

The attached papers are from *The American Statistician*.

Vardeman, S.B and Max D. Morris. 2003. Statistics and Ethics: Some Advice for Young Statisticians. *The American Statistician*. 57(1):21-26

Kirk, Roger E. 1991. Statistical Consulting in a University: Dealing with People and other Challenges. *The American Statistician*. 45(1):28-34

I would like you to read these papers and write a paper (4 to 5 pages @ 1.5 spaces and 12 point font) discussing those aspects that you believe could be important to your career in statistics. I would also like for you to familiarize yourself with the "Ethical Guidelines for Statistical Practice" from the American Statistical Association. As you write your discussion of the papers below, comment on any consistencies or inconsistencies that you observe between the paper and the Ethical Guidelines.

Send your paper to me via email. Include "EXST7083" in the email topic line. I would like the paper as a MS Word document. Include your last name and first initial in the document title. This assignment is due Tuesday, April 17 by class time.

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General

Statistics and Ethics: Some Advice for Young Statisticians

Stephen B. VARDEMAN and Max D. MORRIS

We write to young statisticians about the nature of statistics and their responsibilities as members of the statistical profession. We observe that the practice of the discipline is inherently moral and that this fact has serious implications for their work. In light of this, we offer some advice about how they should resolve to think and act.

KEY WORDS: Graduate study; Integrity; Principle; Professional practice; Research; Teaching.

Dear Gentle Reader:

So, you are embarking on a career in statistics. Good. It is a genuinely noble pursuit, though this may be hard to see as you wrestle with new-to-you technical issues varying from “How do I get this SAS job to run?” to “How do I show this thing is UMVU?” and on occasion find yourself wondering “What is the point of all this?”

This last question about purpose is actually a very important and quite serious one. It has implications that run far beyond your present pain (and joy) of “getting started.” How you answer it will affect not only you, but also the profession, and human society at large. We write to offer some advice and encouragement, and to say how we hope you frame your answer to this simultaneously practical and cosmic question.

What *are* this subject and this profession really all about? And why *are* you doing what you are doing? For sure, there are details to learn (and keep current on throughout a career). There is everything from the seemingly uncountable number of tricks of first year probability theory, to statistical computing, to nonlinear models. It initially looks like “soup to nuts.” You know that statistics is about collecting and handling data. That is true, but incomplete; there is much more than that at work here.

The vital point is that this discipline provides tools, patterns of thought, and habits of heart that will allow you to deal with data *with integrity*. At its core statistics is not about cleverness

and technique, but rather about *honesty*. Its real contribution to society is primarily *moral*, not technical. It is about doing *the right thing* when interpreting empirical information. Statisticians are *not* the world’s best computer scientists, mathematicians, or scientific subject matter specialists. We *are* (potentially, at least) the best at the *principled* collection, summarization, and analysis of data. Our subject provides a framework for dealing transparently and consistently with empirical information from *all* fields; means of seeing and portraying what is true; ways of avoiding being fooled by both the ill intent (or ignorance) of others and our own incorrect predispositions. The mix of theory and methods that you are discovering is the best available for achieving these noble ends. The more you practice with it, the sharper will become your (fundamentally moral) judgments about what is appropriate in handling empirical information.

Others from areas ranging from philosophy to physics might well object that we have claimed too much, wrapping statistics in a cloak of virtue to the apparent exclusion of other disciplines. After all, thoughtful scientists and humanists from a variety of fields are engaged in the pursuit of truth. And any serious education has moral dimensions. Our point, however, is that the particular role that the profession plays in science and society should not be viewed as amoral, and that this fact constrains how we all must think and act as its members.

That society expects our profession to play this kind of role can be seen in the place statistics has as arbiter of what is sufficient evidence of efficacy and safety to grant FDA approval of a drug, or enough evidence to support an advertiser’s claim for the effectiveness of a consumer product. And it can be seen in the fact that many disciplines have “statistical significance” requirements for results appearing in their journals.

Society also recognizes that when statistical arguments are abused, whether through malice or incompetence, genuine harm is done. How else could a book titled *How to Lie With Statistics* (Huff 1954) have ever been published and popular? The famous line (attributed by Mark Twain (1924) to Benjamin Disraeli) “There are three kinds of lies: lies, damned lies, and statistics” witnesses effectively to society’s distaste for obfuscation or outright dishonesty cloaked in the garb of statistical technology. Society disdains hypocrisy. It hates crooked lawyers, shady corporate executives, and corrupt accountants, and it has contempt for statisticians and statistical work that lack integrity. But young statisticians sometimes find themselves being “encouraged” to offer questionable interpretations of data. This pressure can come even from well-meaning individuals who believe that their only interest is in ensuring that their position is treated “fairly.” Maintaining an independent and principled point-of-

Stephen B. Vardeman is Professor, and Max D. Morris is Professor, Department of Statistics and Department of Industrial and Manufacturing Systems Engineering, Iowa State University Ames, IA 50011-1210 (E-mail: vardeman@iastate.edu). The authors gratefully acknowledge the generous input of a number of colleagues. Karen Kafadar, Bob Stephenson, Bill Meeker, and Dean Isaacson provided detailed comments on a first draft of this article. And the input of Ken Ryan, Tammy Brown, Mike Moon, Bill Notz, Tom Dubinin, Frank Peters, David Moore, Bill Duckworth, Bruce Held, Dennis Gilliland, Bobby Mee, Doug Bonett, Dan Nettleton, and Hal Stern is also gratefully acknowledged.

view in such contexts is critical if a statistician hopes to avoid becoming a part of Disraeli's third "lie."

So, you are embarking upon a noble and serious business. We take as given that you have a basic moral sense and a strong desire to personally do good. We also take as self-evident that integrity is a pattern of life, not an incident. Principled people consistently do principled work, regardless of whether it serves their short-term personal interests. Integrity is not something that is turned on and off at one's convenience. It cannot be generally lacking and yet be counted on to appear in the nick of time when the greater good calls. This implies that what you choose to think and do now, early in your career, are very good predictors of what you will think and do throughout the whole of it. You are setting patterns that will endure over a professional lifetime and substantially influence the nature and value of what you can hope to accomplish.

A fair amount has been written about professional ethics in statistics and we do not propose to review it all or comment on every issue that has been raised. For example, Deming's (1986) article is fundamentally a discussion of ethics. Both the American Statistical Association (1999) and the International Statistical Institute (1985) have official statements on ethical guidelines for statisticians. And in a more general setting, the National Academy of Sciences (1995) has published a useful booklet that is primarily about ethics in science and has implications for statistical practice.

Our more specific goal here is to suggest some things that a high view of the discipline means for your present work and attitudes. Aiming to speak to both statistics graduate students and recent grads, we'll begin with some implications for life in graduate school, and then move on to implications for an early career in the discipline.

