Terminology is often chained to such initial biases. Franklin's choice of the arithmetic terms 'positive' and 'negative' to designate the two supplementary types of electricity still plagues our thinking and may have delayed who knows what happier synthesis.

The idiosyncrasies of taste and choice, of abilities and workmanship, embellish and modify a discovery. The work method is determined; the style is not.<sup>8</sup>

But too often the jargon of scientific specialists is like political rhetoric and bureaucratic mumblespeak: ugly-sounding, difficult to understand, and clumsy. Those who use it often do so because they prefer pretentious, abstract words to simple, concrete ones. Such writers want to dignify not only the subject, but also the writer. They believe that important matters require a special vocabulary.

The limitations of scientific jargon can be illustrated by looking at another type of jargon. Consider *turn on*, *out of sight*, *uptight*, *rap*, *cop-out*, *busted*, *bummer*, *groove*, *hip*, *rap*, *out front*, *far out*, *bread*, and *freak out*. Most are vague, shallow substitutes for ordinary words—but they allow members of a particular subculture to exclude outsiders—"The establishment"—from their communications.

In the same way, vague words like *interface*, *operational*, *viable*, *dimension*, and *replicate* often enable scientists to obscure their meaning. "Every profession has its growing arsenal of jargon to fire at the layman and hurl him back from its walls,"<sup>9</sup> says William Zinsser. Consider the words *infrastructure*, *functional*, *gradualism*, *time-*

*phase, reciprocal, systematized, and organizational.* Such words may make what is simple appear complex.

Many words which have specific technical meanings in one context have been popularized in such a way that the original meaning is badly misrepresented. From chemistry and physics, the words *acid test, reaction, end product,* and *potentials* are often misused; from logic *dilemma, beg the question,* and *dichotomy*; from mathematics *factor, progression, to the nth, proportion, curve,* and *differential*; and from architecture *flamboyant, baroque,* and *rococo.*

Perhaps the most insidious jargon has arisen from the cult of psychoanalysis. Freudian English has given us *ambivalent, complex, ego, extrovert, father figure, fixation, id, inhibition, introvert, libido, manic, masochistic, narcissism, phobia, psyche, psychopath, repression, schizophrenic,* and *subconscious.* These words are widely used and are widely thought to be key concepts— but almost no one is quite sure what they mean.

It has been charged that some of the worst, most offensive jargon is spoken and written by sociologists. For example, Fowler asserts that, "Sociology is a new science concerning itself not with esoteric matters outside the comprehension of the layman, as the older sciences do, but with the ordinary affairs of ordinary people. This seems to engender in those who write about it a feeling that the lack of any abstruseness in their subject demands a compensatory abstruseness in their language."<sup>10</sup> Consider such phrases as *coherent social consciousness, situational interactors,* and *adjustment alternatives.*

Why call a slum a *depressed socioeconomic area,* a salesman a *marketing representative,* or a dumb kid an *underachiever?* Why use *facilitate* for ease, *numerous* for many, *remainder* for rest, *initial* for first, *implement* for do, *sufficient* for enough, *refer to as* for call, or *attempt* for try? Why say *utilize* for use, *perform* for do, or *chemotherapeutic agent* for drug? Why not use the plain instead of the formal; stop instead of *cease,* begin instead of *commence,* hide instead of *conceal,* stop instead of *desist,* give instead of *donate,* foresee instead of *visualize,* true instead of *veritable,* buy instead of *purchase,* find instead of *locate,* get instead of *obtain,* send instead of *transmit,* and go instead of *proceed?*

Many of us clutter our prose with unnecessary verbiage. We use a large word where a small one will suffice, or three words where one will do. This waste of words is caused by two things: a failure to understand what words mean, and the notion that an idea is more noticeable and effective if it is reinforced. Thus arise such redundant phrases as *personal friend, short minute, future prospect, solid facts, final conclusion, successful triumph, positive growth, renovated like new, defense posture, tire and fatigue, hopes and aspirations, help and assistance, prompt and speedy, mutual compromise,* and *fatal slayings*—which Edwin Newman calls "the very worst kind."<sup>11</sup>

Some words serve only as excess baggage; eliminating them lightens a heavy sentence without losing meaning. Examples of such words are *nature* (a tool of a useful

nature = a useful tool), *factor* (the time factor), *character* (of an unpleasant character), *aspect* (has a definitive aspect), *condition* (weather conditions), and *quality* (a flaccid quality).

