nature neuroscience

How experts communicate

In Darwin's time, it was possible to write a book that was both a primary scientific report and a popular bestseller. Today, however, that seems like a remote ideal[1]. Not only is it difficult to communicate scientific ideas to the general public, but scientists seem to have increasing difficulty communicating with each other. Even within biology, researchers in different areas of specialization are often unable to understand each other's papers. This is a particular problem for a field such as neuroscience, whose advances have often depended on the exchange of ideas across disciplines. *Nature Neuroscience* seeks to encourage clear writing and to make everything we publish accessible to as many readers as possible. Yet even if this seems uncontroversial in principle, it is surprisingly difficult to achieve in practice.

Despite the obvious advantages of communicating clearly, scientists are often resistant to the suggestion that their articles should be comprehensible to readers outside their own field. For one thing, there is a tendency to equate plain language with oversimplification. As science becomes more complex, the argument goes, an ever-increasing amount of specialist jargon is required to describe it precisely. Even if this is true, however, technical terminology can be explained, and it need not present an insurmountable problem to the scientifically literate reader. A more important deterrent to clear expression—although people are less willing to admit it—is that plain language, no matter how precise, strikes many scientists as somehow unprofessional. It is often seen as a badge of academic credibility to express short simple ideas in long ponderous phrases; why else would anyone choose to write a sentence such as "To elucidate these issues, we utilized the caprine model" instead of "We studied these questions using goats"?

This type of pomposity is easy to avoid once it is recognized, and fortunately many other common problems in scientific writing are similarly easy to correct. One of the most obvious is excessive use of abbreviations. People within the field are likely to be familiar with common abbreviations and process them as if they were words. However, every unfamiliar abbreviation makes an additional demand on the reader's memory. Individually, such problems are minor nuisances, but as they accumulate, they can severely impair understanding. Another common barrier to communication is to describe experimental results in ways that emphasize the method of analysis rather than the phenomenon being studied. For example, "ANOVA revealed a significant main effect of age and a significant interaction effect" is much less informative than "Protein levels decreased significantly with age, and this decline was more pronounced in adrenalectomized animals."

Even when making the effort to write for a wide readership, many authors adopt solutions that are ineffective. For example, vapid introductory statements like "Much recent research has been aimed at understanding synaptic plasticity" are as useless to nonspecialists as they are to anyone else. Concluding paragraphs present a similar temptation to vagueness; saying "this work provides insights" into some problem is less informative than explaining what those insights were. In fact, there is nothing mysterious about writing for nonspecialists. The key is to examine each sentence for hidden assumptions and unfamiliar concepts, and to ensure that they are clearly explained in a way that minimizes the demands on the reader's memory.

The problems posed by a poorly written article are greater for nonspecialists, but even experts comprehend more easily if they do not have to waste mental resources on parsing difficult sentences. Research in linguistics and cognitive psychology shows that sentence structure creates expectations about content and emphasis. Writing that violates these expectations is difficult to read[2]. Clear writing reduces the demands on working memory by presenting information where readers expect to find it. Unfortunately, scientific writing often does the opposite. One common mistake is to separate the sentence's subject from its verb with a long clause that contains important information (for example, "An increase in mRNA, which resulted from transcriptional upregulation by factors binding to the AP1 site, was observed"). Because the reader is distracted by the need for syntactic closure, material between subject and verb receives less attention than it should. The opposite problem occurs when unimportant material is placed in a location that readers naturally emphasize. Each sentence contains at least one 'stress position' near the end, at the point when readers comprehend how the various parts of the sentence relate to each other. Indeed, behavioral studies indicate that readers slow down as they reach the end of a sentence or clause[3]. Material at this location is perceived as being important—whether the author intended it to be or not. Thus, readers are most comfortable when familiar information at the beginning of the sentence creates a context for important new information introduced at the end. These rules do not require writers to avoid complicated ideas or long sentences, only to construct them carefully.

Because young scientists learn by imitating their elders, a culture of bad writing tends to be self-perpetuating. Perhaps the solution is for graduate programs to place more emphasis on formal instruction in scientific writing, but this will only happen if scientists appreciate the need for better communication and understand the steps that can be taken to achieve it.

1 Gould, S. J. *Science* **286**, 899 (1999).
2 Gopen, G. D. & Swan, J. A. *Am. Scientist* **78**, 550–558 (1990).
3 Just, M. A. & Carpenter, P. A. *Psych. Rev.* **87**, 329–354 (1980).