Editorial—A plea for scholarly writing

Scientific writing is a skill that needs to be developed through concentration and practice. By the final draft of a paper, each sentence should have been crafted to convey information clearly, succinctly, and accurately. The standard of writing in current scientific journals has reached an all-time low, in terms of both poor grammar and imprecise communication. This situation has been fueled on one hand by escalating costs of publication and an attempt to shorten papers and, on the other hand, by inadequate training in the structure of the English language.

Changes in the English language

The English language, being a composite of Anglo-Saxon languages and French, is one of the most expressive languages of the world. Many words of Anglo-Saxon origin have a counterpart of French origin. These paired words are not exact synonyms but rather, over the years, have come to express slight nuances of meaning that give to English an unusual precision and richness. Not only has English changed in the above way but also multiple spellings for particular words were reduced to a single, accepted spelling, rules for punctuation that reduced ambiguity were established, and guidelines for grammar and the structuring of sentences came into play. The preparation for the first edition of the Oxford English Dictionary began in 1857 and reached fruition 70 years later after tens of thousands of participants contributed to the organization of 414,825 precise definitions under the editorship of Professor James Murray (Winchester 1998). This dictionary was a milestone in the development of the English language and it became the official standard.

These improvements have been largely ignored in recent elementary and secondary education in the United States and few young Americans understand the structure or usage of their own language, a misfortune that becomes painfully obvious to most teaching faculty on a daily basis. It is paradoxical that many educated foreigners have a better grasp of the structure and grammar of English than do many Americans whose native language is English. How often does one wince at the grammatical errors made by announcers of news on television or at the linguistic atrocities committed in newspaper articles?

As deplorable as is the degradation of English within the populace at large, it has not sunk to the depth plumbed by scientific writing. The refinement of English over the centuries has been fractured by a generation of scientists who supposedly are dedicated to precise thinking and accurate methodology. It is unfortunate that such pinnacles of thought and achievement have been nullified by ambiguous, slovenly communication. At one time, a tertiary teacher could inspire students to achieve a better standard of scientific expression by referring them to current issues of a journal in their field of specialty. Now, many of those articles are best described, not as examples of good scientific writing, but as examples of how one should NOT write scientific papers. In a recent assessment of one of the most prestigious journals published in the United States, I examined the titles of the articles in the issues from the past 5 years. Most contained grammatical errors. Many of the articles, although deserving an ''A'' for scientific content, scarcely merited a ''C-'' were the article to be submitted as a composition for a high school class in English.

An important principle in scientific (and other) writing is that the language should convey precise meaning without recourse to other sources of interpretation. A sentence should say what it means, not provide a clue to a possible meaning that must be gleaned from context. The meaning should be unambiguous. The blatant disregard for the rules of the English language inherent in much scientific writing violates this principle.

Below are listed some of the common mistakes that are made in scientific writing, accompanied by examples taken from papers either published in, or submitted to, prestigious, peer-reviewed scientific journal or books. In some cases, names of persons or species were changed to preserve anonymity of authorship.

Excessive use of nouns as adjectives

The most glaring abuse of English in scientific writing is an excessive use of nouns as adjectives,

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especially by stringing a number of them together (called freight-training). Not only is it difficult to decipher which noun modifies which other, but also the flow of language is interrupted because of the necessity to pause and interpret the meaning. When my graduate students begin writing their dissertations, I challenge them to note examples of freight-training in their reading and write down the various meanings that could be construed from confusing passages. This exercise often leads to a more thoughtful use of language on their part, makes my reading of theses less laborious, and promotes conservation of red pencils.

A few examples from articles published in prestigious scientific journals may illustrate the ambiguity arising from the use of nouns as adjectives:

"*Post-hurricane canopy lizard study methods* are provided . . . "

Try to figure that out. I think it means the methods used in a study of lizards that inhabit canopies that was carried out after a hurricane.

