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Tips for Writing (and Reading) Methodological Articles

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One reason many methodological articles are not very intelligible to their readers is because the content is often inherently difficult. However, a contributing factor in some cases is the tacit assumption that rules of good writing cease to apply when writing about statistics. The authors of this article argue that good writing becomes even more important as the content of the article becomes more complex. Furthermore, they believe that additional rules pertain to writing methodological articles and highlight various ways that methodological article authors can make their work more accessible (and less painful) to researchers who are not methodological specialists. The authors also suggest how nonspecialists can most effectively approach the task of reading a quantitative article.

For some psychologists, writing a methodological article is a fine art of obfuscating needlessly tedious and complex trivia. For others, reading a methodological article ranks right up there with a visit to the dentist's office. Many methodological articles, however, are not accessible to their intended readers, not necessarily because the material is so sophisticated but because the presentation of the material is so obtuse. Our goal in this article is to provide a few suggestions for writing methodological articles. Excellent articles are available on the writing of general psychology articles (e.g., Bem, 1987; Sternberg, 1988, 1992). Hence, we try to avoid repeating these points, except to say that all the rules for good nontechnical writing are at least as important for good technical writing if only because the material is often more complex. Our specific focus is on writing methodological articles for nonspecialists, although some of our comments may also pertain to authors who target specialists.

Quantitative methods articles in psychology take many different forms. Some articles are similar to substantive *Psychological Bulletin* articles insofar as they are literature reviews. The authors of these articles typically synthesize relevant methodological literature or present new statistical methods in a format that is appropriate to a nonstatistical audience. Other authors present the results of original research. The topics range from evaluations and comparisons of current statistical technologies to developments and introductions of qualitatively new research methodologies. Such articles may include highly technical mathematics or extensive computer simulation. Because of the diversity of these articles, we attempt to make points that are useful to as wide a range as possible of current and future methodological article authors.

Preparation

Defining Your Audience

"Perhaps the most important principle of good writing is to keep the reader uppermost in mind" (Knuth, Larrabee, & Roberts, 1989, p. 3). This principle is especially important in technical writing, where your audience may be remarkably diverse, ranging from methodologists who specialize precisely in the topic under investigation to researchers in very different fields who hope to apply a specific new technique in their next study.

Authors often overlook the fact that they wield considerable control over their readership by carefully choosing the journals to which they submit their work. At least three questions should be considered when selecting a journal in which to publish a methodological article. First, how technical is your presentation? The perfect article for a highly technical outlet such as *Psychometrika* may be almost unintelligible to the majority of *Psychological Bulletin* readers. Many journals (*Psychological Bulletin* included) explicitly proscribe the use of complex mathematics, such as calculus or matrix algebra. If not, the editor either requests the author to find a more accessible way to make the points or suggests to the author to submit the work to a more technical journal. Second, how specific is your methodological point? Among methodological journals, some (e.g., *Psychological Bulletin*) target a readership that uses a wide variety of methodologies. In general, articles in which highly specific points about a particular statistical technique are made belong in more specialized methodological journals (e.g., *Structural Equation Modeling*). If the point is more general or pertains to a wider variety of research paradigms, then broader methodological outlets may be more appropriate. Third, how specific are the implications of your article for a particular subdiscipline of psychology? Articles submitted to journals with broad readerships should have implications for researchers almost irrespective of their content area. Even when the technical level of the presentation is low, authors must still face the question of whether the practical implications of the article are broad enough to warrant publication in a journal such as *Psychological Bulletin* or whether a more specialized substantive journal might be more appropriate. Many area journals publish occasional methodological articles (e.g., *Journal of Applied Psychology*), have special sections on methodological advances (e.g., *Journal of Consulting and Clinical Psychology*), or even publish special issues on methodology (e.g., *Journal of Counseling Psychology* and *Journal of Family Psychology*). Consequently, an article on a specific topic, such as reaction times in cognitive tasks, would probably fit well in a cognitive journal,

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whereas an article on reaction time research in general might cut across disciplines and thus be more appropriate for a journal with a broader readership.