ADVICE FOR STATISTICS GRADUATE STUDENTS

"Graduate student ethics" (or for that matter "professional ethics") is really just "plain ethics" expressed in a graduate student (or professional) world. A discussion of it really boils down to consideration of circumstances and issues that arise in a particular graduate student (or professional) setting. So an obvious place to begin is with general student responsibilities. If you are still in graduate school, we urge you to be scrupulous about your conduct in the courses you take. Here are some specifics:

- Resolve to never accept credit for work that is not your own. It should make no difference to you whether an exam is proctored or unproctored. Whatever the homework policy of the course, make it your practice to clearly note on your papers places where you have gained from discussions with classmates or consulting old problem sets of others. It's simply right to give others credit where it is deserved and it's simply wrong to take credit where it is undeserved.

- If course policy is that everyone is "completely on their own," resolve in advance to politely refuse to discuss with peers topics that are off-limits, even if others violate the policy. It may seem a small thing at the time, but you are setting life trajectories that are bigger than the particular incidents.

- Determine to never take advantage of (or over) your peers. If you join a group study session, be ready to make your fair contribution, not just to benefit from the input of others. If you have legitimate access to old files or notes or textbooks that are helpful, let others know about them so that they can benefit as well.

What do these three points say? Simply that you should play by the rules set out and be clear and honest about all contributions made to the work you turn in. Why would anyone do otherwise? Honestly, only to gain an undeserved advantage in a course grade, or to avoid some effort. But a student willing to cut corners for an A or a free weekend will have serious difficulty not cutting corners in later professional responsibilities when the reward is a promotion or pay raise or a free weekend.

Some additional issues are related to the notion of "doing the hard thing." Everyone has things that come harder for them than others. It's human nature to want to avoid what is difficult and to even convince ourselves that really, the easy thing is what is important and the hard thing is worthless. But that is not only obviously silly, it has moral implications. Here is some advice for the student reader:

- Understand that acquiring an advanced education is a difficult enterprise, that there may be times when you *feel* like complaining about this, but that it doesn't really help to do so. Whining wastes energy and can poison the learning atmosphere for others. You are engaged in a noble, if difficult, pursuit. Give it your best shot without complaining. After all, most things worth doing *are* hard.

- Resolve to work on your weaknesses rather than excuse them. Doing good statistical work is important, and demands the best possible personal tool kit. The reasoning "I find methods (theory) easier than theory (methods), so I'll just do methods (theory)" implicitly and quite wrongly assumes that one can do good statistical work with half a tool kit.

- Decide not to denigrate the strengths of others. Give other people credit for what they can do that you cannot. Find your niche without minimizing the honest efforts and contributions of others.

- Determine to take the courses that will enable you to be the best-educated and most effective statistician you can be. These are often academically demanding, and may not form a particularly easy route to a high GPA. While difficulty, per se, is not necessarily a measure of how often you will find the material in a course useful, it *is* related to the mental discipline you will develop. If you choose a course that covers material you could easily pick up on your own or because it is taught by a professor who demands little in exchange for an A, you've cheated yourself. The choices you make about curriculum are moral choices, not just choices of convenience. You have a limited time in graduate school . . . use it wisely. How effective you will be as a professional depends on it. Besides, your choices say something nontrivial about the personal character that you are developing.

- Purpose to do what your thesis or dissertation advisor sets for you to do, as independently as you can. While it may seem that some assignments are arbitrary or unnecessary, remember

that you do not have your advisor's experience as a researcher *or* educator. This person knows what you know, what your abilities are, and the difficulty of your problem. He or she is trying to help you to develop as a responsible and independent member of the profession, one accustomed to consistently working up to your capabilities. Focusing your energy on the challenge of the problem and the opportunity it represents will take you much farther than wasting your energy in grumbling or in negotiating to be led through every detail of a solution.

It is worth adding a further note related to this last point. The advisor–advisee experience has the potential to be invigorating and rewarding (both professionally and personally) for both parties. Think of the efforts you put into it not only as a requirement for the degree, but as the beginning of what may be one of your most important and cherished long-term relationships. Find someone to work with who you like and respect, and put your energy into the enterprise.

Most statistics graduate students work as graduate assistants. Assistants should remember first that an assistantship is not a fellowship, but rather a job. And it is axiomatic that principled people return honest effort for their pay. If you are working on a faculty member's grant, that person must produce quality work in line with the interests of some outside entity. Do what you can to help him or her. If you are a teaching assistant, there are lectures to conscientiously prepare and deliver, papers to carefully grade, and students to help. If you are a consultant, people with real problems of data analysis will appear at your door seeking aid. They need your best effort and advice. Let us amplify a bit:

- If you are a research assistant it is understood that you have “your own” class work and thesis or dissertation to attend to. But some of your weekly hours are first committed to providing the help (programming, library work, report writing, etc.) your employer needs. There are important educational benefits that accrue as you practice at these duties. But the most fundamental reason to carry them out conscientiously and cheerfully is simply that it is the right thing to do. (And it is wrong to think that cutting corners now doesn't say anything about later behavior. Life will always be hectic and there is no reason to expect your work habits after finishing school to be better than the ones you are developing now.)

- If you are a teaching assistant, purpose to make the best of the fact that along with some conscientious, motivated, and pleasant students, you will deal with some unpleasant, intentionally ignorant, lazy, and dishonest students. It simply comes with the territory. For your part, make it a point to model integrity and purpose for all of them. Do your best to convey that what you are teaching them really does matter and how they do it matters as well. Resolve that whatever your “style”/personality (from animated to reserved) your body language will convey a genuine willingness to help. The job takes patience—plan on it. Resolve to treat all of your students well, whether or not their behavior in any sense merits that. And it should go without saying that although you want to be pleasant and approachable, propriety

and impartiality dictate that you are their instructor or TA, not their pal.

- If your assignment is to help with statistical consulting, you are already wrestling (at a “trainee” level) with some of the serious issues faced by one segment of our profession. Carefully consider and handle these now, as you begin to see how the “human element” of statistical consulting requires thoughtful and principled discipline. You're going to have to argue with yourself in conversations like:

- What looks to me like the thing that *should* be done would take two hours to explain and several more hours of my time to implement, while this client would be happy with something less appropriate that I could explain in five minutes . . .
- This client *really* wants “A” to be true, but these data look inconclusive . . .
- This looks pretty much OK except for that oddity over there that the client doesn't really want to discuss . . .

Graduate Student Reader, keep your eyes open during this graduate student experience. Watch your faculty and emulate the ones who take seriously what they do. There are some fine role models in our university statistics departments, excellent members of the profession. Find them, and learn as much as you can about what they think and how they practice statistics.

ADVICE FOR YOUNG PROFESSIONAL STATISTICIANS

Many of the themes we've introduced in the context of graduate study have their logical extensions to early professional life. But there are also other matters that we've not yet raised. We proceed to discuss some of the less obvious extrapolations and further ethical issues faced by young statisticians, organizing our advice around the topics of (1) research/publication, (2) teaching, and (3) professional practice.