"A model incorporating *individual learning rules and migration costs* into a *many-patch ideal free distribution* examines how the spatial distribution of predators and prey mortality are affected." As it stands, this sentence in unintelligible. Does the first part mean: (1) "individual learning rules" and "individual learning migration costs"? (whatever that might be), (2) "individual learning rules" and "individual migration costs"? or (3) "migration costs" and "individual learning rules"? There is no way to decide from the language used. If you already know what the author means, or can get it from context, it may be possible to understand this part of the sentence. A simple way to resolve the ambiguity of this phrase is to reverse the order to read: "A model incorporating migration costs and individual rules for learning into a . . . . " (from context I think that is what the author was trying to say). The second part of the sentence is even worse. Does it mean: (1) a distribution that is free of many-patch ideals? (2) a free distribution somehow involving a many-patch ideal? or (3) nothing at all?

The sentence just discussed was taken from the abstract. It foreshadowed what was to come. The body of the paper was loaded with similar inadequacies. For example: "However, the links between learning as studied by behavioral ecologists working on *foraging and mainstream animal learning* . . . . " Is the author writing about mainstream animals or mainstream learning of animals, or the foraging and learning of mainstream animals, or what? A later sentence reads: "*Foraging theorists became interested in learning* for two reasons . . . . " From context it seems likely that the author does not really mean that theorists that were foraging became interested in learning. (I can see it now: There I was, foraging in the refrigerator for a sandwich when I suddenly became interested in learning.) He is trying to say that persons who theorize about foraging became interested in learning.

"In addition, *captive breeding programs* could be established to supply the *small private keeper demand* for snakes . . . . " Is this a breeding program that is captive or a program of captive breeding? Neither makes very much sense if taken literally. The second part seems to mean either that the demand is by private keepers that are small, or that there is a small demand from private keepers. However, neither is correct. From context, it appears to mean that the demand is by keepers of private collections that are small!

"*Species abundance distribution patterns* of microarthropods in *surface decomposing* leaf-litter and mineral soil on a desert watershed . . ." Note that there are six nouns and a gerund used as adjectives. Three modify "patterns" and two modify "leaf-litter" and the rest are singles. That does not include two compound words (microarthropods and watershed) and one hyphenated one, all of which have built-in modifiers.

"It was found that *larval ingestion rates* were higher . . . ." Does this mean that larvae were ingesting something at a higher rate, or that something was ingesting larvae at a higher rate? It is not clear from the statement itself although one could make a reasonable guess by examining the context. If the former meaning is intended, it could be clarified by the statement: "It was found that the rates at which larvae ingested were higher . . . ." and if the latter, by the statement: "It was found that the rate at which larvae were ingested was higher . . . ." The original statement used nine words (44 characters), the first clarification used 12 words (53 characters), and the second clarification used 13 words (55 characters). Is this too high a price for moving from ambiguity to clarity?

"If *nutrient fertilization* also increases the likelihood and the severity of key plant diseases, then determining the optimal fertilizer application level can become complex." How does one fertilize nutrients?"

"*Dog feeding mechanisms* are well studied." This does not mean mechanisms for feeding something to dogs or of feeding dogs to something but (from context) rather the mechanisms dogs use in feeding. In this case hyphens could be used for clarification. "dog-feeding mechanisms" are quite different from

"dog feeding-mechanisms." The latter should really be "dogs' feeding mechanisms."

"Digital data sampling" Again, hyphens can come to the rescue. "digital-data sampling" is not the same as "digital data-sampling."

In general, compound adjectives can be hyphenated to link the two modifiers. Take the words "life history" for example. When not used to modify another word these two words are not hyphenated, as in the sentence: "The life history of the frog is interesting." When they are used as an adjective they should be hyphenated as in the sentence: "The life-history strategy of the frog is interesting." Clarity can be added to a manuscript by going through it and identifying compound adjectives and hyphenating them. Much of the ambiguity of freight-training can be avoided in this way.

Perhaps the most common, and most humorous misuse of adjectives refers to gender. In the English language, data do not have gender. One commonly encounters references to "male data" and "female data." Perhaps this is why male data are put in separate columns from female data; otherwise "juvenile" data might be generated that would clutter the paper! Of course, the intended meaning is: "data from males" and "data from females."

I leave it to the reader to ponder the meaning of the following: "hatching enzymes," "malformed frog investigation," "field site velocities."

Verbosity

Use of unnecessary words or complicated phraseology does not make a paper appear more scholarly; indeed, just the opposite is true. A series of long words should not be used if a few, shorter ones convey the meaning better. An excerpt from a recent scientific paper illustrates this point: "....enhance your knowledge base of...." really means "...inform you about...."