Writers sometimes use words merely to pad their sentences with extra syllables. Examples of such words are *render inoperative*, *militate against*, *make contact with*, *be subjected to*, *have the effect of*, *play a leading part in*, *make itself felt*, *exhibit a tendency to*, *serve the purpose of*, and *give rise to*. Simple one-syllable conjunctions are replaced by such phrases as *with respect to*, *the fact that*, *having regard to*, *in view of*, *in the interests of*, and *on the hypothesis that*.

A satirical "Glossary for Research Reports" compiled by C.D. Graham, Jr.<sup>12</sup> translates the familiar, rather pompous phrases "It is suggested that...", "It is believed that...", and "It may be that..." to "I think..." Instead of "It has long been known that..." he reads, "I haven't bothered to look up the original reference." For "of great theoretical and practical importance" he reads "A couple of other guys think so too." For "It is clear that much additional work will be required before a complete understanding..." he reads, "I don't understand it." Although Graham is pressing the point for the sake of humor, working scientists will recognize the essential veracity of his translations.

Consider too these examples of pseudo-scientific writing from astronomer Paul W. Merrill's satirical article, "The Principles of Poor Writing."<sup>13</sup>

*Bible:* Render to Caesar the things that are Caesar's.

*Poor:* In the case of Caesar it might well be considered appropriate from a moral or ethical point of view to render to that potentate all of those goods and materials of whatever character or quality which can be shown to have had their original source in any portion of the domain of the latter.

*Shakespeare:* I am no orator as Brutus is.

*Poor:* The speaker is not what might be termed an adept in the profession of public speaking, as might properly be stated of Mr. Brutus.<sup>14</sup>

Besides the use of jargon and nonsense words, one of the main causes of dullness in scientific and technical reports is the use of the passive voice. Apparently, many writers think that passivity is more appropriate to the dispassionate communication of objective results than the use of active verbs and straightforward sentence construction. They write, "The wave motions are caused by the wind," instead of, "The wind causes the wave motions." Unnecessary use of the passive voice makes for tedious, monotonous, lifeless prose.

Syntax, or the sequence of words within the sentence, is also crucial to style. In 1789, George Henry Lewes wrote,

Words are not like iron and wood, coal and water, invariable in their properties, calculable in their effects. They are mutable in their powers,

deriving force and subtle variations of force from very trifling changes of position; colouring and coloured by the words which precede and succeed; significant or insignificant from the powers of rhythm and cadence. It is the writer's art to to arrange words that they shall suffer the least possible retardation from the inevitable friction of the reader's mind. The analogy of a machine is perfect. In both cases the object is to secure the maximum of disposable force, by diminishing the amount absorbed in the working.<sup>15</sup>

In order to demonstrate the importance of style, E.B. White has taken Thomas Paine's familiar and enduring sentence, "These are the times that try men's souls," and has tried to alter its style while preserving its meaning. He came up with these variations: "Times like these try men's souls." "How trying it is to live in times like these ! " "These are trying times for men's souls." "Soulwise, these are trying times."<sup>16</sup> Would any of these have endured? Obviously, each of the variations destroys the elegant simplicity of Paine's style.

Lewes proposed another illustration of the importance of economy in writing. He took his example from the Bible:

"God said: Let there be light! and there was light." This is a conception of power so calm and simple that it needs only to be presented in the fewest and the plainest words, and would be confused or weakened by any suggestion of accessories. Let us amplify the expression in the redundant style of miscalled eloquent writers: 'God, in the magnificent fulness of creative energy, exclaimed: Let there be light! and lo ! the agitating fiat immediately went forth, and thus in one indivisible moment the whole universe was illumined.' We have here a sentence which I am certain many a writer would, in secret, prefer to the masterly plainness of Genesis. It is not a sentence which would have captivated critics."<sup>15</sup>

In 1946, George Orwell satirized pseudo-scientific jargon by composing a parody of a well-known verse from Ecclesiastes.<sup>17</sup> Here is Orwell's "Modern English" version:

"Objective consideration of contemporary phenomena compels the conclusion that success or failure in competitive activities exhibits no tendency to be commensurate with innate capacity, but that a considerable element of the unpredictable must invariably be taken into account."