If you have finished a Ph.D., you have been introduced to the craft of research in statistical theory or methods. You are in a position to help develop the profession's supporting body of knowledge and to contribute to our journals. It's important to consider the corresponding responsibilities. These are tied closely to a proper view of the purpose of publication in statistics. Published statistical research should provide reliable and substantial new theory or methodology that has genuine potential to ultimately help statisticians in the practice of the discipline. Statistical publication should not be treated as a game. It is, and should be treated as, a serious and moral business. Here are some points of advice issuing from this high view of what the research and publication activity is all about:

- Resolve that if you choose to submit work for publication, it will be complete and represent your best effort. Submitting papers of little intrinsic value, half-done work, or work sliced into small pieces sent to multiple venues is an abuse of an important communication system and is not honorable scholarship. It is not the job of editors or referees to proofread or complete your papers, or to insist that you follow up on important issues that you know exist. See the “Let's just send it off and let the reviewers

sort it out” impulse for what it is, a temptation to off-load your work to someone else. And the “I’ll just submit this half-done thing to an outlet that will print anything” strategy does nothing of real value for anyone. It wastes time and effort of those in the review system, and when “successful” it dilutes our literature. This makes important work harder to find, and in the end calls into question our very reason to exist as a profession.

- Purpose that when asked to do the job of a referee, you will do it thoroughly, impartially, and in as timely a manner as possible. There is no obvious short-term payoff to doing what is right here. But the integrity and currency of the scientific publication process depend on competent and principled referees taking the job seriously. Resolve never to do a shoddy/cursory review job, or worse yet to let calculations about personalities (and personal advantage) govern how you judge a piece of work. Even though many statistics journals use a “double-blind” system, the profession is small, and you will find it increasingly rare that you have no idea who authored a paper you receive for review. So remember that the *spirit* of the blind review policy is honorable, and that you have an obligation to conduct your review in this spirit even when you cannot be completely “blind.” And do what you can as an individual to help fix the widely recognized problem that the review process in statistics is presently much slower than in many other disciplines.

- Decide to routinely take the advice of editors and referees regarding papers that you submit for publication. Occasions are rare where editors or referees have it all wrong or purposely treat an author unfairly. Most often, the advice they offer is constructive and when followed substantially improves an article. Until an editor signals clearly that he or she has no further interest in a piece you have submitted, you should almost always make good faith efforts to revise your paper in accord with his or her advice. Serial journal-shopping for a venue that will publish a submission with essentially no revision may minimize the total effort an author expends on a paper, but the practice wastes the overall energy of the profession and has a negative effect on the overall quality of what is published.

- Determine to be scrupulous about giving credit where it is due. If another has contributed substantially to the content of a paper, co-authorship is typically appropriate and should be offered. (On the other hand, *never* list a colleague as co-author of a paper until you have that person’s explicit permission to do so.) And include acknowledgments of others deserving thanks for less extensive, but real, help with an article.

- Resolve to acknowledge priority and the derivative nature of your work with due humility. If after the fact of publication you find that some of your results can be found in earlier work, immediately send an acknowledgment to that effect to the journal where your paper appeared. In writing your papers in the first place, we encourage you to be forthright and helpful about what you know is already published on your subject, delineating carefully what others have already said and where your new contribution lies. (No one ever really “starts from scratch.” Don’t fall prey to the temptation to leave unsaid what you know is already known, thinking that to do so strengthens your own position.) And *never* borrow published/copyrighted words, even of your own authorship, without acknowledgment. To do so is pla-

giarism and is completely unacceptable. (This caution extends, by the way, to thesis and dissertation work, even if that work is never submitted to a journal for formal publication.)

A note related to this last point: Avoiding plagiarism places an extra burden on students whose writing skills are not strong, especially those struggling with English as a second language. But it is essential to find one’s own words and not simply copy or even paraphrase those of another (even for parts of a paper that are background and obviously don’t purport to provide new technical content). This is a very serious integrity issue.

Next, let’s consider issues relevant to teaching of statistics as a professional. There are reasons to do this whether or not you have plans for a career at a college or university. Teaching/training is increasingly done “in house” by corporations and consultants, and it could be argued that most professional presentations are essentially teaching efforts. The logical extension of the advice offered above to graduate teaching assistants is, of course, relevant here. But there is an important extra dimension to discuss, related to the freedom and responsibility that a professional has in answering the question “What will govern what and how I teach?” Will it be “What’s easy for me?” Or will it be “What will get the best short-term reaction from the students?” Or will it be “My best professional judgement as to what the students need for the long term and my best understanding of how to effectively convey that information?” This is a moral choice. Here is some amplification:

- Determine that you won’t fall into the trap of organizing all courses around your technical specialty. This is an issue of fundamental humility and recognition that none of us has put all that is needed into our personal little package (to say nothing about the matter of “truth in advertising!”). But we suspect that you know what we are talking about, having seen people turn every course they teach into a platform to show off their own work.

- Purpose not to be governed by what is easy to do. This is not an entirely separate issue from the previous one. But we are also thinking about cases where the case is not so blatant or not tied directly to one’s specialty. It’s a lot of work to learn new methods and software to include in a course, to freshen examples, to develop new laboratories and assignments for students, to replace outdated topics and means of presentation. And it’s sometimes possible to “get by” without investing that effort. But doing so is simply wrong. We urge you not to take that route.

- Resolve to do the best for your students, whether or not they appreciate your efforts in the short term. We live in a “consumer” society. There is huge pressure on teachers in all contexts to make students happy. But statistics is hard, and students DON’T know what they need. You will. We hope that you opt to do your best to provide that, not simply what will get the best crowd reaction. Lots of jokes, little in the way of course demands, and high grades can please many audiences. And leave students ignorant. Of course we should aim to be engaging in our presentation of our subject. But the point of teaching is to genuinely improve subject matter knowledge and the reasoning powers of students. It is not to produce feel-good experiences for them. (In this regard, we were recently dismayed to see an Iowa community college president quoted in the *Des Moines Register* (2001) as

proudly saying “We are really a service organization first and an educational institution second.” While that may in fact be true, it is a terrible commentary on the state of the institution.)

Those of you beginning academic careers will face enormous demands for early success. Most universities require substantial accomplishments in both research and teaching during the first six years of employment, and some place the bar so high that seemingly superhuman effort is required. If numbers of refereed publications and instructor evaluations are the “keys to success,” can you afford to have *real quality* as your primary goal? Is there enough time in six short years to accomplish all that is required if you take our advice seriously? These are real and hard questions. How you use your assistant professorship is critical to your long-term professional success, and it is obvious that you must take your institution’s expectations into account. But, we urge you as you face these issues to remember that one who spends an assistant professorship cutting corners is at best prepared to be an associate professor who knows how to cut corners . . . not one who has learned how to make a difference.

Turning finally to the area of professional practice, we note that most of what has been written about ethical guidelines for statisticians concerns what is appropriate in public practice, in lending aid to others in the impartial and efficient collection and analysis of their data. This is understandable, as (1) the discipline’s whole reason to exist is ultimately to provide such aid and (2) this activity is both subtle and full of pitfalls. Both the ethical guidelines and public skepticism typified in the “lies” quote of Disraeli point to the fact that statistics can be used to form highly technical and even technically correct support for statements which are in fact not true. We might hope this could happen only when nonstatisticians practice statistics without proper technical understanding of the subject. But statistical lies are by definition immoral uses of statistical arguments, whether technically correct or not, and stem from societal pressures that affect statisticians and nonstatisticians alike. What then must you do in society to preserve the discipline’s (and your own) integrity?