After selecting a journal, continue to strive to write for as broad an audience as possible. Failure to relate specific methodological points to the variety of situations to which they might pertain unnecessarily limits the impact of the article. Use examples from diverse research areas; refer the reader to wide-ranging applications of your procedure; and elaborate on the implications of your methodology for diverse research paradigms. Pitching your article to too narrow an audience may not get it the attention it deserves.

Most articles have multiple audiences. A hierarchical structure permits an article to be read for its general ideas by some readers and for its specific details by others. Presenting a general overview of the problem and the solution early in the article enables all readers to walk away with the overall gist of the message. Then, increasing the amount of detail as the article progresses allows readers to go as far as they want (or need) into the intricacies of the methodology. At the same time, authors and readers alike need to be sensitive to the dangers of stopping too soon. Authors might motivate readers to persevere by issuing periodic cautionary notes that describe potential hazards of implementing this new technique (among other things) before reading the next section.

Obtain feedback on the article from a variety of sources. For example, sharing a draft of the article with other authors who have written articles in the same general area may provide valuable expert feedback. It may be especially useful to seek the opinions of individuals whose expertise and perspective differ from your own. For example, some authors may benefit from involving a methodological expert who can ensure the technical accuracy of the article. All authors may benefit from the input of a knowledgeable nonspecialist, who can endow the work with a healthy respect for some of the readers' primary concerns, paraphrase statistical jargon, enrich the article with substantive examples from nonquantitative journals, and maintain a focus on the article's practical implications.

Motivating the Reader

Most psychologists are content to continue plying the traditional statistics and methodologies learned in graduate school. A pretty serious wake-up call is needed to alert psychology authors to new alternatives. Before proving anything with numbers and formulas, prove to the reader that what you propose can make a real difference. A specialist who encounters your article may immediately appreciate the relevance and potential importance of your article simply by reading the title and the abstract. The nonspecialist, however, is likely to need more guidance. Consequently, be as explicit as possible about the purpose of the article. Furthermore, make the point as early as possible in the article; otherwise, many readers may not struggle beyond the first paragraph or even the abstract.

To some extent, the point is the same as Sternberg's (1992) advice that all psychology authors should "tell readers why they should be interested" (p. 12). This point is even more important when writing a methodological article, however, if only because there is likely to be a larger gap between the author's background and the reader's. The author may be drawn to the topic because of its theoretical elegance or mathematical challenge, whereas readers are more likely to be interested in knowing whether this article means that they should design their studies differently or analyze their data with a new technique.

As Knuth et al. (1989) stated, "present the reader with something straightforward to start off with" (p. 76). Hand the readers a statement that explains what the article is about and why they should read it. Most *Psychological Bulletin* articles have one of the following points at their center:

1. Methodological advances allow interesting questions to be answered that previously were not amenable to a solution.
2. Here is a way to increase your statistical power.
3. You may not be testing the hypothesis you thought you were.
4. If you have data that depart from standard assumptions, there may be better ways to analyze your data.
5. A new statistic is better than the standard statistic.

Remember, presenting a new solution is of little value if the reader does not understand the problem yet. A voluminous review of every nuance of a methodological conundrum is unlikely to hold anyone's interest unless one is working on the particular problem. If the problem is truly important, an author should be able to state in a few sentences at the beginning of the article what the problem is, why it is important for psychologists, and why it has been difficult to solve.

Reviewing the Literature

Stipulating that prospective authors conduct a thorough literature search prior to formulating a methodological article is hardly an earthshattering notion. Less obvious, however, is that searching the relevant literature for methodological articles is often quite different from reviewing the literature for substantive articles. The multidisciplinary nature of methodology requires that the researcher be familiar with previous work in a variety of other disciplines. What appears to be a new statistical technique in psychology may have already been proposed in the statistics literature. The *Current Index to Statistics* (American Statistical Association, 1994), an annual keyword index, is extremely useful for identifying relevant statistical literature on a particular topic.