The original was:

"I returned and saw under the sun, that the race is not to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding, nor yet favour to men of skill; but time and chance happeneth to them all."

Orwell used this example to lament the loss of vivid, concrete images from modern prose. He said, "Modern writing at its worst does not consist in picking out words for the sake of their meaning and inventing images in order to make the meaning clearer. It consists in gumming together long strips of words which have already been set in order by someone else, and making the results presentable by sheer humbug. The attraction of this way of writing is that it is easy. It is easier—even quicker, once you have the habit—to say *In my opinion it is not an unjustifiable assumption that* than to say *I think*."

Orwell pointed out that in the same way as words like *epic* and *historic* are used "to dignify the sordid processes of international politics," such words as *phenomenon*, *element*, *individual*, *objective*, *categorical*, *effective*, *virtual*, *basic*, *primary*, *promote*, *constitute*, *exhibit*, *exploit*, and *utilize* "are used to dress up simple statements and give an air of scientific impartiality to biased judgements." He said, "Bad writers, and especially scientific, political and sociological writers, are nearly always haunted by the notion that Latin or Greek words are grander than Saxon ones, and unnecessary words like expedite, ameliorate, predict, extraneous, deracinated, cladestine, subaqueous and hundreds of others constantly gain ground from their Anglo-Saxon opposite numbers."<sup>17</sup>

Scientific writers could well heed the six concise rules that Orwell set forth in his essay "Politics and the English Language":

- (1) Never use a metaphor, simile or other figure of speech which you are used to seeing in print.
- (2) Never use a long word where a short one will do.
- (3) If it is possible to cut a word out, always cut it out.
- (4) Never use the passive where you can use the active.
- (5) Never use a foreign phrase, a scientific word or a jargon word if you can think of an everyday English equivalent.
- (6) Break any of these rules sooner than say anything outright barbarous.<sup>17</sup>

Facts—whether baseball scores or historical dates or atomic numbers—are chaos until they have been selected, isolated, and combined in relation to one another. Meaning is the selection and juxtaposition of evidence. It is as futile for a TV sportscaster to try to present all the available information on a baseball game as for a scientist to try to present *all* the data on a given phenomenon. The compulsion to include everything, leaving nothing out, does not prove that one has unlimited information; it proves that one lacks discrimination.

A. N. Whitehead has asserted that the task of science "is the discovery of the relations which exist within that flux of perceptions, sensations, and emotions which forms our experience of life. The panorama yielded by sight, sound, taste, smell, touch, and by more inchoate sensible feelings, is the sole field of activity... I insist on the

radically untidy, ill-adjusted character of the fields of actual experience from which science starts. To grasp this fundamental truth is the first step in wisdom, when constructing a philosophy of science. The fact is concealed by the influence of language, molded by science, which foists on us exact concepts as though they represented the immediate deliverances of experience."<sup>18</sup>

In a speech almost a century ago, William James discussed the problem of using language to bring order out of chaos—the function of style:

The real world as it is given objectively at this moment is the sum total of all its being and events now. But can we think of such a sum? Can we realize for an instant what a cross-section of all existence at a definite point of time would be? While I talk and the flies buzz, a sea gull catches a fish at the mouth of the Amazon, a tree falls in the Adirondack wilderness, a man sneezes in Germany, a horse dies in Tartary, and twins are born in France. What does that mean? Does the contemporaneity of these events with one another, and with a million others disjointed, form a rational bond between them, and unite them into anything that means for us a world? Yet just such a collateral contemporaneity, and nothing else, is the real order of the world. It is an order with which we have nothing to do but to get away from it as fast as possible. As I said, we break it: we break it into histories, and we break it into arts, and we break it into sciences; and then we begin to feel at home. We make ten thousand separate serial orders of it, and on any one of these we react as though the others did not exist. We discover among its various parts relations that were never given to sense at all (mathematical relations, tangents, squares, and roots and logarithmic functions), and out of an infinite number of these we call certain ones essential and lawgiving, and ignore the rest. Essential these relations are, but only *for our purpose*, the other relations being just as real and present as they; and our purpose is to *conceive simply* and to *foresee*. Are not simple conception and prevision subjective ends pure and simple? They are the ends of what we call science; and the miracle of miracles, a miracle not yet exhaustively cleared up by any philosophy, is that the given order lends itself to the remodeling. It shows itself plastic to many of our scientific, to many of our aesthetic, to many of our practical purposes and ends."<sup>19</sup>

Various authors have commented on the peculiar problems of organizing and writing a scientific paper.<sup>20,21</sup> Robert A. Day's "How to Write a Scientific Paper"<sup>22</sup> is notable among recent contributions. But few of these writers bother to define style.

Ultimately, style is what gives meaning to thoughts. The sense data of commonplace experience are highly disordered. We impose order by the rigor and neatness of language. If, as Albert Einstein said, "The whole of science is nothing more than a refinement of everyday thinking,"<sup>23</sup> then in scientific writing style is the principle by which everyday thoughts are refined. "Science is built up with facts, as a house is with stones," said Jules Henri Poincaré, "but a collection of facts is no more a science than a heap of stones is a house."<sup>24</sup> Style is the architect.



"The only thing that is indispensable for the possession of a good style is personal sincerity"<sup>25</sup> says Herbert Read. But sincerity is not enough. In order to promote the vigorous and efficient exchange of scientific information, scientific writers should be trained in rhetoric, the effective use of language. Students must be convinced that they do not *know* what they mean until they can *say* what they mean. Perhaps all undergraduate science majors should be required to take at least one college course in scientific writing.

It is well known that skills can be taught, but the essential ingredient of good style—honesty—is often thought to be innate. It is not. S. Leonard Rubinstein, director of the writing program at the Pennsylvania State University, asserts that, "If a man intends to impress someone, his work will not be clear, because he does not intend clarity: he intends to impress.... A man's intention is his instrument. He must learn that instrument. He must be honest. And to be honest, he must recognize that desire to be honest is not enough. Honesty is a skill, and the skill must be learned."<sup>26</sup>

One of the best definitions of style for scientists was written in 1948 by the atomic physicist J. Robert Oppenheimer. He said:

The problem of doing justice to the implicit, the imponderable, and the unknown is of course not unique to politics. It is always with us in science, it is with us in the most trivial of personal affairs, and it is one of the great problems of writing and of all forms of art. The means by which it is solved is sometimes called style. It is style which complements affirmation with limitation and with humility; it is style which makes it possible to act effectively, but not absolutely; it is style which, in the domain of foreign policy, enables us to find a harmony between the pursuit of ends essential to us and the regard for the views, the sensibilities, and aspirations of those to whom the problem may appear in another light; it is style which is the deference that action pays to uncertainty; it is above all style through which power defers to reason.<sup>27</sup>

I hope that this discussion of the importance of style doesn't cause an epidemic of writer's block among its readers. Those who might take the matter of style too seriously can take comfort in Benjamin Franklin's conclusion to a letter describing his electrical experiments:

Those thoughts, my dear friend, are many of them crude and hasty; and if I were merely ambitious of acquiring some reputation in philosophy, I ought to keep them by me, till corrected and improved by time, and farther experience. But since even short hints and imperfect experiments in any new branch of science, being communicated, have oftentimes a good effect, in exciting the attention of the ingenious to the subject, and so become the occasion of more exact disquisition, and more compleat discoveries, you are at liberty to communicate this paper to whom you please; it being of more importance that knowledge should increase, than your friend should be thought an accurate philosopher.<sup>28</sup>

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