First, recognize that *a professional statistician should never behave like a courtroom lawyer*. The practice of law is based on an adversarial model in which each lawyer represents an assigned point of view—that which will yield the most positive outcome for his or her client. While the use of lies and intentionally misleading statements is prohibited in legal proceedings, legal strategy certainly does involve the selective use of evidence so as to present the truth (or some part of it) in the light most favorable to a particular point of view. But a key aspect of this model of litigation is that decisions are made by an unbiased authority (a judge or jury) based not on the case presented by a single side, but only after arguments presented by all parties are heard.

Statisticians usually do not operate in such well-controlled adversarial systems. If you *do* work in this kind of arena you must keep absolutely clear the distinction between an objective analyst and an advocate, and never purport to be (or think yourself) the first when you are the second. If you are employed by an organization (whether on a permanent basis or as a consultant) you are by definition not disinterested in its well-being. And if you are working “pro bono” for a cause you support, you are not dis-

interested in furthering the cause. In either case, it is axiomatic that your professional judgment is potentially clouded by what you (quite naturally) want to be true. And you will be no fair judge of the extent to which this clouding has occurred. There is real danger here. There is little that is more damning to the discipline than for one of its professionals, implicitly claiming some degree of objectivity, to be publicly exposed as overstating a statistical case in favor of his or her employer or cause.

More commonly, statisticians function as consultants to those who must make decisions. We do this through careful and thoughtful design of data collection mechanisms and analysis of assembled data. But “careful and thoughtful” here are words that acknowledge a critical fact: *Statistical analysis of data can only be performed within the context of selected assumptions, models, and/or prior distributions*. A statistical analysis is actually the extraction of substantive information from data and assumptions. And herein lies the rub, understood well by Disraeli and others skeptical of our work: For given data, an analysis *can* usually be selected which will result in “information” more favorable to the owner of the analysis than is objectively warranted.

The only “cure” for this difficulty is statistical practice based on assumptions embodying an informed, balanced, and honest representation of what is known. “Known,” not “wished for,” “desired,” “convenient,” or even “other-than-worst-fears.” This has implications for how statisticians must be and act if they are to be both effective and ethical.

- *Statisticians must be knowledgeable about the system under study*. They should not present themselves as competent to analyze data from systems about which they have no substantive understanding. Real data are not “context-free.”
- *On the other hand, statisticians must recognize and acknowledge the limitations of their “subject matter” knowledge*. Data and variation are ubiquitous. Knowing how to handle them can give you important and even uncommon insights in a variety of contexts where you have limited subject matter credentials. But the fact that you can make contributions in league with experts in a variety of fields doesn’t substitute for credentials in those fields. The credibility of the statistical profession depends upon its members being scrupulous about what they know and what they don’t know. Never forget that you are not the context expert.
- *Statisticians must go out of their way to see that their analyses allow interpretations of the available data which are tenable but not popular in the statistician’s organization*. This does not mean “be a troublemaker,” but it does mean that you should carefully think through how available data would be interpreted by those with all possible rational points of view.
- *Statisticians must write complete reports stating the results of their entire informed thought processes—including what they know, what they have assumed, what they have decided cannot be assumed, and what conclusions tenable assumptions support*. Our reports should contain “complete and sufficient” analyses upon which any rational point of view can be argued. If you come to the conclusion that one of the spectrum of sensible interpretations is “best” in a particular application, make it your goal to be absolutely transparent about your reasoning. People

should be able to easily see your full set of model assumptions, understand what methodology you have used to make inferences in that model, and have access to diagnostic and robustness work you have done. (This advice is sound in general. But it is perhaps especially relevant to explicitly Bayesian analyses. A consumer of a posterior distribution has a moral right to know how strongly it depends upon the prior.) Honest statistical work has nothing to hide. It says what it says. It doesn't try to obscure points where alternative conclusions are possible if other assumptions are made or different analysis paths are followed, and admits where model fits are short of perfection or conclusions are highly model-dependent.

As a statistician, your allegiance must be to finding the conclusions which can be supported by data and careful assumptions. Does this make the business of assumption selection more difficult than it seemed in your statistics coursework? Does it seem as though you must take these issues more personally and seriously than our favorite semi-academic phrase "Let X_1, X_2, \dots, X_n be iid $F \dots$?" Does it sound like your formulation of these assumptions may have more to do with nonmathematical *values* than has been discussed in your textbooks? Yes, this and more is true. Ethical statistical practice requires that you *take responsibility* for acquiring substantive understanding, knowing all rational points of view, and making decisions well beyond those based entirely in data.

- You must examine yourself to see that you are not even subconsciously leaning toward analyses which you believe will "please the boss" or yourself, or simplify the problem unjustifiably. This means that you cannot afford to think of yourself as a data technician or a hired gun. You must be secure enough to simultaneously separate any prior vested interest (yours or others') in the outcome from your analysis, and meld together seamlessly everything you know about the subject matter of your investigation with the structure of your statistical work. *You cannot do this unless you have strength of character and integrity.*

- You must not stop with the obvious or even the most likely explanation of data, but find ways to examine them so that all rational viewpoints can be informed. This means that you will work harder and longer than anyone who reads your reports will ever know. You will not rest until you *know* you understand all the information contained in the data, where "information"

is defined by the context of your work across the spectrum of rational viewpoints. *You cannot do this unless you develop an ethic of self-reliance, thoroughness, and hard work.*

- You must understand fully what your assumptions say and what they imply. You must not claim that the "usual assumptions" are acceptable due to the robustness of your technique unless you really understand the implications and limits of this assertion in the context of your application. And you must absolutely never use any statistical method without realizing that you are implicitly making assumptions, and that the validity of your results can never be greater than that of the most questionable of these. *You cannot do this unless you remain dedicated to being the best technical statistician you can possibly be, understanding that this involves knowing and understanding the mathematical arguments as well as the computational techniques behind every tool you need.*

Well there it is, more than enough advice to keep a young statistician busy for a career. We hope we don't sound too much like myopic cranks, finding "serious ethical issues" to raise in even the most mundane contexts. Instead, we hope that we have argued effectively that ethical matters are central to our discipline and provided some insight into issues that this raises. We further hope that you determine to take the matter of principle most seriously.

Carry on, Gentle Reader.

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REFERENCES

- American Statistical Association (1999), "Ethical Guidelines for Statistical Practice," <http://www.amstat.org/profession/ethicalstatistics.html>
- Deming, W. E. (1986), "Principles of Professional Statistical Practice," in *Encyclopedia of Statistical Science* (vol. 7), eds. S. Kotz and N. Johnson, New York: Wiley.
- Des Moines Register* (2001), "Western Iowa Tech Among Nation's Fastest Growing Schools," December 31, 2001, pp. B-1.
- Huff, D. (1954), *How to Lie with Statistics*, New York: Norton.
- International Statistical Institute (1985), "Declaration on Professional Ethics," <http://www.cbs.nl/isi/ethics.htm>.
- National Academy of Sciences (1995), *On Being a Scientist: Responsible Conduct in Research*, Washington, DC: National Academy Press. Also available online at <http://www.nap.edu/books/0309051967/html/>.
- Twain, M. (1924), *Mark Twain's Autobiography*, New York: Harper & Brothers.