Quantitative psychologists must also be aware of the methodological literatures in other social sciences. For example, authors on structural equation modeling often must be familiar with recent advances that have appeared in sociology literature (such as *Sociological Methods and Research* and *Sociological Methodology*). Finally, methodologists must be cognizant of the ideas transmitted to the next wave of researchers through recent methodology textbooks. Articles that critique methodologies from texts published a decade ago are not of much value if those presentations no longer appear in more recent books. Similarly, articles that constitute pedagogical reviews of already published methodologies must differ substantively from modern textbook presentations of the same material. Synthesizing literature that has heretofore appeared exclusively in specialized methodology journals may be quite valuable. Once new methodologies appear in textbooks, however, they are likely to be inappropriate journal topics even if previous literature reviews have not appeared in journal format.

Occasionally, relevant literature lurks in unexpected places.

In statistics, problems can sometimes be transformed in such a way that they take on an entirely different appearance (even though they are technically unchanged). Under the alternative guise, new literature, if not new insights, may be hiding.

Communicating Technical Material

Many psychologists' worst adult memories are from their first graduate statistics class. With a few well-chosen mathematical proofs and equations, you have the power to dredge up nightmares of endless take-home exams and to rekindle feelings of deep-seated insecurity—not exactly the recipe for tempting the reader past the first few opening paragraphs of your article. You might rationalize that these simply are not the people who will read your article anyway, but that is precisely the (unfortunate) point.

Some authors appear to operate from the assumption that clarity and rigor represent opposite ends of the same dimension: These authors argue that if everyone can understand their arguments, then their points must not have much insight. Certainly some arguments require a great deal of prior knowledge without which even the clearest prose fails to be comprehensible. Nevertheless, it does not follow that clarity and rigor are enemies of one another. The author must adopt a different attitude, such as by wondering how he or she can make this inherently difficult (and potentially tedious) material as accessible as possible.

Clarity is especially critical in technical writing where the presentation of ideas is usually cumulative. If the author does not communicate the first points clearly, readers will probably be lost and therefore be unable to appreciate the remainder of the article. Be aware of what the reader knows because either the material has already been presented in the article or some background knowledge can be safely assumed (Knuth et al., 1989). If your article is closely related to an earlier article, it is usually necessary to summarize the major points of the previous article in considerable detail. Do not expect readers to be familiar with recent articles, and do not require them to read the articles before they can comprehend yours. Good advice is generally to start at a lower technical level than you would think. Even more difficult, however, is to anticipate what the reader expects next. Prepare the reader for the relations between different sections of the article so that individual pieces become a coherent whole.

Presume that many readers will skim (or altogether skip) anything that even slightly resembles an equation. Why fight it? Too much mathematical material in an article written for nonspecialists may effectively reduce actual readership to zero. The most obvious solution is to relegate technical details to an appendix. This is frequently a useful strategy; however, authors must take care that the main message of the article is clear even to those who do not read the appendix.

At times, equations are necessary for the main message of the article, in which case they should not be placed in an appendix. Indeed, a statistics article in a specialized journal may (and perhaps should) contain as many equations as words. When it comes time for the unavoidable mathematical argument, consider a few simple steps:

1. Tell the reader what you are going to show and why it is important.
2. Define your terms clearly when you first introduce them (and do not be afraid to remind the reader of key terms along the way).
3. Within the mathematics section, do not forget that you can use words too. Phrases such as "substituting Equation 3 into Equation 4 produces the following" are far superior to phrases such as "it follows that" or insults such as "obviously." Remember, too, that symbolic expressions are parts of sentences and should be punctuated as such as well.
4. Pause periodically to explain particular equations and comment on how they fit into the big picture.
5. At the end of the mathematics section, provide a verbal summary of the main points and why they are important.

Formulas can often be made more comprehensible by the presentation of "special cases." For example, some formulas may become simpler when sample size becomes extremely large. Simplifications may also arise when certain terms are assumed to be equal to one another or to zero. Yet another simplification sometimes emerges when a formula is written for the special case of two groups or in its univariate form instead of the more general multivariate form. Even if the rest of the article uses the more complex form of the formula, readers will usually find this presentation to be more meaningful if they have been able to grasp the essential meaning of the formula through special cases.