Ambiguous wording

"The *evolution* of locomotion *during prey capture*." This must be very rapid evolution—but is it the locomotion of the predator or the locomotion of the prey that evolves at such a great speed? Probably the intended meaning is: "the evolution of locomotion involved in the capture of prey."

"This species is another frog reported as *potentially threatened by Smith* (2006)." It sounds as though Smith is threatening the frog! It should read: This species is another frog reported by Smith (2006) as potentially threatened.

"There was strong evidence of activation that had been inferred in previous beetle reports." This sound like beetles wrote the report. The phrase should be "reports about beetles."

"Behavior in small bird flocks, medium bird flocks and large bird flocks...." leaves one wondering whether birds or flocks are of different sizes. One cannot tell from the wording of the sentence. Hyphens would help. If the birds are of different sizes, then "small-bird flocks, medium-bird flocks, and large-bird flocks" would make sense. If it is the size of the flocks that varies, then "small bird-flocks, medium bird-flocks, and large bird-flocks" would indicate that. Still better would be a complete revising of the sentence to read either "Behavior of birds in small, medium-sized, and large flocks" if that were the intended meaning, or "Behavior of small birds, medium-sized birds, and large birds in flocks..." were the alternate interpretation intended.

One who can't distinguish between extra-marital sex and extra marital sex is likely to become acutely aware of the importance of hyphenation!

"....on the basis of research on largely human subjects...." surely was intended to mean " largely on the basis of research on humans." Are you largely human?

Poor punctuation

Older books on grammar indicated that commas should set off all parts of a series. More recently, the tendency is to allow dropping the last comma of a series (known as the Oxford comma or serial comma) (Truss 2006), thereby leading to ambiguity. Indeed, this alternative is now often deemed to be the "correct" one and the older standard to be incorrect.

Consider the following example: "As more information on the actual geographic pattern of pesticide residues becomes available, it will be possible to test the association between pesticide uses, *predominate* winds, and residues that are assumed in the previous study." Use of a comma after "winds" indicates that there are predominate winds and there are residues (the correct meaning).

Now examine the paragraph without the Oxford comma: "As more information on the actual geographic pattern of pesticide residues becomes available, it will be possible to test the association between pesticide uses, predominate winds and residues that are assumed in the previous study." Absence of the Oxford comma indicates that there are predominate winds and there also are *predominate* residues (an incorrect meaning). Ambiguity frequently arises when the comma is omitted before

the last of a series and in such cases the Oxford comma should be used. I suggest that for the sake of consistency it should always be used.

The importance of correct punctuation can be illustrated by the oft-cited anecdote about a teacher's response to a principal who told students that studying punctuation was a waste of time. The teacher went to the blackboard and wrote: ''The principal said the teacher is wrong.'' The principal smiled approvingly, whereupon the teacher punctuated the sentence as: ''The principal, said the teacher, is wrong.'' The smile left his face.

The present editorial is not an appropriate place for a detailed treatment of punctuation and the reader is referred to a delightful, humorous book on the subject: ''Eats, Shoots & Leaves'' by Lynne Truss (2006). Incredibly, this small book became a best seller.

Plurality of the word ''data''

The word ''data'' is a plural noun. The singular is ''datum.'' Hence, the proper usage is ''data are'' not ''data is.'' Similarly, one should say ''these data'' not ''this data.'' I have to correct such errors repeatedly in almost every article I edit, even those written by senior scientists. Recently, at an otherwise excellent symposium, every presenter that used the word ''data'' did so incorrectly. I did not notice many people wincing. In business and law it has become commonplace to use ''data'' as a singular noun but that should not give scientists license to be equally slovenly.

More or Less

The word ''more'' has two opposites. ''Less'' is the correct choice when dealing with amounts, and ''few'' should be used when dealing with numbers. It is incorrect to say ''less animals'' instead of ''fewer animals.''

Which or that?

Another common pitfall is the incorrect use of ''which'' for ''that.'' Consult a good style manual for correct usage of these two words.

Do, did, and in (uncertain objects of verbs)

A recent example of an uncertain object of a verb is: ''Males consumed more prey than females.'' This implies that males consumed females to a greater extent than males consumed prey. In fact, from context, males did not eat any females at all but rather the comparison was between males and females in the amount eaten. The sentence should read: ''Males consumed more prey than *did* females. This kind of error is common in scientific writing. Use of ''did'' or ''do'' (''Males consume more prey than *do* females'') can clarify these ambiguities.