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Statistical Consulting in a University: Dealing With People and Other Challenges

ROGER E. KIRK*

Statistical consulting is examined in terms of the stages of the first consultation, roles that a consultant can assume, and challenges associated with statistical consulting in a university. Some of the challenges that are discussed are (a) dealing with the human side of consulting, (b) consulting on an extremely wide range of research problems, (c) coping with clients having diverse statistical backgrounds, (d) dispelling inappropriate expectations about what statisticians can and cannot do, and (e) contending with a university reward system that penalizes those who engage in statistical consulting as opposed to those who pursue their own research.

KEY WORDS: Consulting roles; Human side of consulting; Interpersonal skills; Stages of the consulting process.

1. INTRODUCTION

Statistical consulting is defined as the collaboration of a statistician with another professional for the purpose of devising solutions to research problems. Statistical consultants practice their craft in a variety of settings, such as government, industry, medical centers, and universities. Although the settings differ, they are similar in terms of the stages of the first statistical consultation and the roles that consultants are expected to play [see, e.g., Froberg, Holloway, and Bland (1984); Hunter (1981); Moses and Louis (1983); and Stegman (1985)]. This article reviews these similarities, discusses several important interpersonal skills, and examines some challenges that face statistical consultants in a university.

2. STAGES OF THE CONSULTING PROCESS

The first statistical consultation with a client usually has five stages: (1) establishing rapport, (2) identifying the research problem, (3) setting goals, (4) agreeing on a division of responsibility, and (5) reviewing what has occurred [for alternative descriptions, see McCulloch, Boroto, Meeter, Poland, and Zahn (1985); Platt (1982); and Zahn and Isenberg (1983)].

2.1 Establishing Rapport

The first stage of a consultation usually begins with an exchange of pleasantries and small talk. Its purpose is to establish rapport with the client. First-time clients are often apprehensive because they do not know what to expect and

may feel defensive about their statistics background. It is important to allay a client's apprehension by exhibiting an accepting, caring attitude—an attitude that encourages the open exchange of information. The first stage of a consultation ends when the consultant says, "Well tell me about your project" or the client says, "The reason I'm here is. . . ."

2.2 Identifying the Research Problem

The second stage of a consultation is concerned with identifying the research problem. During the early part of this stage, the client does most of the talking. The consultant asks questions when necessary to clarify points. The following information needs to be communicated. What questions does the client want to answer, why are these questions important, and what has the client accomplished thus far?

Early in the second stage it is important to determine if the person to whom the consultant is talking is the real client and if others are involved in the research. There is a small group of researchers who, because they are busy or intimidated by statisticians, attempt to consult through an intermediary. Without fail, such clients receive inferior advice and waste the consultant's time. The consultant should insist on seeing the real client or clients.

It is also important to understand the significance of the client's research. How does it fit into the knowledge base of a discipline? Are there well-established research traditions in the discipline that should be followed? In the second stage of a consulting session the consultant should obtain an accurate and relatively complete understanding of those aspects of the research that have implications for its design and analysis. Incorrect assumptions about how data have been collected, for example, should not be allowed to vitiate the analysis and interpretation of an experiment. A consultant should follow up points with "Let's see if I've got this right" or "Are there any other things I should know about?" It is best not to trust the details to memory; take notes during the session. For complex projects, I like to send the client a written summary of my understanding of the project and the agreed-upon course of action. For less complex projects, a verbal summary may suffice. In either case, written notes are invaluable.

The second state of a consultation can be thought of as the discovery stage. In addition to learning about the research problem, the consultant also learns about the client's expectations, research environment, time and money constraints, and statistical sophistication. This information is especially useful since it will influence the kinds of recommendations that can be made in the third stage.

2.3 Setting Goals

There is usually a natural and often imperceptible transition to the third stage of the consultation. This transition

*Roger E. Kirk is Director of the Behavioral Statistics Program, Baylor University, Waco, TX 76798 and President of Research Consultants, Inc., 4000 Green Oak, Waco, TX 76710. The views expressed here reflect more than 30 years of consulting experience in medical centers, universities, and industry. The author thanks the referees for their valuable comments and suggestions.

occurs when the client's conversation no longer contains relevant new information about the research project and the consultant's questions indicate a good understanding of the project. The third stage is concerned with setting goals: determining the questions that are to be answered and the actions that are to be taken. By this time the client's research problem will have been couched in terms of statistical hypotheses. If the consultant has been sufficiently articulate and the client has been sufficiently attentive, the consultant will be rewarded with words such as "Yes, that is what I want to know" and "I see, this test will tell me if the two variables are independent." If the consultant has been fortunate enough to see the client before data have been collected, this is the time to talk about sampling strategies, randomization, threats to internal and external validity, informed consent, and ethical issues, if any, posed by the research. If the data have already been collected, the consultant will want to determine the conditions under which the data were collected and whether the client controls the use of the data.

If a client's research project is complex or involves an unfamiliar area, the consultant may choose to bring this third stage to a close with a request for a few days in which to think about the project. In the case of a complex project, visiting the site where the data will be collected or seeing a dry run can be helpful. If the research involves an unfamiliar area, ask the client for reprints of related research and the names of colleagues with whom the project can be discussed. It is important to understand the client's research project and avoid giving snap answers. It is only a matter of time before clients and attorneys discover statistical malpractice. The specter of a malpractice suit should be sufficient motivation for providing the client with a written summary of an agreed-upon course of action and a request for clarification if the client's understanding is different from the consultant's.

2.4 Agreeing on a Division of Responsibility

Once agreement has been reached on the research questions to be answered and the actions to be taken, the consultant steers the session to the fourth stage. This stage is concerned with the division of responsibility between the consultant and the client. Who will do what and when? Most consulting centers have a policy statement describing their services and fee structure. The client should be given a copy of this information prior to a consultation, if possible. But policy statements usually deal only with general issues. The client and consultant need to discuss openly their expectations about what each will do, when it will be done, and how much it will cost, and, of course, reach an agreement. For example, is the consultant expected to write a preliminary draft of the results? What about joint authorship? These kinds of details need to be spelled out.

2.5 Summing-up Stage

The last stage of a consultation I call the summing-up stage. This is the time to review what has occurred. As this stage draws to a close, the consultant has one more oppor-

tunity to ask, "Is there anything else I should know about the project?"

3. CONSULTING ROLES

Clients come to a first consultation with varied expectations about what statistical consultants do. The most common roles that consultants are expected to assume are those of helper, leader, data-blesser, collaborator, and teacher. These roles and others have been described by numerous writers, including Barnett (1976), Boen and Zahn (1982), Bross (1974), Hunter (1981), Hyams (1971), Marquardt (1979), Snee (1982), and Stegman (1985). My own, perhaps idiosyncratic, assessment of these roles is as follows.

3.1 Helper Role

The helper role is characterized by a low level of personal involvement on the part of the consultant in the substantive aspects of the client's research project. In this role, the consultant acts as a technician and responds to the client's questions and directions. Typically, the client needs one or more specific items of information—would it be better to run a t test or a Mann-Whitney U test?—or the client needs to have a particular analysis performed. The consultant's job is to supply the information or run the analysis.