Of course, authors must also exercise good judgment about how much verbal explanation surrounding the mathematical presentation will be useful to readers. Unnecessary verbiage simply slows readers down and can make concentrating on the major points more difficult. On a related point, although word variety can reduce repetition and subsequent boredom, technical terms should generally not be interchanged even when they have the same precise meaning because many readers may not know whether the change in working reflects a change in meaning.

Notation

The wise use of symbols in a quantitative article provides a clear and parsimonious form of communication. It is much simpler for both the reader and the author to write σ_j instead of "population standard deviation within group j." Whereas the advantage is most obvious in equations, the careful use of symbols in text can also prevent awkward and excessive verbiage. Careless or thoughtless notation, however, may frustrate the most dedicated reader even when the expository text of the article is exemplary. A few straightforward rules go a long way to ensure that symbols help rather than hinder the reader. For example, providing an explicit definition of each symbol when it is first introduced is essential. Even something as seemingly straightforward as n may need to be defined. Although the American Psychological Association's *Publication Manual* (1994) stipulates that n be used to denote sample size within a group and N be used to denote total sample size, some readers may not be aware of this notation. Even when the initial meaning is explicit and clear, readers may benefit from an occasional reminder of what a symbol represents, especially if it has not been used for several pages. Also helpful is to take advantage of mnemonic coding wherever possible. Standard notation should be used if it has been established. The *Publication Manual* (1994) provides an extensive list of common statistical abbrevi-

ations and symbols. Even when standard notation does not exist, it is still important to follow general conventions, such as using Greek letters to represent population parameters and Latin letters for sample statistics. Needless to say, the same symbol should never be used to represent two different concepts, nor should two different symbols be used to represent the same concept. Finally, authors must be aware of the need to balance the parsimony obtained from symbols with the added burden placed on readers to remember what each symbol represents. In general, the best advice is to use as few symbols as possible.

Examples and Figures

A mathematician's natural tendency is to derive the most general form of an expression first and only then consider special cases. This strategy can be effective in articles written for nonspecialists if the author explains the general problem thoroughly and builds a compelling case for needing the general form in the first place. Nonspecialists, however, often crave a few special cases as appetizers, which then whet their appetite for the most general case. Although this sequence is typically less elegant mathematically, beginning with concrete examples may allow nonspecialists to follow the underlying logic more easily. This approach is similar to the *particular–general–particular* teaching technique recommended by Rourke (as cited in Mosteller, 1980). To explain an abstract idea, begin with a specific example that motivates the need to develop a solution to the problem. A general approach to the problem can then be considered along with a general solution. A sense of closure and full understanding may be absent, however, unless the general principles are followed by their application to a specific problem.

Using the particular–general–particular strategy is often consistent with using appropriate examples. Numerical examples are especially helpful in methodological articles. Authors can fulfill the first step of Rourke's (cited in Mosteller, 1980) strategy by providing an initial discussion of a problem in need of a solution. Once the author has presented the general solution, the initial problem can be revisited through a numerical example. A dilemma facing the author is to make the example complicated enough to be realistic and yet simple enough to illustrate the general methodological principle clearly. At times, the best resolution of this dilemma may involve a succession of increasingly complicated examples (see Cole, 1987). Ideally, examples also provide sufficient information to allow readers to work through computations or programming themselves, so they can check the accuracy of their understanding as well as their ability to apply procedures to actual data. Sometimes providing a numerical example on the basis of a small number of cases is either so unrealistic as to be misleading or it is simply infeasible. However, authors should be aware that useful alternatives may exist in these cases. For example, Willett and Sayer (1994) provided complete longitudinal data on a subsample of cases and effectively integrated their presentation of the subsample with their discussion of the actual total sample. For some types of problems, presenting the sample covariance matrix (or other summary statistics) may be sufficient to allow readers to duplicate the authors' results (see MacCallum & Browne, 1993, for an example). Willett and Sayer's inclusion of the LISREL program code in an appendix also illustrates an additional approach for helping readers to check their understanding of the proposed method and to use it appropriately for their own data. Although examples are often essential for clear communication, both authors and readers must understand that examples in and of themselves do not establish desirable properties of a proposed method.