''The effect of such strong temporal decline in calcium is most severe in species breeding in seasonal ponds or small streams . . .'' suggests that ponds and small streams are both seasonal, something that, from context, was not true. This ambiguity can be eliminated by use of the word ''in,'' as in ''breeding in seasonal ponds or *in* small streams.''

Reviewed in Smith and Jones (2008)

If taken literally, a citation in this form is absurd; presumably it stands for ''reviewed *in the paper by* Smith and Jones.'' Why not merely write: ''reviewed *by* Smith and Jones,'' an accurate statement that is just as short as the original incorrect one.

Redundancy

There are common redundancies that are frequently found in scientific writing. Note that the previous sentence has a redundancy: *common* versus *frequently*. No meaning is lost by shortening this sentence either to: ''There are common redundancies found in scientific writing.'' or better still: ''There are redundancies that are frequently found in scientific writing.''

A common redundancy is: ''point in time'' when merely ''time'' would suffice. Another is: ''revert back.'' The single word ''revert'' is sufficient.

Temperature

One frequently finds references to ''hot temperatures'' or statements that temperatures at one site were ''cooler'' than at another. Temperatures are neither hot nor cold. Objects are hot or cold; temperatures are high or low.

What generates such fracturing of the English language?

Other than the abandonment of teaching English rigorously in children's early education, the main reason for recent degradation in communication by scientists seems to be the cost of publication. Most journals have financial strictures and need to conserve funds. Accordingly, authors are under pressure to condense their manuscripts as much as possible and delete all extraneous material. A common instruction to a potential author from the editor and reviewers is to explain topics A, B, and C in more detail, clarify why technique E was used, and

so on, all of which demands use of more space. These instructions are commonly followed by a demand to reduce the length of the paper by 20%. The only way an author can comply is to use ''compact,'' ''condensed,'' or ''direct'' style, a euphemism for a telegraphic, grammatically incorrect, confusing, and ambiguous obfuscation, i.e., modern scientific writing. At first, authors abhorred this style of writing but it has become so habitual that to many it now appears correct, and may even be preferred. It recalls a phenomenon I have experienced in reading manuscripts. After reading a thesis in which a particular, common word was consistently misspelled, by the end of the article the incorrect spelling had become familiar and the correct usage began to appear strange. I have lost several words by this process; at one time I could spell them but now I have to look them up!

Many incorrect uses have become so ritualized in particular disciplines that they now constitute a code that is understood by all practitioners of that field (but not to outsiders). Attempts to correct these and put them into English that is understandable by scientists in other specialties engenders objections on the ground that ''this is the way it is written in my particular field.'' The question is not whether it *is* written that way, but whether it *should* be written that way. Is it not just as undesirable to produce bad writing as it is to produce bad science? The adherence to codified, nonsensical expressions is one reason scientists are having increasing difficulty in communicating their findings to the public at large. If one has to codify technical terms, then it should be done in a grammatically correct manner. This can be achieved by the judicious use of hyphens (see examples above), or it could be achieved by adopting the practice in Germanic languages of making a new word by merely combining two others such that the new one has a specific, unambiguous meaning, separate from its components. The word ''dataset'' is in common usage. Perhaps many more such words, either hyphenated or directly combined, should be coined, rather than using two words that, although accepted by the practitioners of the discipline, lack clarity.

I suggest that we have gone too far in reducing publication costs. Quality is expensive. Is it worthwhile to condense a paper to the extent that the meaning is not clear, or the language absurd? It may be better to publish fewer papers, but insist on a higher standard of language as well as of scholarship. If a paper is scarcely understandable by a native English speaker, think how confusing it would be to someone for whom English is a second language (but see above).

The editorial policy of *ICB* is to produce a scholarly journal of high quality, both in science and in writing. Authors are encouraged, once their manuscript is deemed to be ready for submission, to go over it one more time and make sure each sentence conveys precise, grammatically correct, unambiguous meaning.

Lest the reader consider this brief note an example of editorial arrogance, I should acknowledge that even in the last draft I found myself guilty of some of the sins against which I have railed. If any corruptions of the language remain, the reader is entitled to gleefully gloat upon them.

References

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