The helper role in which the consultant dispenses information or crunches numbers is a common and often appropriate role. Unfortunately, it is not a very satisfying role from the consultant's perspective. One reason why the role is not very satisfying is that often the consultant does not know and, worse yet, does not expect to know the outcome of the session. Did the client use the Mann-Whitney U test? What did the reviewers say about the statistical analysis? One of the rewards of consulting comes from solving a client's problem. Feedback about the outcome of a consultation is less likely to occur in a helper role than in the collaborator and teacher roles, which are described later. Another reason why consultants are not attracted to the helper role is that it can lead to bad consulting. For example, inappropriate analyses can be expected when clients ask the wrong questions or omit important details concerning the data.

3.2 Leader Role

Some clients want a statistical consultant to play a leader role—to assume responsibility for making sense out of the client's data. The leader role requires a consultant who is willing to become intellectually involved in the client's project and a client who prefers a passive role. Consultants should be wary of the leader role—there are pitfalls. The first danger signal occurs when the client has difficulty articulating his or her research questions. Such clients usually prefer to dwell on the quantity of data that has been collected. As one client put it, "With so much data, surely there must be something here." Consultants who accept the challenge of discovering what that something is all too often rediscover the truism that data that have been collected without clear questions in mind rarely answer interesting questions.

Consultants who assume the leader role may find themselves working in an area of science in which they have little or no expertise. The result is often bad science. As Hunter (1981, p. 72) observed, "Since the client will typically know much more about the data than the statistician, a better, more insightful, analysis will be possible if the client is actively involved." There are other pitfalls to the leader role. For example, one of my colleagues spent several months designing an experiment and analyzing the data for a very passive client. The design and analysis, which were quite ingenious, cast doubt on a then widely held theory. I remember my colleague's frustration when she discovered that her contribution was to be rewarded with a footnote citation instead of joint authorship. Disappointment is often one of the consequences of failing to spell out the details of a consulting relationship.

3.3 Data-Blessor Role

The role of data-blessor is one that no statistician likes, but most find impossible to avoid. A typical scenario goes something like this. The client appears at your door just before lunch with the final draft of a manuscript and asks, "Do Tables 3 and 4 look okay?" You examine the tables, make several suggestions, and then make a hasty exit for what remains of your lunch hour. A year later you receive a reprint of the research and there, to your dismay, is a footnote expressing appreciation for your contributions to the statistical analysis of the data. Your frustration grows as you read the paper and discover that the client has run 50 *t* tests and reported that 3 are significant at the .05 level. How can the statistician avoid this scenario? Thirty years of consulting have convinced me that, in spite of one's best efforts, a consultant will fall into this trap from time to time. A strongly worded policy statement requiring written approval of all credit lines will minimize but not eliminate this problem.

3.4 Collaborator Role

Few statistical consultants would stay in the profession if they were limited to the roles of helper, leader, and data-blessor. The role that makes the consultant's work personally satisfying is that of collaborator. In this role the client and consultant pool their talents and expertise so that the resulting research is better than that which would have occurred in the absence of the collaboration. In the ideal case the consultant is involved in the research from its inception and continues the involvement through the report-writing stage. In addition to the tangible reward of joint authorship, the consultant is rewarded with the opportunity to learn about another area of science and the satisfaction of seeing a project through to its completion.

3.5 Teaching Role

The last role that I want to mention is that of teacher. Good consulting rarely takes place in the absence of teaching—the two are inseparable. Both the consultant and the client assume the teaching role at various times during a consultation. For example, the client learns about design and statistical issues and how to approach similar problems

in the future; the consultant learns about another area of science.

Teaching takes place quite naturally as the consultant and client attempt to identify, formulate, clarify, and, perhaps, reformulate the research question. As these efforts progress, the client learns about the kinds of things that consultants consider important: identification of the independent and dependent variables and possible confounding variables, random assignment, estimation of sample size and power, and so on. In the give and take of determining the questions that are to be answered and the actions that are to be taken, the client learns how subtle changes in a research design affect the kinds of conclusions that can be drawn. Such give-and-take exchanges help to dispel the notion that statistical wizardry can somehow compensate for the absence of sound logic in the design of a project. An important by-product of good consulting is a client who is better prepared to design future research projects.

4. DEALING WITH THE HUMAN SIDE OF CONSULTING AND OTHER CHALLENGES

It is generally agreed that successful consulting requires both statistical skills and interpersonal skills (Stinnett 1988). Unfortunately, most graduate programs in statistics give little attention to the latter area, the human side of consulting (Boen and Zahn 1982; Zahn and Isenberg 1983). I want to turn now to several interpersonal skills that are rarely taught in graduate programs in statistics: negotiating for a desired consulting role and guiding the course of a consultation.

4.1 Negotiating for a Desired Consulting Role

Clients enter a consulting relationship expecting consultants to play a particular role. Consultants can either accept the role that is thrust upon them or try through negotiation to obtain a different role. Negotiation is a back-and-forth kind of exchange for reaching an agreement when two parties have some interests that are shared and others that are opposed. First-time clients and even seasoned researchers are often unaware of the different roles that are possible in a consulting relationship. In such cases, a bit of education may lead immediately to a mutually beneficial role. In other cases, one or more of the negotiating principles recommended by behavioral scientists can be helpful in attaining a desired role.

The most important negotiating principle is to try to understand the underlying concerns that motivate a client's behavior and then deal with the concerns rather than the behavior. For example, a client who begins a consultation with a series of questions and is reluctant to discuss the research hypotheses may be motivated by a desire to be in control, a fear of exposing gaps in their statistical knowledge, or a desire to minimize the cost of the consultation. If the client is motivated by a desire to control, the consultant is likely to play the helper role. If, however, the client is concerned about costs, it may be possible to trade consulting time for joint authorship and become a collaborator.

Behavioral scientists have identified five other important negotiating principles.

1. A consultant should avoid attacking a client's position; instead, let the client know that his or her position is understood—understanding does not imply agreement. If a client thinks that his or her position has been understood, he or she is more likely to be receptive to the consultant's position.

2. Clients have multiple interests; develop a climate for agreement by first focusing on shared interests and then turn to interests that are opposed.

3. Clients are more likely to accept the role suggested by a consultant if it seems the right thing to do—right in terms of being fair, reasonable, or honorable.

4. Clients are more likely to accept a suggestion if there is a precedent for the suggestion. A precedent is both an objective standard and a persuasive argument. The use of a precedent conveys a desire to be fair.

5. When there is a disparity between the client and consultant in power or prestige and the difference favors the client, the consultant should try to negotiate on the basis of principle.