The juxtaposition of specific and general issues may be ideally suited for methodological articles that demonstrate how advances in computer software can offer new methodological opportunities. The impact of such a presentation can usually be greatly increased by couching the presentation in terms of more general methodological issues. Try to use software examples to illustrate fundamental methodological principles. Good examples are O'Brien and Kaiser's (1985) demonstration of how syntax choices in SPSS multivariate analysis of variance yield different analyses in repeated measures designs and Bryk and Raudenbush's (1987) discussion of how hierarchical linear modeling addresses basic questions in the analysis of change. The combination of computer software, a broad consideration of more general quantitative issues, and specific numerical examples enables readers to not just use the statistical program but also better understand the advantages and disadvantages of various data analytic strategies.

Another useful tool for communicating technical material is the use of figures. Figures may be useful for showing results from numerical examples or for displaying the results of simulation studies. An often overlooked advantage of figures, however, is their use for depicting mathematical relationships. Plotting mathematical functions often illuminates the meaning underlying an abstract mathematical expression. For example, some of our own work (Maxwell, 1994; Maxwell, Cole, Arvey, & Salas, 1991) illustrated how contour plots can show the meaning and practical implications of mathematical derivations. Recent advances in graphics software open the door to a multitude of possibilities for visual representations of multivariate data and relationships. Methodologists should be at the forefront of advances in graphics (see Cleveland, 1985, 1993; Tufte, 1983, 1990).

Simulation Studies

Much of the methodological work submitted to psychology journals involves simulation studies. Simulations can be extraordinarily valuable because they allow the author to describe properties of statistics under suboptimal conditions where underlying assumptions have not been met. As a consequence, mathematical derivations of properties may be cumbersome if not impossible. Effective communication of simulation studies involves special considerations beyond those of other methodological articles; simulation studies are experiments and must be described and interpreted in this light.

For example, careful thought must be given to the selection of specific parameter values to manipulate. An infinite number of ways exist for distributions to depart from homoscedasticity. How does the author select a realistic sample of distributions to examine? Although there is no simple answer, some sources can supply useful evidence of the types of distributions obtained in actual empirical work in the behavioral sciences (e.g., Micceri, 1989). Sawilowsky and Blair (1992) provided an example of how this type of information can be incorporated into the de-

sign of simulation studies. Of course, previous simulation studies in related areas can also provide a useful framework for selecting conditions to simulate.

As in all experiments, the author should be prepared to interpret the results obtained from the specific parameter values in the context of a broader theoretical framework. For example, the specific results obtained with exactly 20 or 50 participants per group in the simulation are valuable only to the extent that the author can establish a case for generalizing the findings to other sample sizes (even if these specific values were not included in the simulation). The author must also plan an appropriate number of simulation replications so that obtained results are sufficiently precise. Obtaining 8 significant results out of 100 simulated replications at an alpha level of .05 does not necessarily indicate that the test under consideration is liberal. The excessive error rate might simply reflect sampling error. Many replications are quite appropriate when a high degree of precision is required.

Simulation studies typically produce an enormous amount of data. After doing all of the work to generate the data, the author may be tempted to show the reader all the results of this massive effort. Authors, however, must distill this mass of information down to its essence, especially for a nonspecialist readership. Most important, the author must decide what conclusions emerge from systematic patterns in the data and organize the presentation of results accordingly. In addition to typical reports of proportions, means, and standard errors, Maxwell (1980) illustrated how correlates of the primary statistics can provide an even broader context for interpreting results obtained for the selected parameter values. Other approaches for establishing a broad framework include making an approximate argument (see the appendix of Hedges & Olkin, 1984, for an example) and using exact theory for simplified cases and developing large sample theory (see Hedges, Cooper, & Bushman, 1992, for both of these approaches). In addition, Harwell (1992) discussed methods for integrating results from simulation studies, which are valuable ideas for the prospective simulation researcher.