The last negotiating principle was used by my colleague mentioned earlier who felt that she deserved more than a footnote citation for her design and analysis. The client was a well-known psychologist, and it was important to preserve a long-standing relationship with his laboratory. My colleague negotiated on the basis of principle by citing the official position of the American Psychological Association. Principle 7f in the *Ethical Principles of Psychologists* (American Psychological Association 1990) states, "Major contributions of a professional character made by several persons to a common project are recognized by joint authorship, with the individual who made the principal contribution listed first." The *Publication Manual of the American Psychological Association* (American Psychological Association 1983, p. 20) goes on to say that "Substantial professional contributions may include formulating the problem or hypothesis, structuring the experimental design, organizing and conducting the statistical analysis, interpreting the results, or writing a major portion of the paper. Those who so contribute are listed in the by-line." When the psychologist realized that my colleague's work clearly qualified as a major contribution and that an ethical principle was involved, he graciously agreed to joint authorship.

When a client resists a role that would be mutually beneficial, most likely there is a problem in perception or communication. If perceptions are inaccurate, begin by trying to see the issues through the client's eyes. Sharing perceptions is an effective way to pinpoint the problem. If misunderstandings exist, reframe the issues to correct the misunderstanding. And consultants should recognize that clients do not have a monopoly on perception and communication problems.

4.2 Influencing the Direction of a Consultation

Over the years, behavioral scientists have learned a lot about the consulting process. They know, for example, that nonverbal cues are especially important in setting the tone of a consulting session. I am referring here to simple things such as the importance of eye contact—maintaining eye

contact is usually interpreted as acceptance or approval; avoiding eye contact, as rejection. In a few hours, a consultant can learn to use a variety of simple interaction techniques for guiding the course of a consultation. These techniques, which were described 40 years ago by Robinson (1950), are concerned with the effects of a consultant's verbal and nonverbal responses on a client's subsequent responses. Robinson discovered, for example, that some responses have little effect on the client's next response or the general direction of the consultation. These responses are *silence*; *acceptance remarks* such as saying yes, uh-huh, and nodding one's head affirmatively; and *restatement*, which consists of repeating or paraphrasing what the client has just said. For example, if the client said, "We ran each subject on two consecutive days; the order of the treatment conditions was randomized," the consultant could respond, "You ran each subject on consecutive days and randomized the order of the treatment conditions." This restatement lets the client know that the consultant understands, but the response does not direct or constrain the client's subsequent responses.

If a consultant wants to direct or constrain the client's subsequent responses, *clarification*, *approval*, and *general leads* can be used. Consider the following two exchanges. The client begins by saying, "In the previous study, blood sugar level didn't seem to make a difference, so we didn't attempt to control it in this study." The consultant responds, "You feel that blood sugar level isn't a relevant variable." The client says, "Uh-huh, but I told Dr. Haynes that we should try to control the blood pressure of the experimental and control groups. What do you think?" The consultant responds, "That seems like a good idea. Are there any other variables that should be controlled?" In the first exchange, the consultant clarified something that the client said—that it was not necessary to control blood sugar level. Notice that no new ideas were introduced. In the second exchange illustrating, respectively, approval and a general lead, the consultant interjected his or her ideas into the consultation. The effect of approval and general leads is to reduce the client's range of potential responses. In this example, the client is further disposed to (a) control blood pressure and (b) consider the possibility of controlling other variables. General leads encourage the client to think more deeply about a topic. They are general enough, however, that they do not arouse the client's resistance.

The use of *interpretation* and *urging* directs the client's thinking along a particular line. In both cases the consultant introduces new elements into the conversation. The following interpretation remark states something that can be inferred from the client's statement and introduces a new element that the client is expected to accept. The client begins, "We had considered controlling age, but it didn't seem practical—ummm—it would have reduced our sample by a third." The consultant responds, "You think that it is important to control age, but the reduced sample size would result in an unacceptably low power." An urging remark attempts to narrow the client's range of responses even more by suggesting that a particular course of action be followed. For example, the consultant could have responded to the statement about controlling age as follows: "I think that you

should control age; let's see if we can use an analysis of covariance here."

The strongest direction in a consultation results from the use of *information gathering, rejection, and the introduction of new and apparently unrelated material*. The following exchange illustrates information gathering. The client asks, "If we use analysis of covariance—ummm—don't we have to assume that the within-group regression lines are linear and parallel? I'm not sure that this make sense here." The consultant responds, "Let's go over this again (*pause*) are you thinking about using age as the covariate?" Alternatively, the consultant could have responded, "You don't need to worry about that. Linearity won't be a problem (*pause*) and we can use the Johnson–Neyman procedure if the regression lines aren't parallel." This rejection remark, unlike the information gathering remarks, attempts to change the direction of the client's thinking.

The introduction of new and apparently unrelated material, like the use of rejection, has the effect of changing the direction of a client's thinking. Clients usually interpret the introduction of such new material as rejection, although this may not be what the consultant intends. For example, the consultant could have responded to the client's question about using analysis of covariance and the necessary assumptions as follows: "Didn't you say that the experimental group had 31 subjects and the control group, 35?" The client's feeling of rejection is apparent in the answer: "Well I (*pause*) I think—ummm—that we lost four subjects in the experimental group."

As these examples illustrate, a consultant has a range of responses that can be used to guide the course of a consultation. Behavioral scientists also have investigated procedures for dealing with a variety of interaction problems that occur during a consultation, such as overcoming a client's resistance to suggestions, dealing with an aggressive or abusive client, and learning how to be nonjudgmental when a client fails to meet the consultant's standards. Fortunately, these procedures can be taught to consultants; see Kirk (1982).

4.3 Consulting on a Wide Range of Research Problems

In the discussion that follows, I want to focus on some challenges that face statistical consultants in a university. What are some of these challenges? To begin with, clients in a university seek consultations on an extraordinary range of research problems. Within a two-hour period I have helped a graduate student design a questionnaire to measure religious attitudes and performed an analysis for a senior researcher to determine whether the water in 26 wells has the same chemical profile.

How can a consultant be prepared to deal with this diversity? It turns out that the picture is not quite as bleak as I have painted it. The majority of research problems can be handled using five or six basic statistical procedures. For example, Van Belle (1982) identified six topics that accounted for two-thirds of the statistical procedures mentioned by consultants and clients. His list is similar to the list of the most used procedures in industry, prepared by a committee of the American Statistical Association (1980). These reports are reassuring, particularly to the novice con-

sultant. But what about the occasional really tough problem? When I encounter such a problem, I never hesitate to tell a client that I need some time to think and that I will get back to him or her in a few days. No one expects statistical consultants to be omniscient.

Statistical consultants who have been out of graduate school for a few years face a different kind of diversity—a statistical knowledge base that is increasing exponentially. There is no easy way for consultants to stay current in the field. I have tried to conscientiously follow a reading program and participate in continuing education short courses at professional meetings. Unfortunately, pressures at work often interfere with my best intentions. Professional associations could assist us by videotaping courses and making them available for home rental.

4.4 Working With Clients Having Varied Statistical Backgrounds

Working with clients having varied statistical backgrounds presents another challenge. In this imperfect world, some clients will have minimal statistical backgrounds along with math and computer phobias. How should a consultant proceed when the most appropriate statistical analysis for a client's research project requires knowledge that the client does not possess? One response is for the consultant to perform the most appropriate analysis and expect the client to somehow obtain the background necessary to understand the analysis. This response inevitably leads to frustration for both the client and the consultant.

An alternative response is for the consultant to assume the role of collaborator and take responsibility for those aspects of the analysis that are beyond the client's capabilities. If this arrangement is acceptable to both parties, it solves the analysis dilemma. Unfortunately, such an arrangement is not always mutually acceptable, and sometimes the arrangement is inappropriate, as when the research project is a graduate student's thesis or dissertation.

What about those situations in which the client's statistical knowledge is limited and the collaborator role is unacceptable or inappropriate? In such situations I feel that the use of a statistical analysis that is congruent with the client's statistical sophistication is preferable to the use of a state-of-the-art analysis. The secret to working with a wide range of clients is to work at the client's level of expertise. A client who has had one research methods course, for example, will have trouble understanding and defending the use of analysis of covariance or canonical correlation. The most naive client, however, can be helped to understand graphs and descriptive statistics. As a general principle, use procedures with which the client is familiar. Avoid the temptation to dazzle clients—use the simplest procedure that will answer the client's question and, preferably, one that is commonly used in the client's research area.

Having said these things, I must admit that there is merit in Stegman's (1985) position that we do not do our clients a favor by providing them with simple answers to complex questions. As Feinstein (1970) observed, clients will not develop the intellectual muscles to walk if they can avoid the necessary effort by being pushed in a statistical wheelchair. Perhaps there is an acceptable middle ground between

Stegman's and Feinstein's positions and that expressed earlier. One compromise is to selectively embrace both positions: make the client walk if the client shows a willingness to acquire more intellectual muscles, otherwise work at the client's level of expertise.

4.5 Cleaning Up the Mess

Another challenge involves the client who contacts the consultant after all of the data have been collected. The worst offenders are graduate students who have relied on the advice of their major professor. Often their data fail to address the questions of interest and may even defy an appropriate statistical analysis. And there is always that large group of fairly prolific researchers who have become comfortable with outmoded or inappropriate research strategies. Their favorite statistics book was published in 1952, and they have not opened the book in the last 10 years. Such clients challenge both the consultant's patience and teaching skills.

4.6 Surviving in Academe

Statistical consultants in a university often have a heavy consulting load and a strenuous teaching schedule. Such demands leave little time for consultants to pursue their own research programs. University administrators have traditionally rewarded research, teaching, and service, in that order. This reward system puts consultants at a disadvantage in achieving tenure and advances in rank and salary. Unfortunately, most universities do not have special criteria for evaluating faculty whose job descriptions contain a significant service component. In the universities with which I am familiar, statistical consultants are expected to publish and obtain grants at the same rate as their nonconsulting colleagues. Obviously, this is not possible, and those consultants who try to compete with their nonconsulting colleagues become candidates for early burnout.

Some statistical consultants succumb to an inflexible university reward system that places a low value on service and give up consulting. When this happens, everyone loses. The alternative is to try to change the reward system. But anyone who has fought the system knows that change does not come easily. I am convinced that statistical consultants must initiate an ongoing, educational campaign to get administrators, department chairpersons, and faculty in other departments to reassess the rewards for research and service. And statistical consultants should encourage faculty in other areas such as speech therapy, social work, and clinical psychology who also have heavy service commitments to join them in this educational effort. There is strength in numbers. For example, Faculty Senates and Promotion and Tenure Committees are more likely to study a problem and make recommendations to the administration if it can be shown that the problem affects several departments.

As part of an ongoing, educational campaign, consultants should periodically forward reports of their consulting activities to their university administration and chairperson. In these reports, it is important to emphasize the consultant's academic contribution to each project (J. R. Boen, personal communication, February 15, 1989). As Boen put it, "Let

the administration know that the statistician's contribution goes beyond just cranking out numbers."

Statistical Consulting Centers can play an important role in an ongoing, educational campaign. For example, new clients can be given literature recommending changes in the university's reward system, the advantages of collaborative working relationships, and the conditions under which a consultant should be listed as a joint author or co-grantee.

Consulting statisticians have been reluctant to speak out on the issue of joint authorship. Many consultants fail to request joint authorship when it is clearly deserved. I have found the official statements of the American Psychological Association cited earlier helpful in clarifying the issue. The guidelines concerning authorship are clear; what remains is for consultants to educate their clients.

Statistical consultants who seek academic parity must be prepared to (a) mount an aggressive, ongoing, educational campaign; (b) energetically pursue collaborative relationships; and (c) be assertive with respect to joint authorship. One thing is certain—inequities in the present reward system will not disappear on their own.

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REFERENCES

- American Psychological Association (1990), *Ethical Principles of Psychologists*, Washington, DC: Author.
- (1983), *Publication Manual of the American Psychological Association* (3rd ed.), Washington, DC: Author.
- American Statistical Association Committee on Training of Statisticians for Industry (1980), "Preparing Statisticians for Careers in Industry," *The American Statistician*, 34, 65–80.
- Barnett, V. D. (1976), "The Statistician: Jack of All Trades, Master of One?" *The Statistician*, 26, 261–279.
- Boen, J. R., and Zahn, D. A. (1982), *The Human Side of Statistical Consulting*, Belmont, CA: Lifetime Learning Publications.
- Bross, I. D. J. (1974), "The Role of Statistician: Scientist or Shoe Clerk," *The American Statistician*, 28, 126–127.
- Feinstein, A. (1970), "Clinical Biostatistics VI. Statistical 'Malpractice'—The Responsibility of a Consultant," *Clinical Pharmacology and Therapeutics*, 11, 898–914.
- Frøberg, D. G., Holloway, R. L., and Bland, C. J. (1984), "A Continuity Model for Research Consultation in Family Medicine," *The Journal of Family Practice*, 19, 221–224.
- Hunter, W. G. (1981), "The Practice of Statistics: The Real World Is an Idea Whose Time Has Come," *The American Statistician*, 35, 72–76.
- Hyams, L. (1971), "The Practical Psychology of Biostatistical Consultation," *Biometrics*, 27, 201–211.
- Kirk, R. E. (1982), "A Practicum Model for Training Consulting Statisticians," in *Proceedings of the Wisconsin Workshop on Consulting Intern Programs*, ed. B. L. Joiner, Madison, WI: University of Wisconsin Statistical Laboratory.
- Marquardt, D. W. (1979), "Statistical Consulting in Industry," *The American Statistician*, 33, 102–107.
- McCulloch, C. E., Boroto, D. R., Meeter, D., Pollard, R., and Zahn, D. A. (1985), "An Expanded Approach to Educating Statistical Consultants," *The American Statistician*, 39, 159–167.
- Moses, L., and Louis, T. A. (1983), "Statistical Consulting in Clinical Research: The Two-Way Street," *Statistics in Medicine*, 3, 1–5.
- Platt, R. D. (1982), "Client-Consultant Interaction," in *Teaching of Statistics and Statistical Consulting*, eds. J. S. Rustagi and D. A. Wolfe, New York: Academic Press, pp. 503–509.
- Robinson, F. P. (1950), *Principles and Procedures in Student Counseling*, New York: Harper & Brothers.
- Snee, R. D. (1982), Comment on "Preparing Statisticians for Careers in the Federal Government: Report of the ASA Section on Statistical Education Committee on Training of Statisticians for Government," by