A final (or "first") concern for simulation studies is that they are sometimes completely unnecessary. Authors occasionally fail to appreciate the value of the analytic proof. If properties of a statistic can be derived mathematically under specified conditions, then there is no need to study the statistic through simulations under these same conditions. Such simulations add no information whatsoever to what is already known mathematically. Such simulations only serve to validate the algorithms used in the simulation itself. Thus, including such conditions in a simulation may be useful to verify that the simulation is correct under baseline conditions. Authors should not, however, make the mistake of inferring that these results are informative in and of themselves.

Once Burned, Twice Shy

Identify the limits of your findings early in the article. Imagine a reader's frustration at having plowed through a statistical treatise on distribution-free alternatives to maximum likelihood structural equation modeling only to discover at the end of the article that the sample size requirements are 10 times what the reader usually has available. Trudging through a second methodological masterpiece may not end up very high on this reader's list of things to do.

One frequent way in which limitations manifest themselves is through assumptions. Unfortunately, authors sometimes fail to state assumptions explicitly. Without a clear statement of assumptions, the reader has no starting point for statistical claims made in the article. Although a detailed statement of assumptions might best appear in an appendix, most articles would benefit from a general overview of the assumptions near the initial statement of the problem and proposed solution.

In a related vein, authors should avoid the temptation to present a new methodology as a panacea. In all likelihood, any new method carries with it some disadvantages as well as advantages. Authors do readers a disservice when their presentation is one sided. Although a certain degree of enthusiasm is understandable and even desirable, balance is also important.

Tips for Reading Methodological Articles

Not surprisingly, many of the tips for writing methodological articles apply equally well to reading quantitative articles. Ideally, the goals of the author and the reader are virtually identical. In many cases, the advice for authors can be generalized to readers simply by substituting *reader* for *author*.

Just as authors should often strive for a hierarchical structure, readers may also benefit from approaching a methodological article hierarchically. For many readers, attempting to read a technical article word for word from beginning to end is a guaranteed prescription for frustration. Instead, it is often far better to skim the article initially to develop a broad understanding of the article. A second reading might involve close reading of the introduction and the conclusion, again simply skimming the details of the justifications for the conclusions. Only on the third reading might there be any serious attempt to begin to understand the details of the actual argument. In any case, readers should frequently expect that they will need to reread methodological articles before they feel comfortable with their understanding of the material. Throughout this process, it is often helpful to take notes on the key points of the introduction and conclusions as well as on the basis for the conclusions. Similarly, readers can benefit from making a list of symbols and brief descriptions of what they represent.

Just as authors can improve clarity of technical points by presenting special cases, readers can also check their understanding of such points by considering special cases even if the author does not provide them for the reader's convenience. Along these lines, readers can also attempt to reproduce the results from a numerical example. Finally, when all else fails, readers can ask for help. Just as authors usually benefit from the advice of someone with a different perspective, readers may also discover that sharing an article with a colleague allows both individuals to reach a higher level of understanding.

Summary

Attention to fundamental rules for good writing is especially important when writing articles on methodology or statistics. Such basic rules are insufficient, however. Additional concerns arise as the content of psychological articles becomes increasingly technical or mathematical. With an eye toward improving

the written presentation of methodological material, we outline a number of tips for technical writing:

1. Keep the reader uppermost in mind.
2. Select the journal for your article carefully.
3. Write for as broad an audience as possible.
4. Obtain feedback from someone whose expertise and perspective is different from your own.
5. Be especially clear at the onset because methodological presentations are often cumulative.
6. Convince your reader that it is important to read this article.
7. Be aware of the unusually diverse literature that is relevant to methodological articles.
8. Be sensitive to what your readers do and do not know.
9. Strategically define your symbols.
10. Encapsulate and clearly summarize technical material.
11. Consider using the particular–general–particular approach to technical presentations.
12. A figure is worth a thousand equations.
13. Keep the work relevant to real-world situations.
14. Be mindful of the value of mathematical proofs.
15. Confess the limitations and shortcomings of even the best new methodologies.

Needless to say, following these guidelines and 100 others will not guarantee publication. The packaging will make the product pretty, it will get the article read, and it will help the material to be understood, but the bottom line will always be the quality of the authors' ideas and their ultimate relevance to psychological research.

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